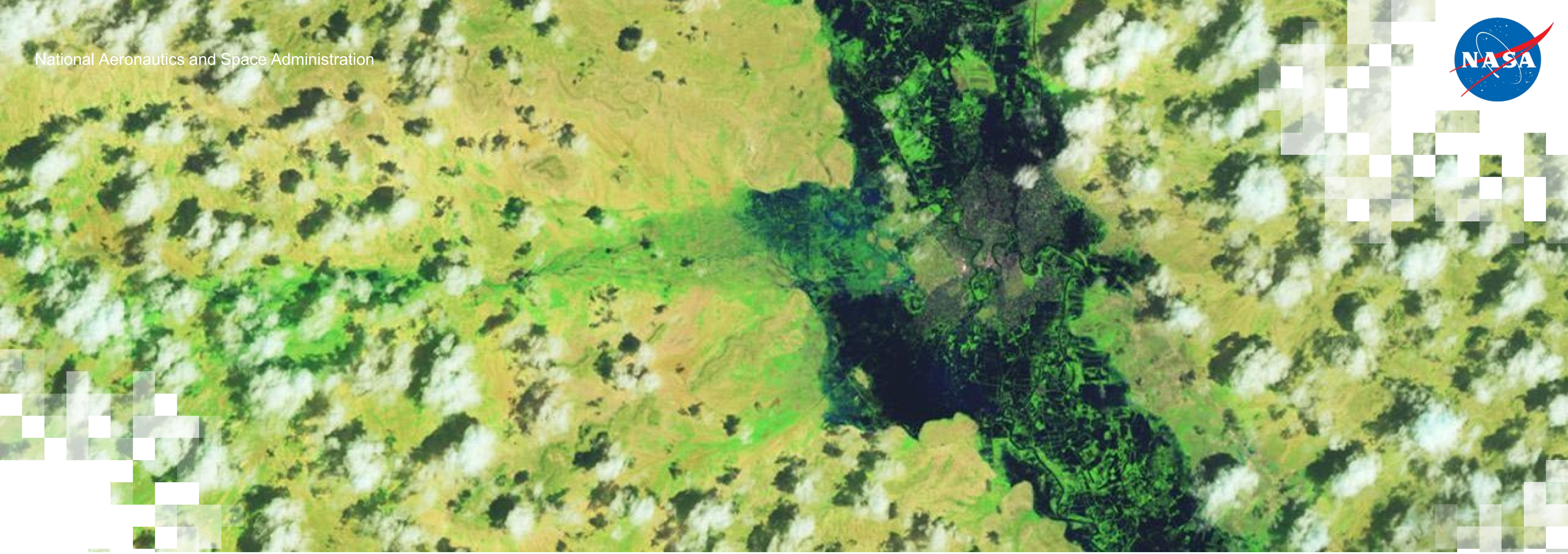
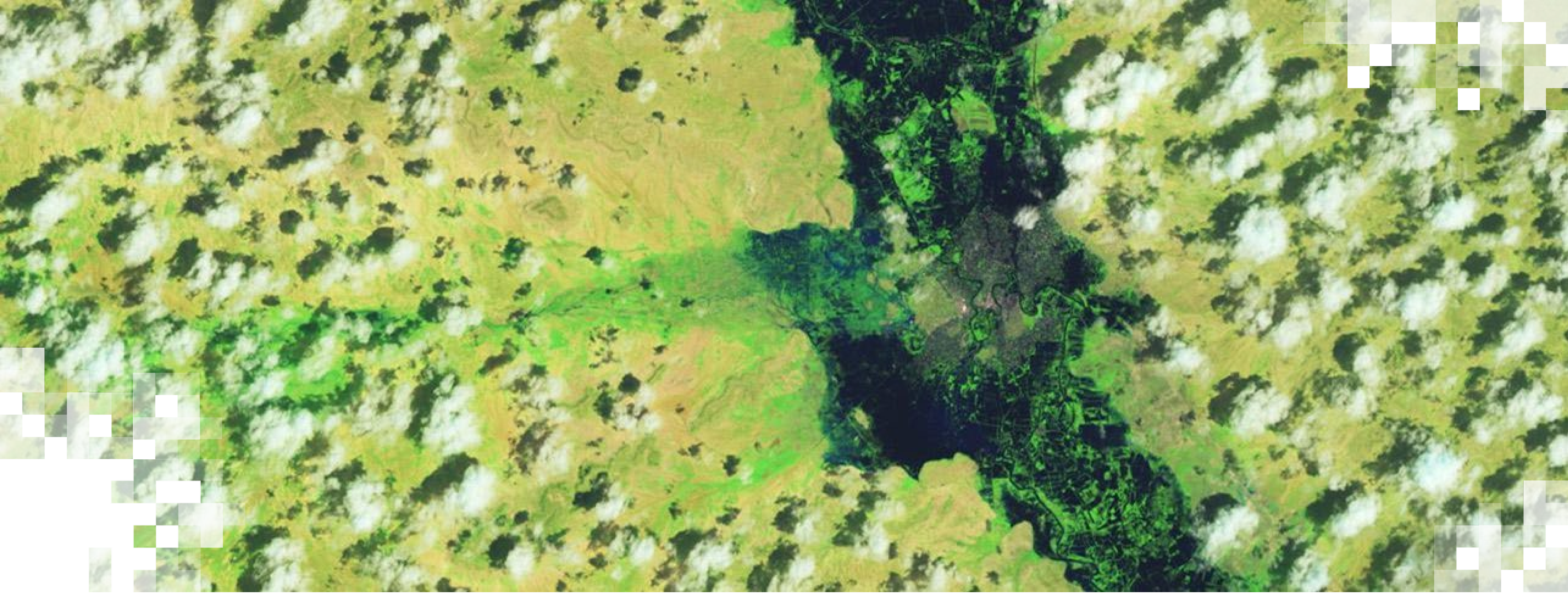


Earth Observations for Humanitarian Applications

Part 2: Gauging Long-Term Heat Stress in Refugee Settings

Andrew Zimmer (Montana State University), Jamon Van Den Hoek (Oregon State University)

June 13, 2024



Earth Observations for Humanitarian Applications
Overview

Motivation for Training

- More than 114 million individuals have been forcibly displaced worldwide as a result of persecution, conflict, violence or human rights violations (UNHCR).
- Refugees, internally displaced people (IDPs), and other displaced populations are made more vulnerable to climate change impacts due to their socio-political marginalization.
- Recent Earth observation (EO)-driven research that recognizes this has made progress towards characterizing the manner and magnitude of climate-related risks in humanitarian (refugee and IDP) settings.

In the outskirts of Thata in Pakistan, women displaced by the 2010 flooding line up to fetch water.
Credit: Asian Development Bank

Training Learning Objectives

By the end of this training, participants will be able to:

- Recognize the importance of measuring flood risk, long-term heat stress, and drought effects in refugee and IDP communities around the world.
- Apply workflows incorporating Earth observations, geospatial, and demographic data to identify localized climate risk in refugee and IDP settings.
- Discuss decision making strategies for mapping and managing climate conditions with risks faced by refugee and IDP communities.
- Summarize opportunities and shortcomings of specific Earth observations and geospatial datasets for climate risk and development indicators in humanitarian settings.

Prerequisites

- Humanitarian Applications Using NASA Earth Observations
- Monitoring and Modeling Floods using Earth Observations
- Satellite Remote Sensing for Agricultural Applications
- Satellite Remote Sensing for Measuring Urban Heat Islands and Constructing Heat Vulnerability Indices

Training Outline

Part 1

Assessing Flood Risk in Refugee Camp Settings

June 6, 2024

Part 2

Gauging Long-Term Heat Stress in Refugee Settings

June 13, 2024

Part 3

Tracking Drought Effects on Agricultural Landscapes in Refugee Settings

June 20, 2024

Homework

Opens June 20 – **Due July 5** – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.

Part 2 Objectives

By the end of Part 2, participants will be able to:

- Identify and apply open geospatial datasets (global model outputs and Earth observing data & products) to analyze long-term heat stress for refugee camps anywhere in the world.
- Summarize specific humanitarian challenges when gauging long-term heat stress in refugee camps.

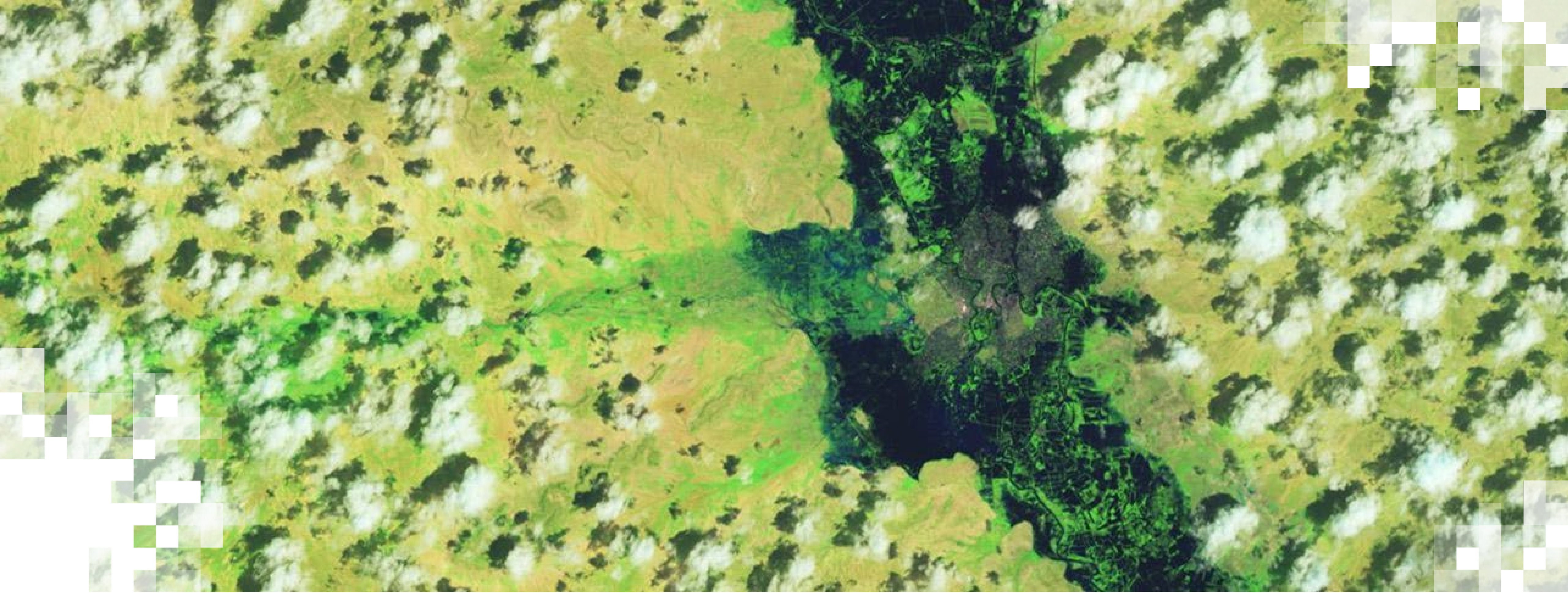
How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get through all the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

Part 2 – Trainers

Andrew Zimmer
Research Scientist
Montana State University

Jamon Van Den Hoek
Associate Professor of Geography
Oregon State University

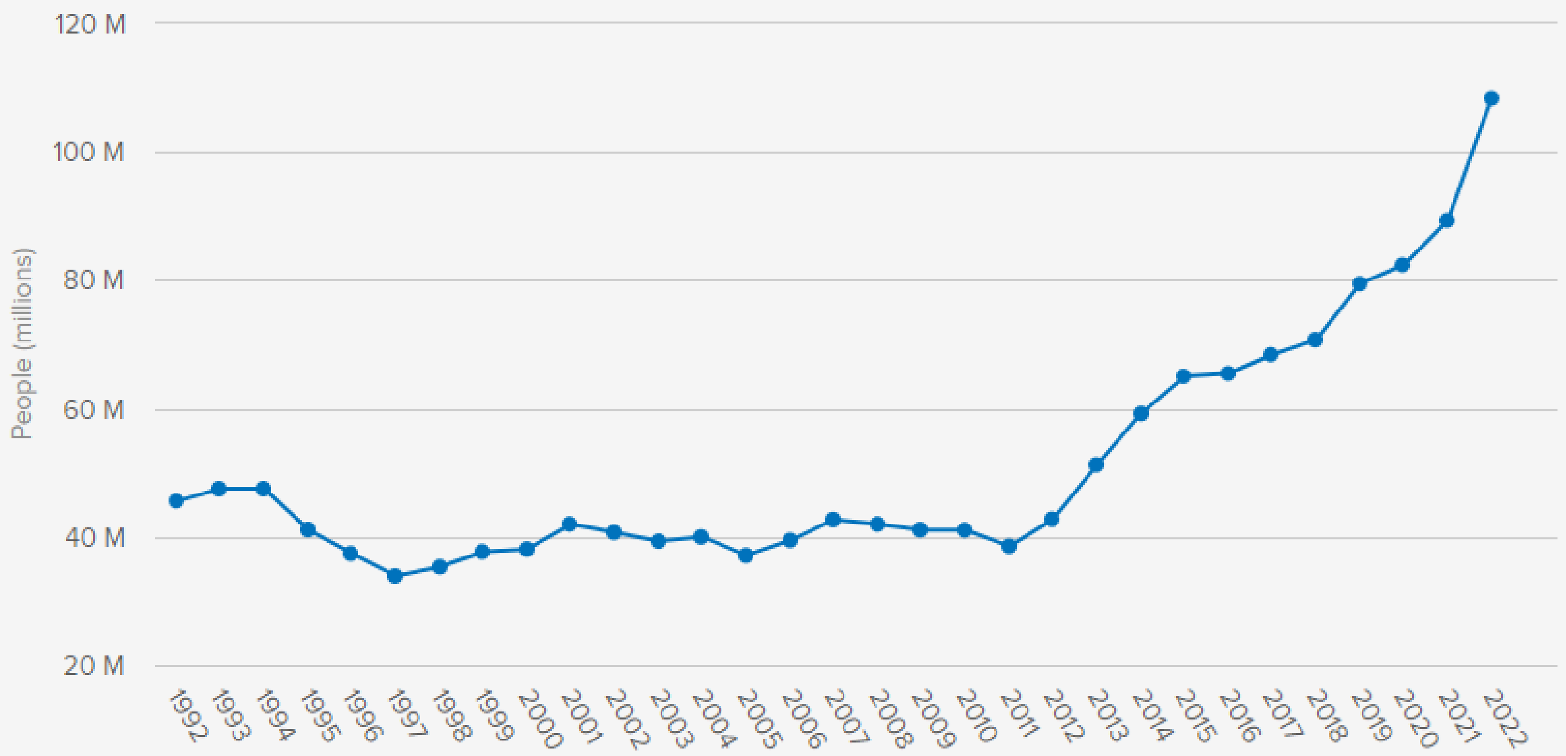


Earth Observations for Humanitarian Applications

Part 2: Gauging Long-Term Heat Stress in Refugee Settings

108.4 million people worldwide were forcibly displaced

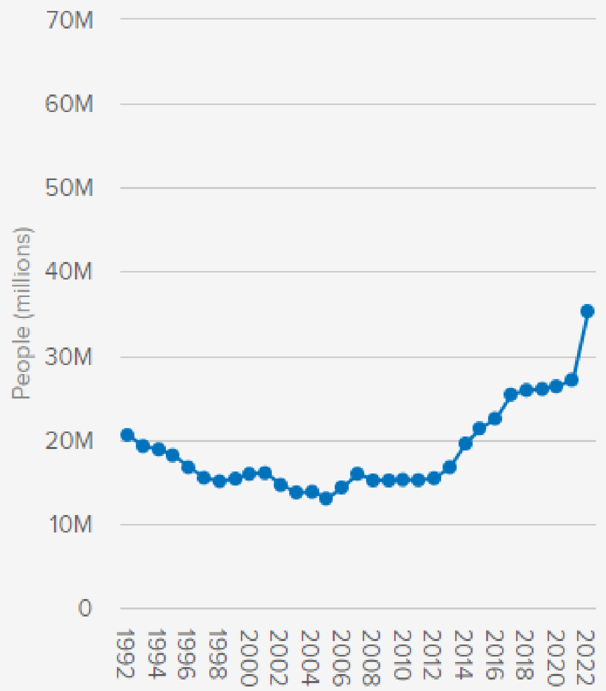
At the end of 2022 as a result of persecution, conflict, violence, human rights violations or events seriously disturbing



14 June 2023
Source: UNHCR Global Trends 2022

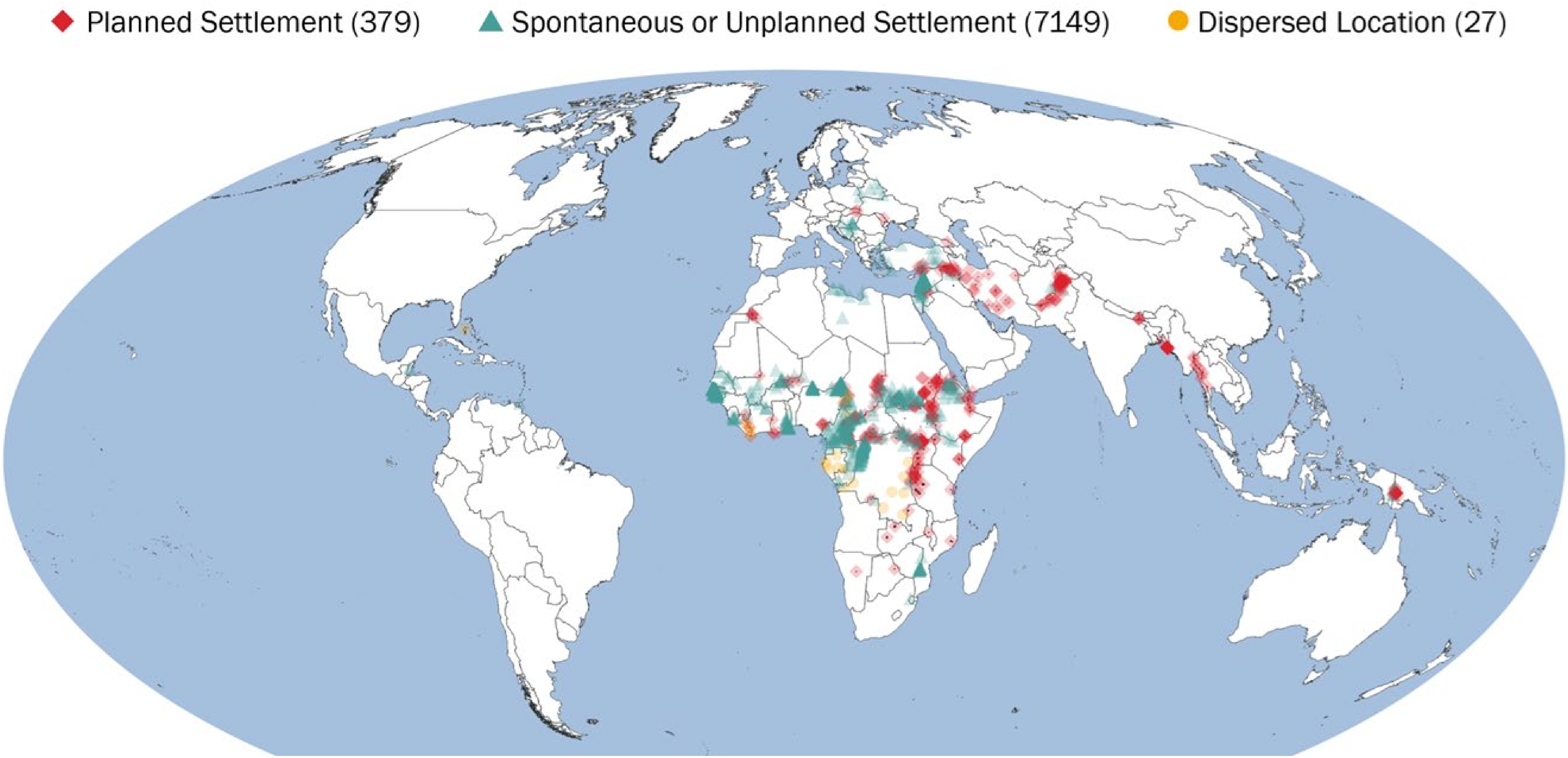
35.3 million refugees

- 29.4 million refugees under UNHCR's mandate.
- 5.9 million Palestine refugees under UNRWA's mandate.



14 June 2023
Source: UNHCR Global Trends 2022

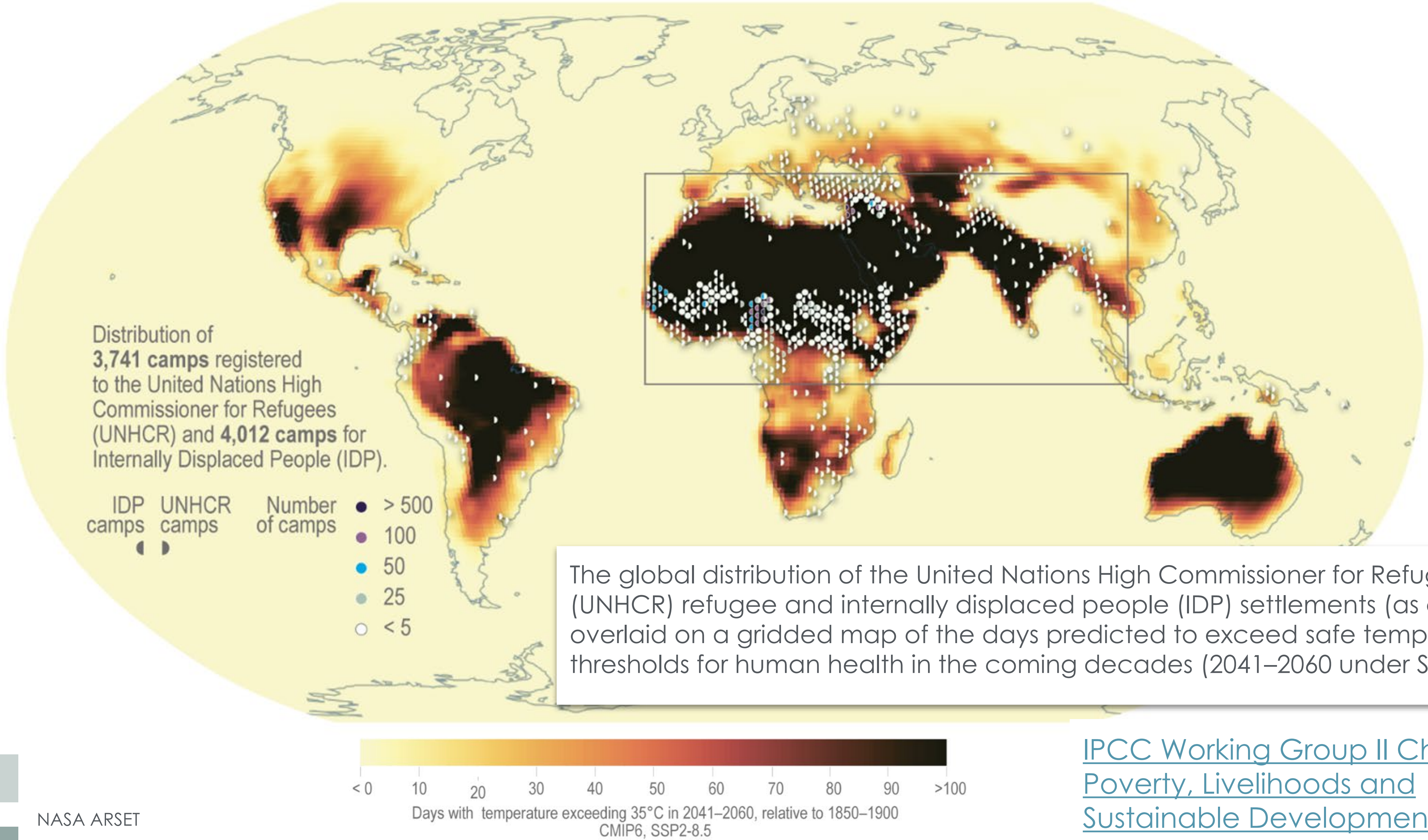
[Figures at a glance | UNHCR]



Credit: Van Den Hoek based on [UNHCR data]

Present-day global distribution of camps for refugees and internally displaced people

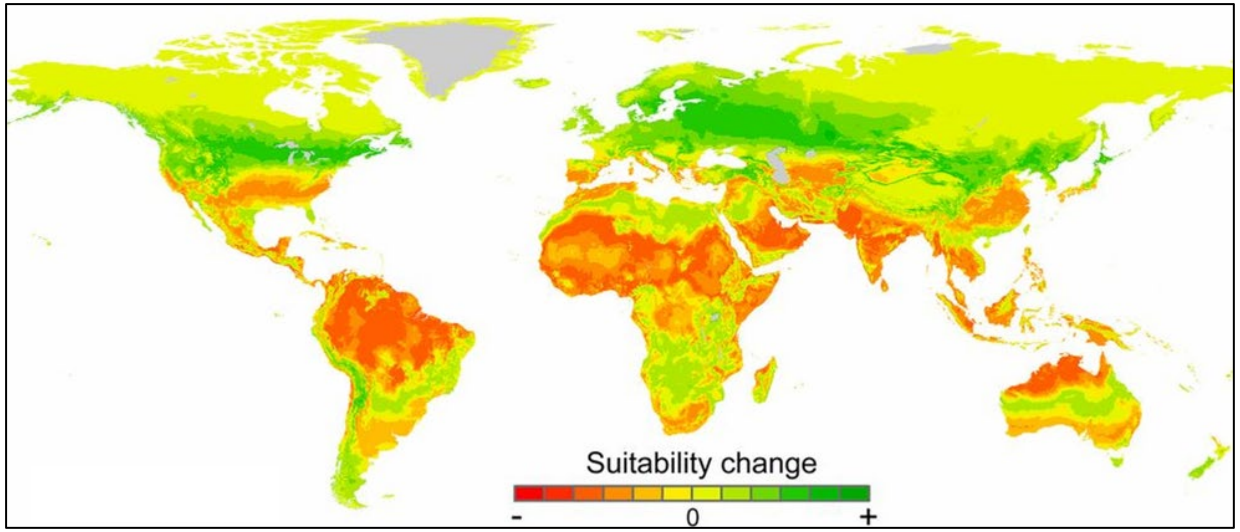
Background of days with temperature exceeding 35°C in 2041–2060



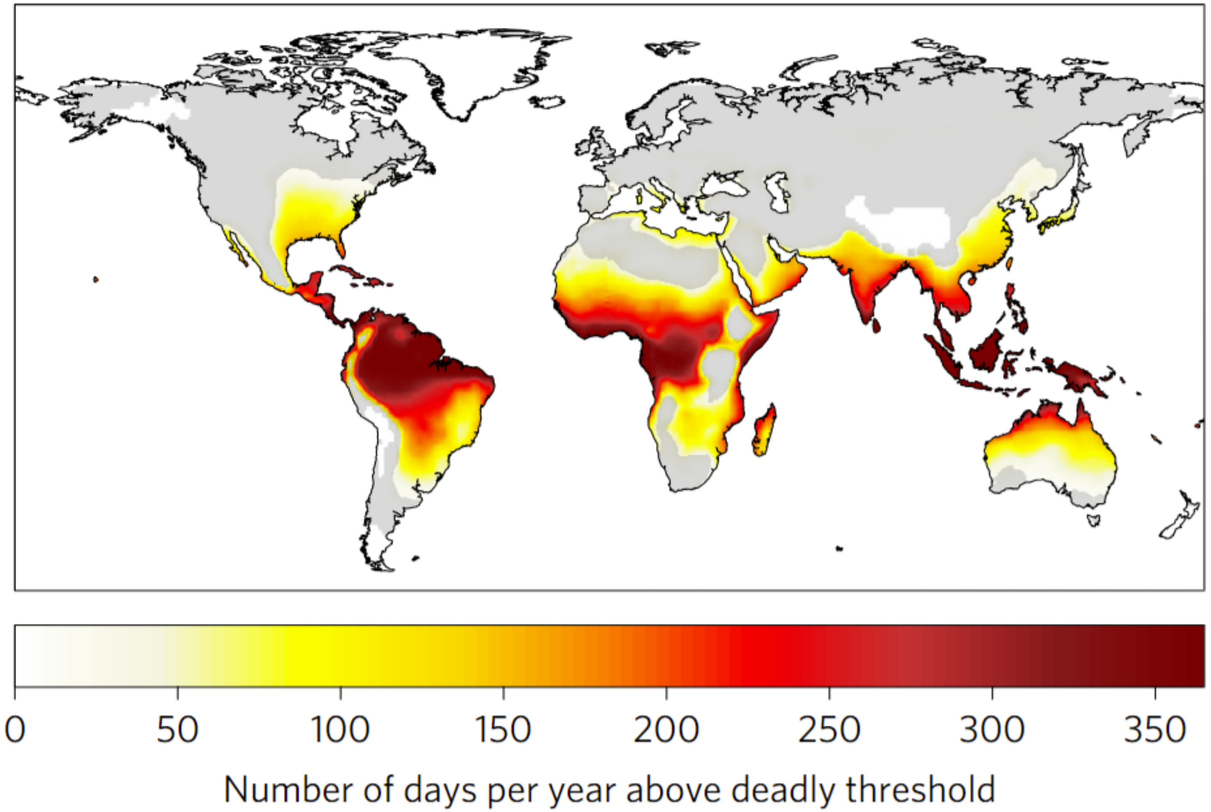
The global distribution of the United Nations High Commissioner for Refugees (UNHCR) refugee and internally displaced people (IDP) settlements (as of 2018) overlaid on a gridded map of the days predicted to exceed safe temperature thresholds for human health in the coming decades (2041–2060 under SSP2 8. 5).

[IPCC Working Group II Chapter 8: Poverty, Livelihoods and Sustainable Development]

Climate change is expected to broadly make conditions unsuitable (and potentially uninhabitable) for many regions currently hosting refugees.



[Future of the human climate niche]



[Global risk of deadly heat]

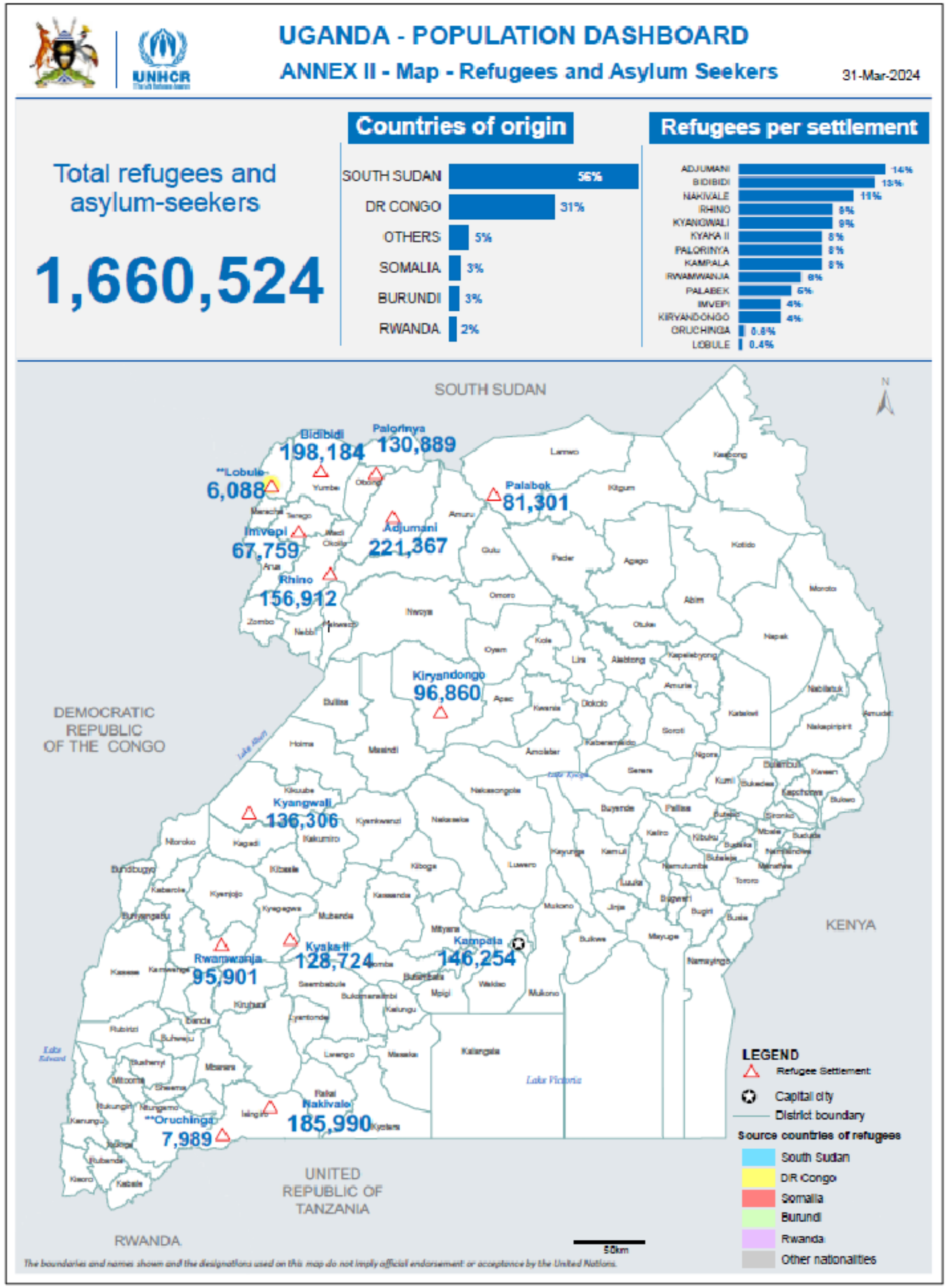
Extreme heat is of great concern but still underexplored in refugee settings.

- The effects of exposure to extreme heat are most pronounced in socioeconomically disadvantaged communities and those with the fewest resources to adapt.
- Refugees are among the most vulnerable to heat-health risks posed by climate change, as they tend to be concentrated in regions facing rapid warming but with few assets to adapt to extreme heat.
- Refugees may be unfamiliar with the local climate, language, and customs in the camp setting; this means they may face unfamiliar risks and may have limited access to essential public health information necessary for managing extreme heat.
- Refugee camps may be commonly thought of as a temporary solution but the average stay in a camp is more than 10 years.
- That refugees have so few assets for climate change adaptation and are encamped for such long durations presents the worrying scenario of increasing exposure to extreme heat with no recourse.

Refugee Settlements in Uganda

- Africa's largest refugee host country with support for over 1.5 million people, mainly from South Sudan (57%) and the Democratic Republic of the Congo (32%).
- Refugees primarily live in rural settlements (not “camps”) in the north and west in close proximity to non-refugee host communities.
- Women and girls make up 51% of the total refugee population, and children comprise 57%; refugees over 60 years old account for 3% of the population.
- Uganda’s refugee policies promote self-sufficiency and food security.
- However, droughts mean that refugees often face limited access to clean and safe water and increased malnutrition and hunger.

[UNHCR Uganda Operational Update - March 2024]

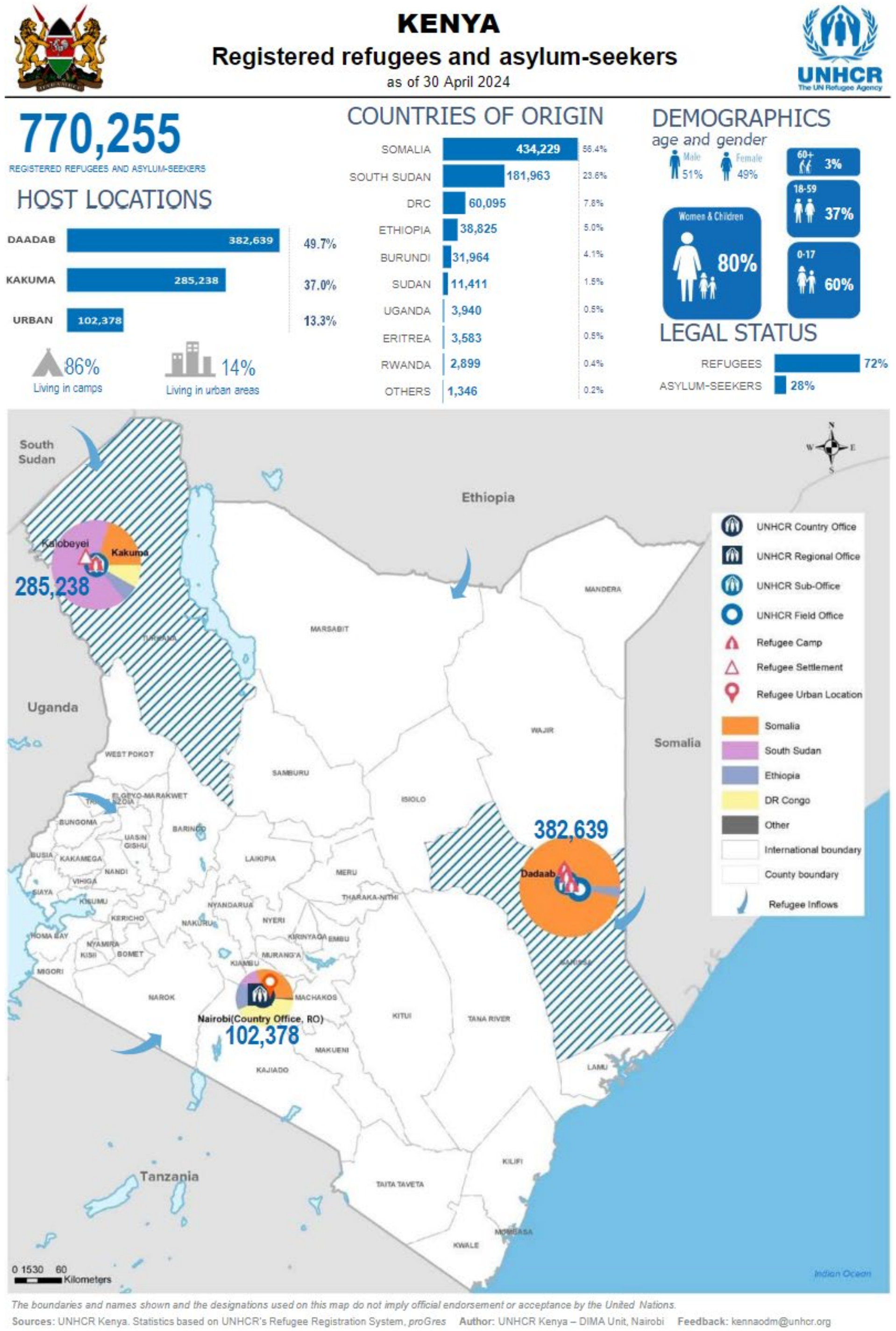


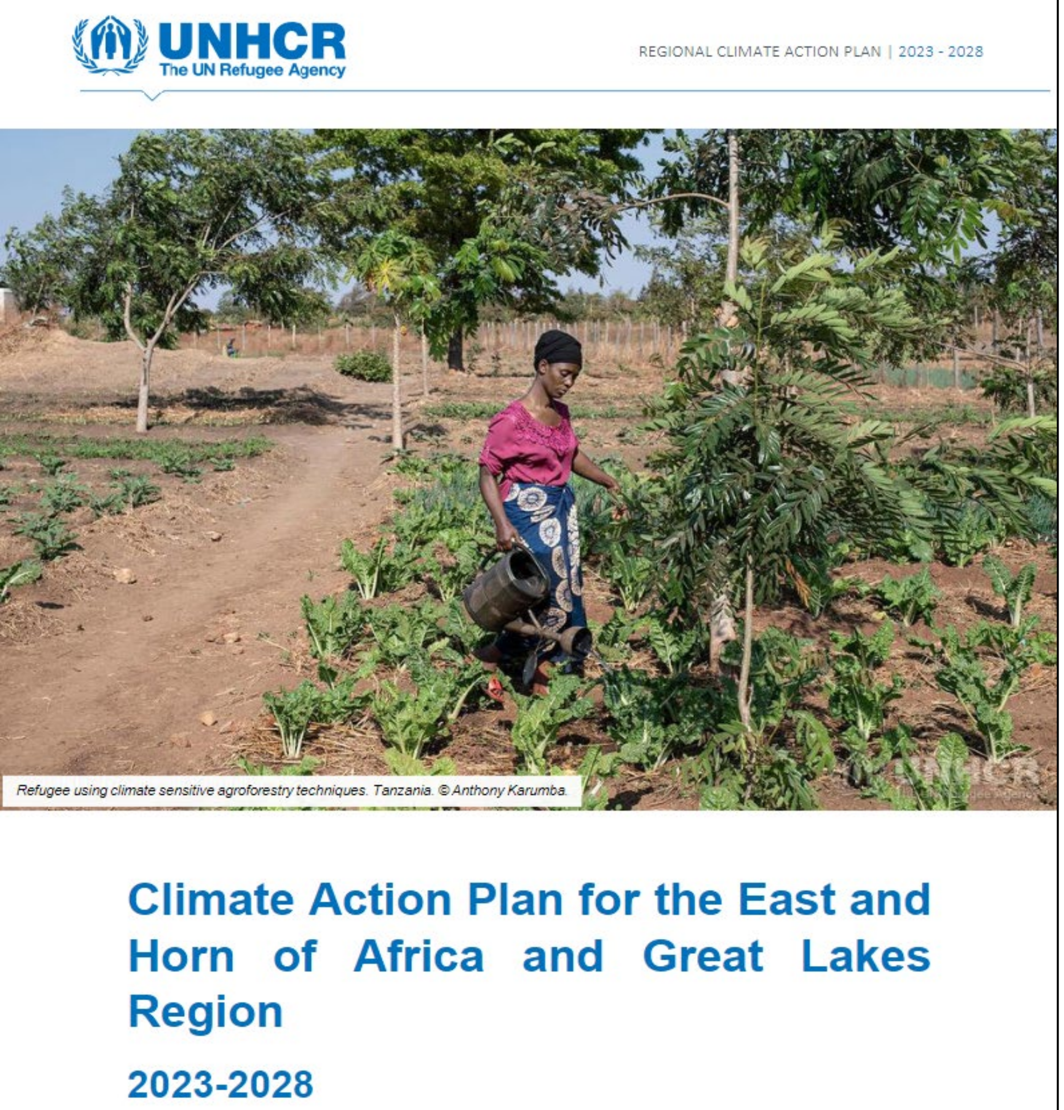
Uganda has 13 refugee-hosting districts (Adjumani, Isingiro, Kampala, Kamwenge, Kikuube, Kiryandongo, Kyegegwa, Koboko, Lamwo, Madi-Okollo, Obongi, Terego and Yumbe). Refugees are hosted in 13 settlements (Adjumani[1], Bidibidi, Imvepi, Kiryandongo, Kyaka II, Kyangwali, Lobule, Nakivale, Oruchinga, Palabek, Palorinya, Rhino Camp and Rwamwanja), in addition to the urban refugees in Kampala.

Refugee Camps in Kenya

- Kenya is one of Africa's major refugee-hosting countries with refugees predominantly from Somalia, South Sudan, and the Democratic Republic of the Congo.
- Refugees mainly live in the Dadaab and Kakuma refugee camps, as well as in urban areas like Nairobi, coexisting with local host communities.
- Women and girls constitute 50% of Kenya's refugee population, and children make up 56%; refugees over 60 years old represent 4% of the total population.
- Kenya's refugee policies focus on providing education, healthcare, and livelihood opportunities, though challenges such as resource limitations persist.

[UNHCR Kenya Infographics April 2024]





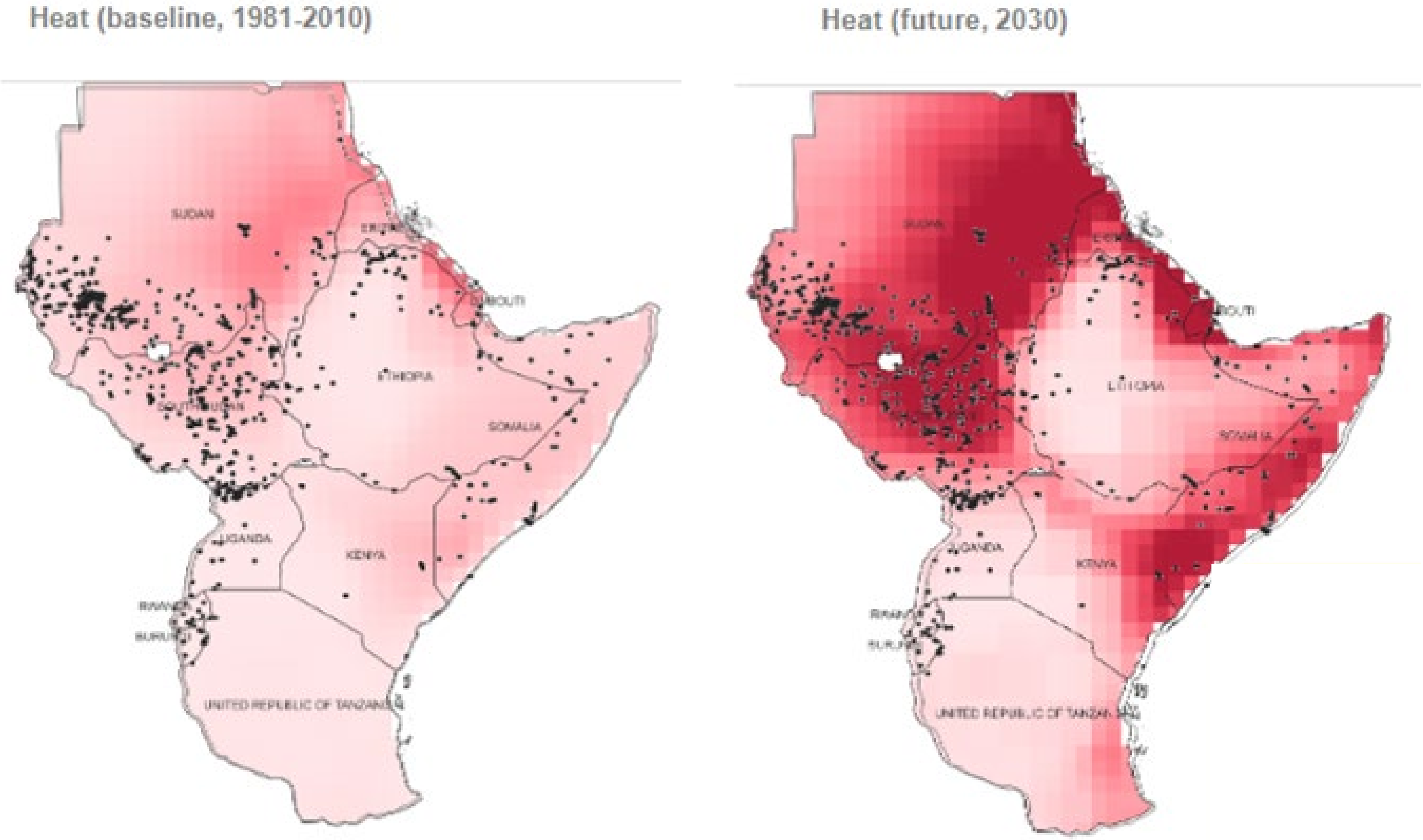
UNHCR
The UN Refugee Agency

REGIONAL CLIMATE ACTION PLAN | 2023 - 2028

Refugee using climate sensitive agroforestry techniques. Tanzania. © Anthony Karumba.

Climate Action Plan for the East and Horn of Africa and Great Lakes Region

2023-2028

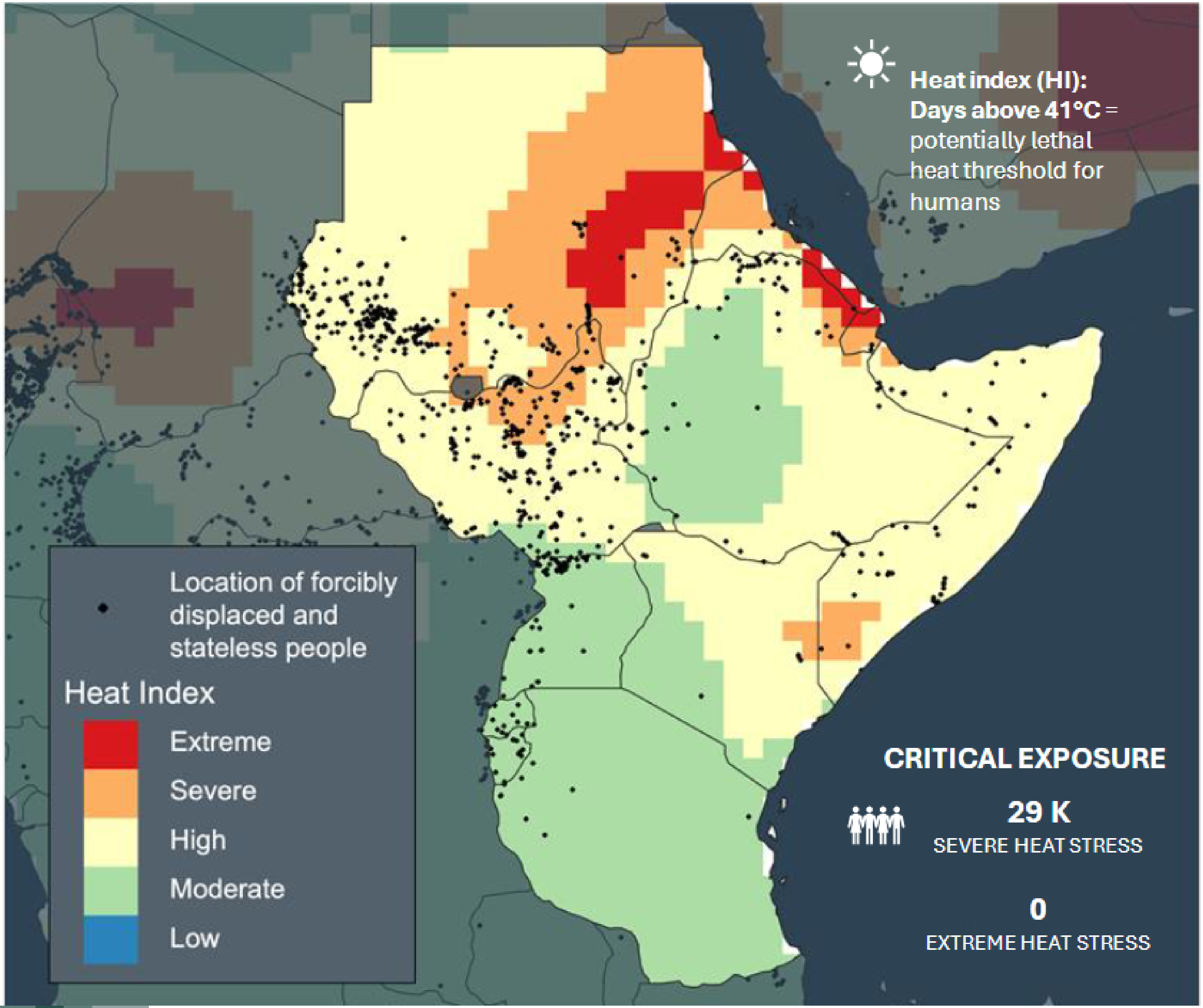


In the future, the largest increase in heat stress will occur in **Sudan, South Sudan, Eritrea, Djibouti, Somalia and Kenya**

[Regional Climate Action Plan for the East and Horn of Africa and Great Lakes 2023-2028]

Exposure of forcibly displaced and stateless persons to extreme heat in EHAGL

Baseline conditions



Interpretation

Many locations of forcibly displaced and stateless people are exposed to high-severe heat stress, apart from areas of the Great Lakes region which fall into the moderate class.

Heat hazard is categorized as severe when the average annual number of days meeting or exceeding an index value of 41°C is greater than or equal to 30 days.

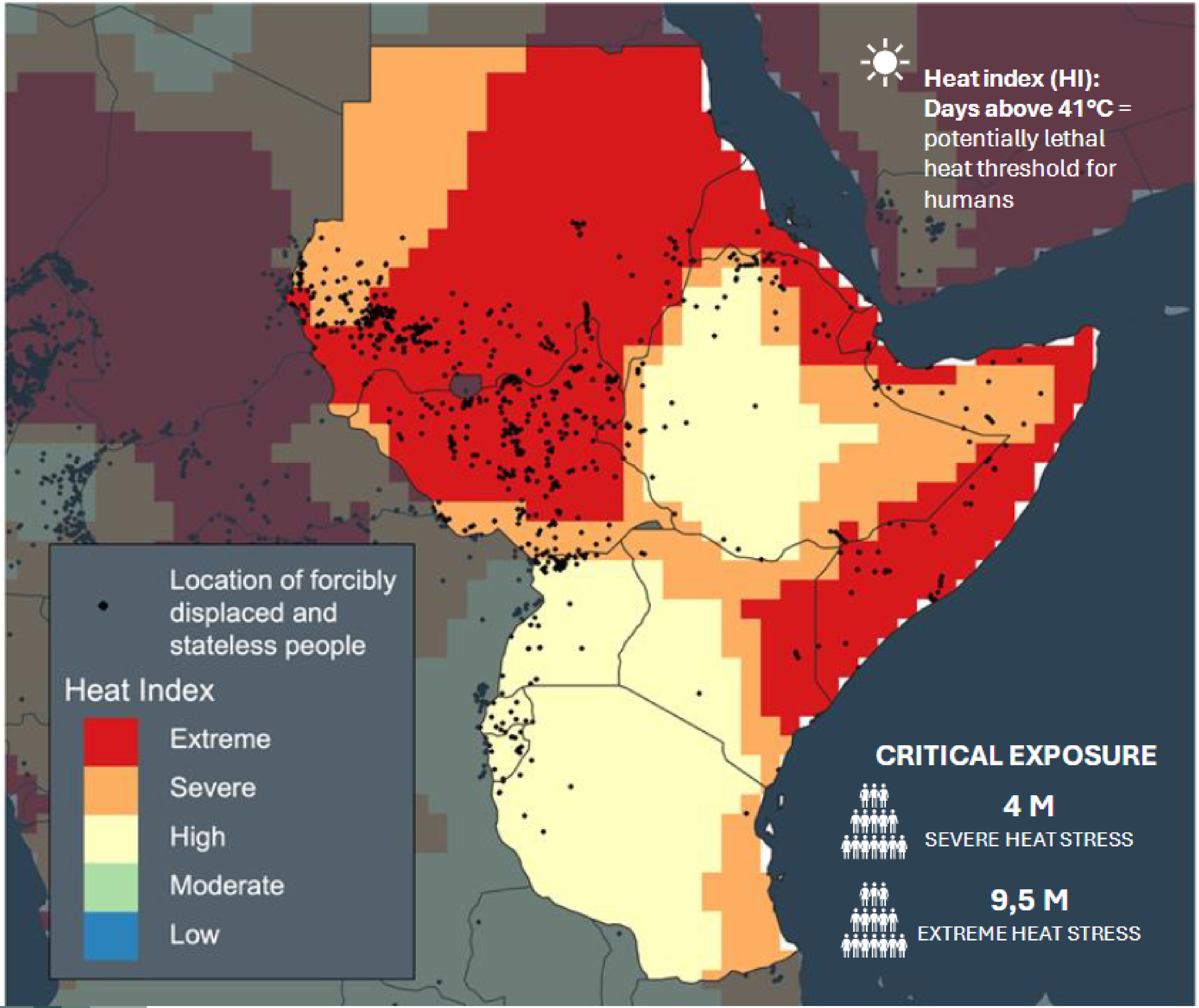
A heat index value of ≥ 41°C corresponds to the category of potentially lethal heat threshold for humans, where prolonged exposure will likely lead to dangerous or lethal health issues[1].

Regional Climate Action Plan for the East and Horn of Africa and Great Lakes 2023-2028

[1]Schwingshackl, C., Sillmann, J., Vicedo-Cabrera, A. M., Sandstad, M., & Aunan, K. (2021). Heat stress indicators in CMIP6: Estimating future trends and exceedances of impact-relevant thresholds. Earth's Future, 9, e2020EF001885. https://doi. 10.1029/2020EF001885

Exposure of forcibly displaced and stateless persons to extreme heat by 2040 in EHAGL

Projected climate hazards, displacement figures stable (end 2022)



Interpretation

By 2040, there is a substantial increase in heat stress in the EHAGL region, with large parts of the region being exposed to severe or extreme levels of heat stress. There are no more areas with moderate heat stress remaining. Somalia, Djibouti, Eritrea, South Sudan, and Sudan are particularly affected.

The number of forcibly displaced and stateless persons exposed to severe to extreme levels of heat stress is moving from 29K under baseline conditions to just over 13 million FDSP's exposed by 2040.

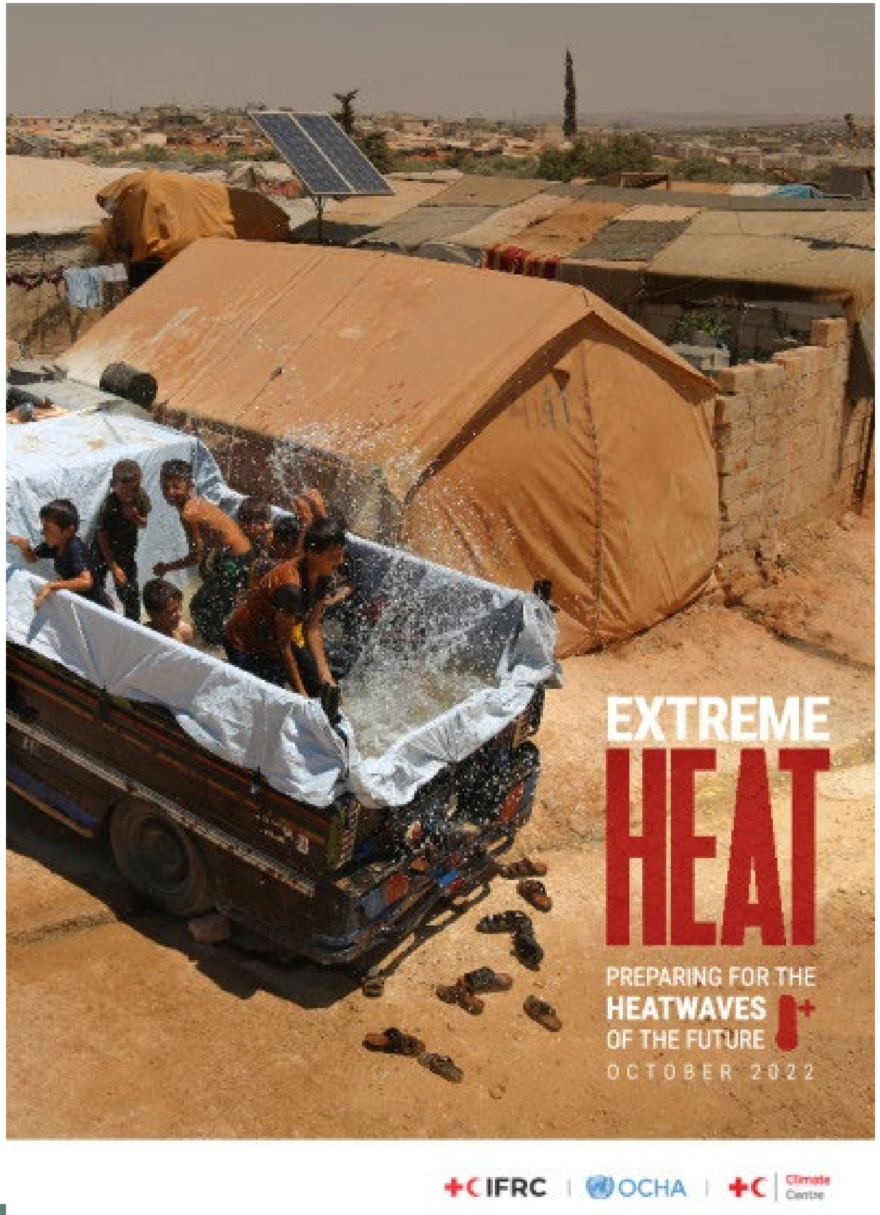
Regional Climate Action Plan for the East and Horn of Africa and Great Lakes 2023-2028

[1] Schwingshackl, C., Sillmann, J., Vicedo-Cabrera, A. M., Sandstad, M., & Aunan, K. (2021). Heat stress indicators in CMIP6: Estimating future trends and exceedances of impact-relevant thresholds. Earth's Future, 9, e2020EF001885. https://doi. 10.1029/2020EF001885. Projections are based on SSP5. Estimates are conservative as displacement figures are expected to increase.

How is heat risk currently considered in refugee camp management?

- While the need to minimize the detrimental impacts of climate exposure of refugees is increasingly recognized, there remains little site-specific information on climate vulnerability for most refugee populations.
  - Climate risks are only briefly mentioned in UNHCR's Camp Site Planning Minimum Standards or Principles & Standards for Settlement Planning documentation.
    - *"Ensure climate related and other hazards are identified, from the onset of planning, and that adequate mitigation measures have been planned, taking into consideration both existing and long-term threats (for example due to climate change)."*
  - UNHCR has not adopted minimum standards for acceptable levels of climate risk and exposure in refugee settings.
  - UNHCR does not provide guidance on how climate risk should be assessed at the camp level.
- But there is increasing recognition by international humanitarian actors around the need to better anticipate and prepare for extreme or dangerous heat.

Extreme heat: Preparing for the Heat Waves of the Future



- Joint report by the International Federation of the Red Cross, United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), and Red Cross Red Crescent Climate Centre:
  - In emergency settings, camps and camp-like environments combine physical, demographic and socioeconomic characteristics that can make them a uniquely dangerous environment for extreme-heat impacts.
  - They are often densely populated (particularly when settled spontaneously) and located on marginal land with limited fresh water and a lack of shading, greenspaces and other natural features that can mitigate extreme temperatures.
  - Camp managers should also consider testing the practice of low-cost monitoring and heat-risk mapping in camp settings to better understand the nature of heat risk in their environments.

Heat Impacts to Human Health

- Extreme heat can be hazardous to human health, and the incidence of extreme heat is increasing as a result of climate change.
- Exposure to extreme heat can have wide ranging physiological impacts for all humans.
  - Amplifies existing conditions
  - Can result in premature death and disability
- Negative impacts of extreme heat exposure are predictable and preventable with action.

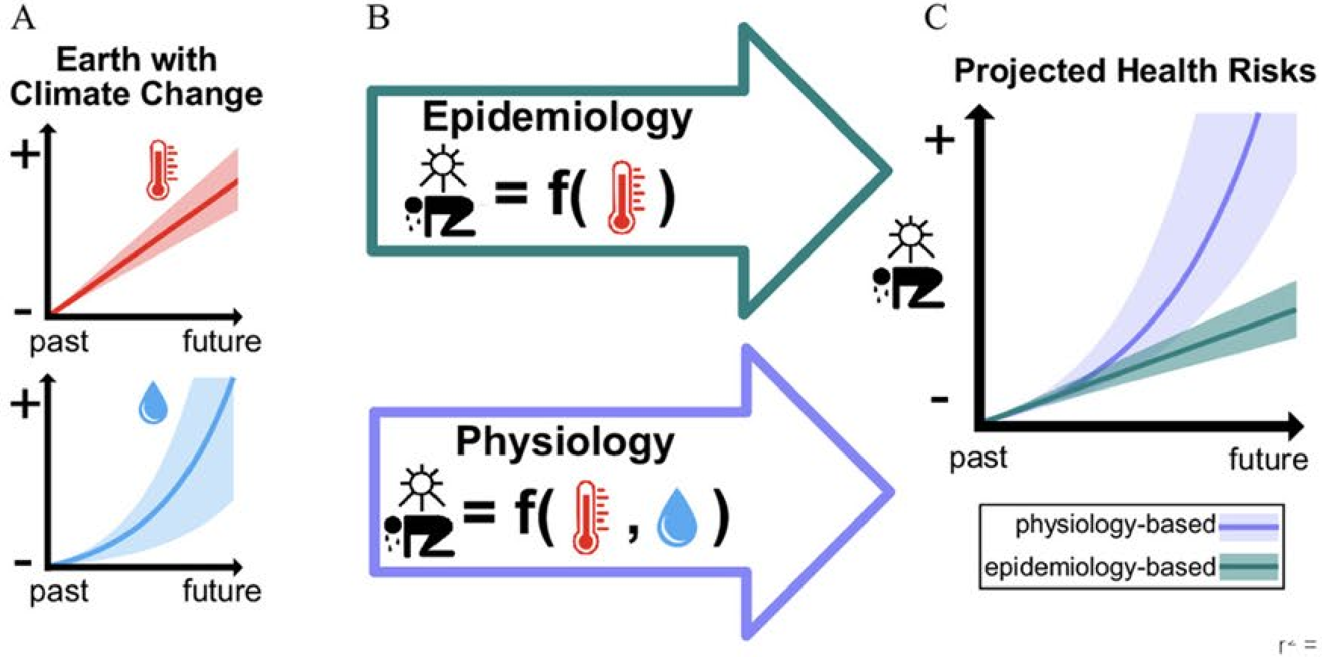




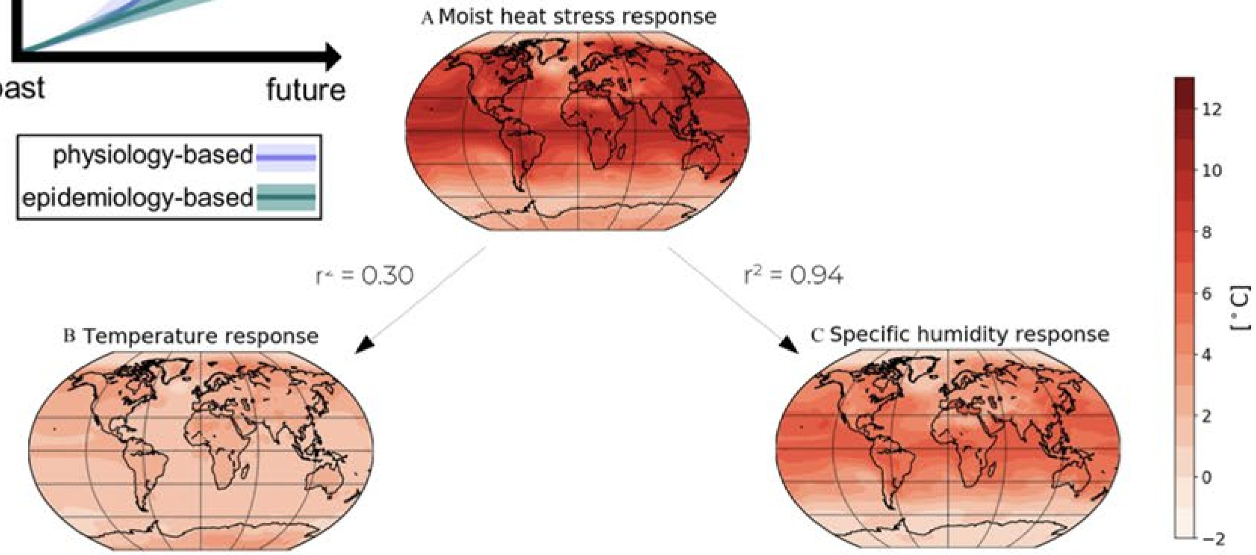
Heat Impacts to Human Health

There are 300 + “Heat stress” metrics used to study how temperature affects human health and well-being, according to the World Meteorological Organization.

Heat Impacts to Human Health



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



Baldwin *et al.* 2023

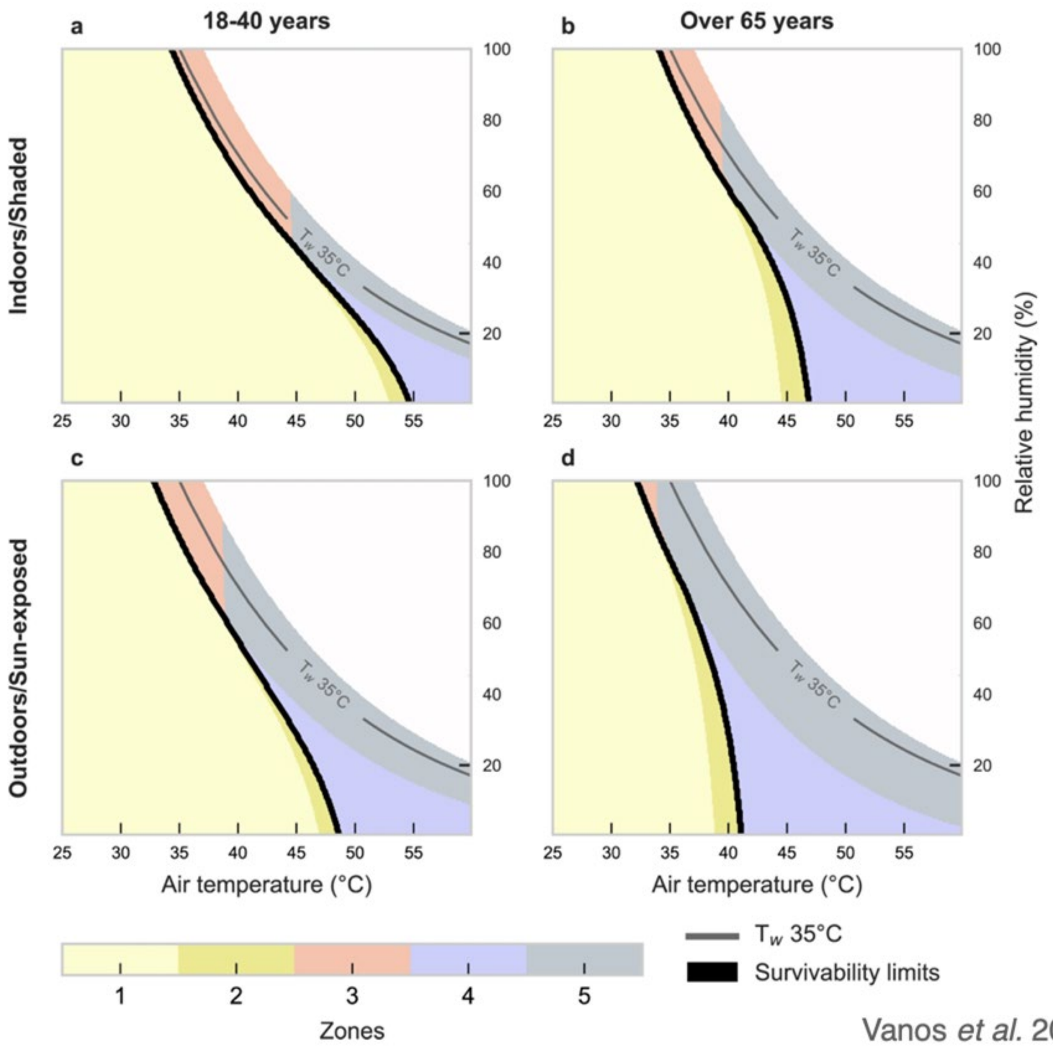
X

Heat Impacts to Human Health

Wet Bulb Temperature (what we'll use in the demonstration) of 35°C has been proposed to be lethal with 6 hours of exposure (Sherwood & Huber, 2010), but this could be as low as 31°C (Vecellio et al., 2022).

WBT measures evaporative cooling

New research reconciles dangerous dry air vs. dangerous moist air temperatures for different demographics (Vanos et al., 2023).



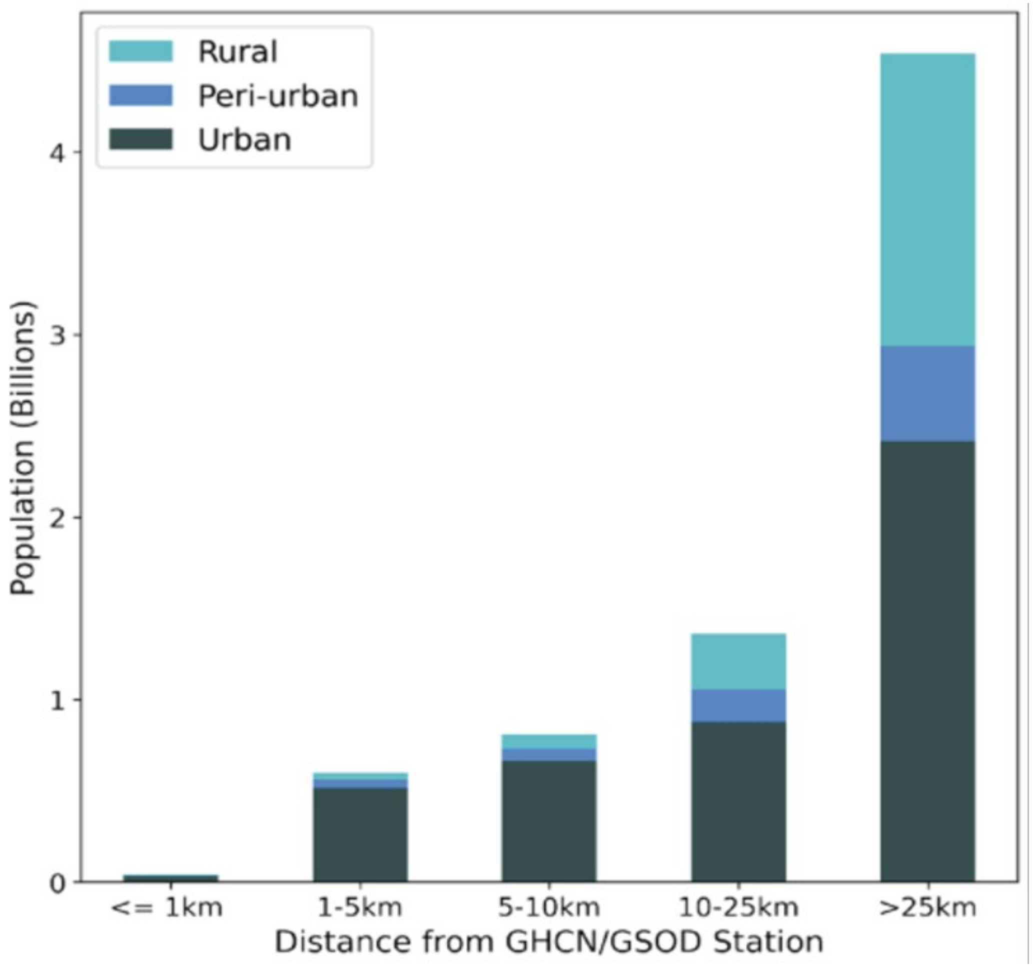
Vanos *et al.* 2023

What Climate Data Do We Use?

- We have pretty poor spatial and temporal weather records.

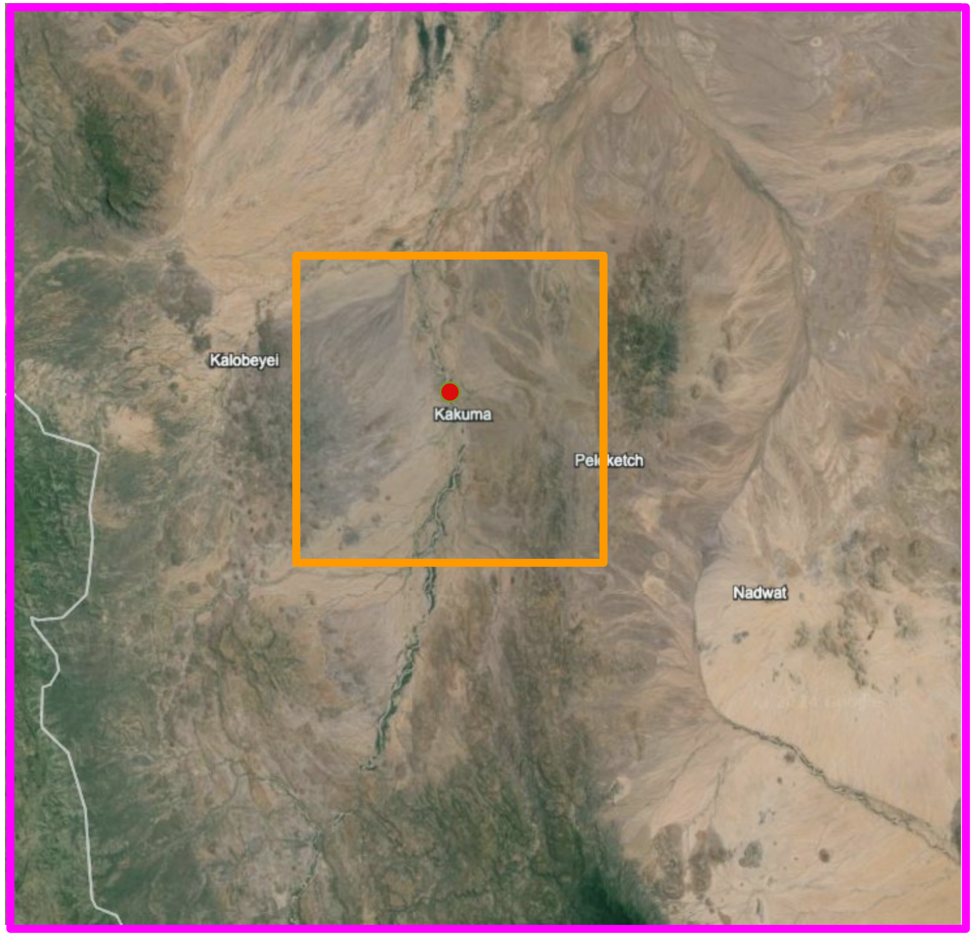
- Over 4,000,000,000 people live more than 25 km from a weather station with a robust record.

- Gridded climate data can help to fill the gap!

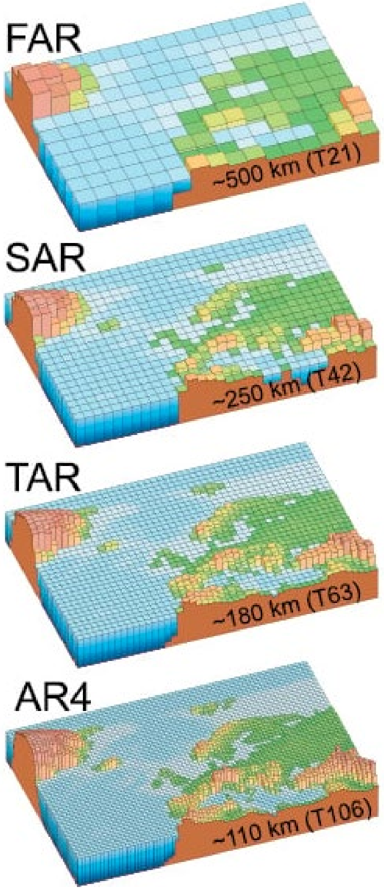


Zaitchik & Tuholske, 2021

What Do We Mean by Gridded Climate Data?



- CMIP-6 Climate Projection
  ~ 100 x 100km
- Camp Location
- ERA-5 Temperature Record
  ~ 30 x 30 km

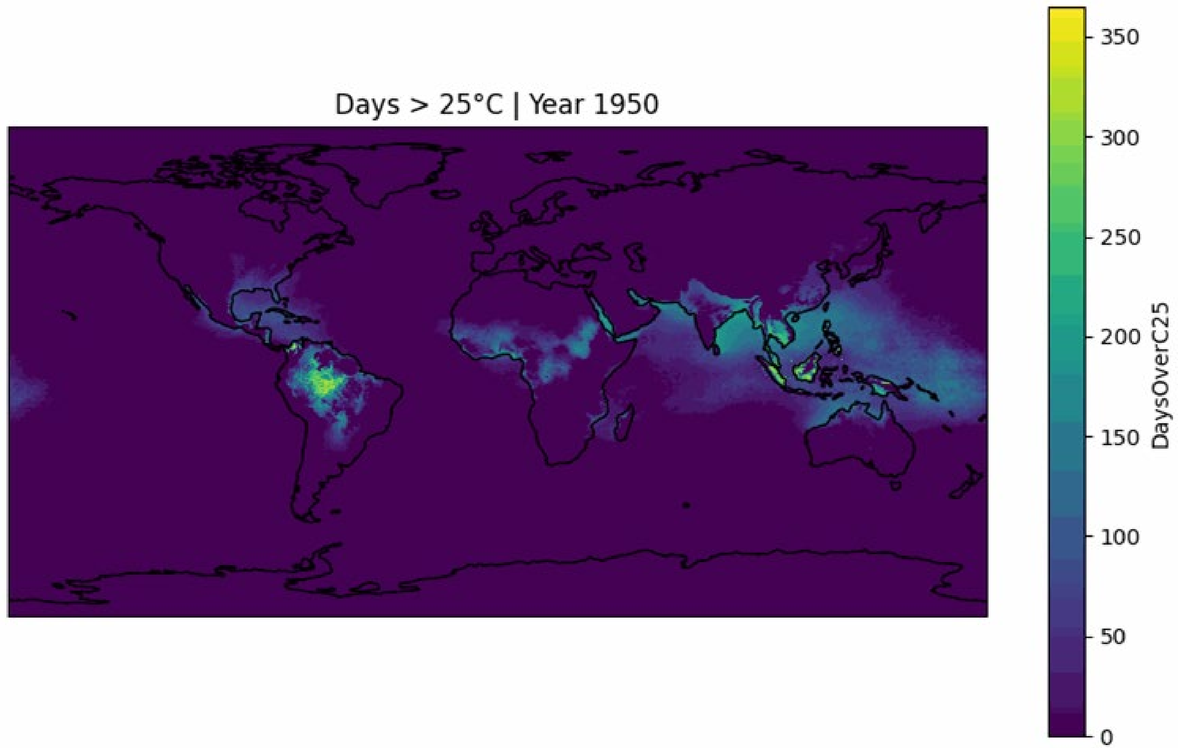


European Centre for Medium-Range Weather Forecasts Reanalysis Data (ERA5)

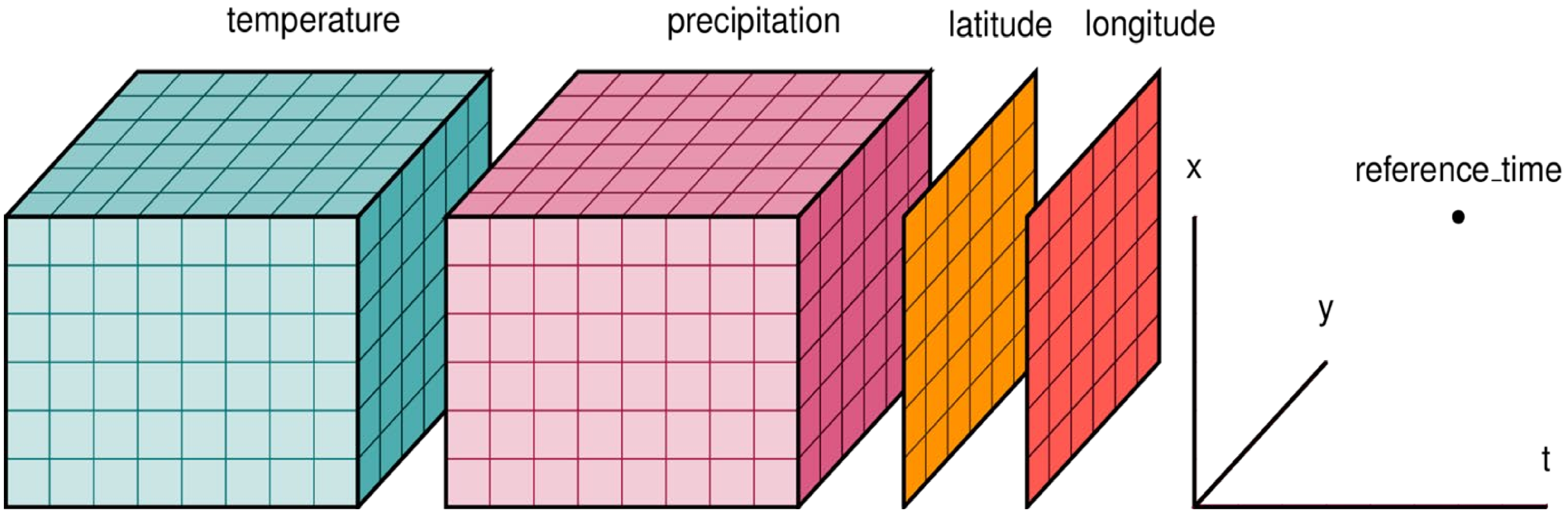
- Fifth generation European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climate.
  - Covers January 1940 – Present.

- Provides hourly estimates of atmospheric, land, and oceanic climate variables.
- Covers Earth on a 31km grid and resolves the atmosphere using 137 levels from the surface up to 80km high.

- Processing Wet-bulb temperature (TW) using NEWT
  - Non-iterative Evaluation of Wet-bulb Temperature (Rogers & Warren, 2023)
  - https://github.com/robwarrenwx/atmos



Primer on Data Structures

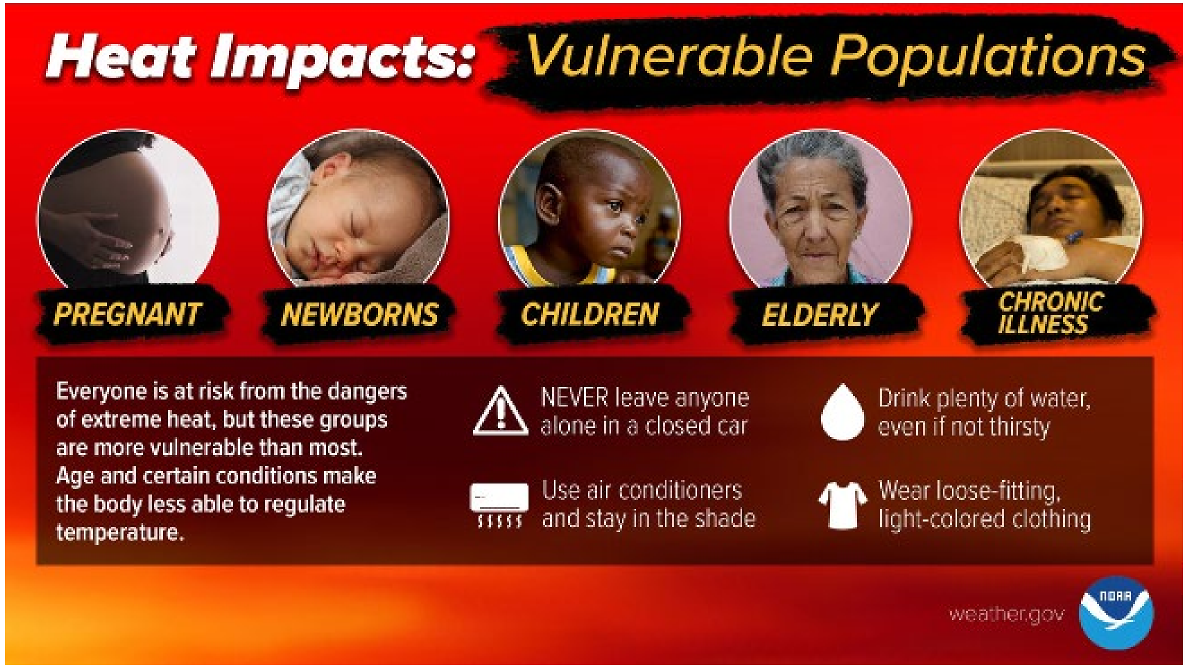


Challenges of Defining Extreme Heat Risk

- Lots of different ways of measuring extreme heat:
    - Maximum temperature?
    - Minimum temperature?
    - Diurnal range in temperature?
    - Continual exposure?

- Who is exposed to extreme heat?
    - Inside vs. outside populations
    - Air conditioning!

- Who is vulnerable to extreme heat?
    - Age-sex considerations
    - Underlying health conditions



Moving from Concept to Investigation

- We’re interested in looking at extreme heat exposure for refugee settlements.
- We want to use open-access datasets.

Research Question:

- What are the characteristics of extreme heat exposure for refugee camps in 2023?

Investigation:

- Where are settlements located?
-
- What climate data do we use?
-
- What heat metrics do we use?
-
- What thresholds should we apply?
-
- Over what time period are we interested?
-
- How should we aggregate and present our results?
-

Moving from Concept to Investigation

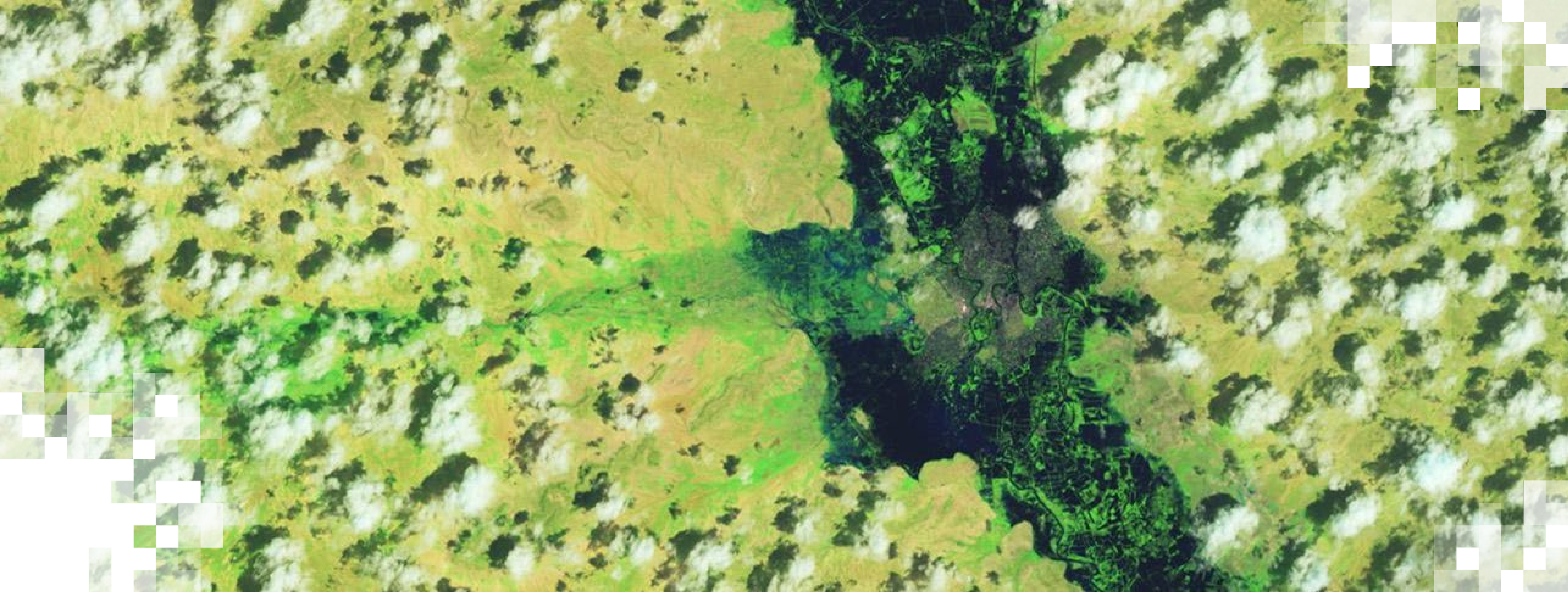
- We're interested in looking at extreme heat exposure for refugee settlements.
- We want to use open-access datasets.

Research Question:

- What are the characteristics of extreme heat exposure for refugee camps in 2023?

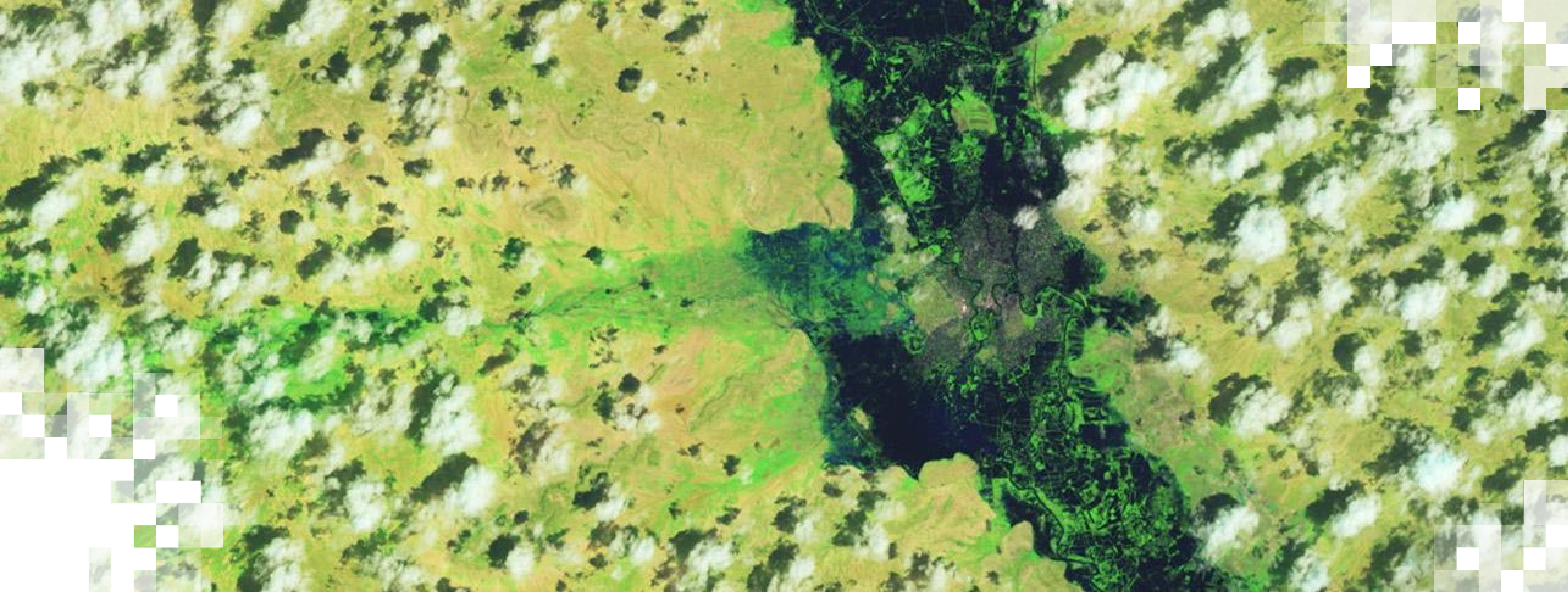
Investigation:

- Where are settlements located?
- **Uganda and Kenya (UNHCR Data)**
- What climate data do we use?
- **ERA5 Reanalysis Data**
- What heat metrics do we use?
- **Wet Bulb Temperature (Tw)**
- What thresholds should we apply?
- **# Days over Tw > threshold**
- Over what time period are we interested?
- **2000s**
- How should we aggregate and present our results?
- **Camp, Country and Region**



Demonstration using Google Colab, Google Earth Engine & Python

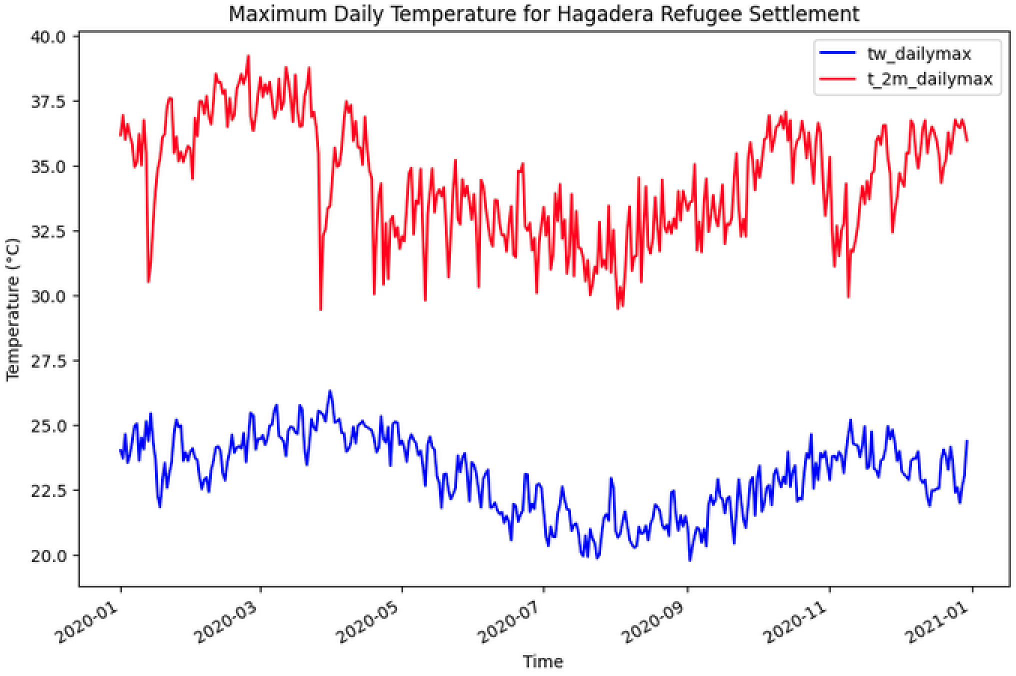
https://colab.research.google.com/drive/1l1Azjt1OlMxmblFFVEMFPujft7p9XxjU?usp=sharing

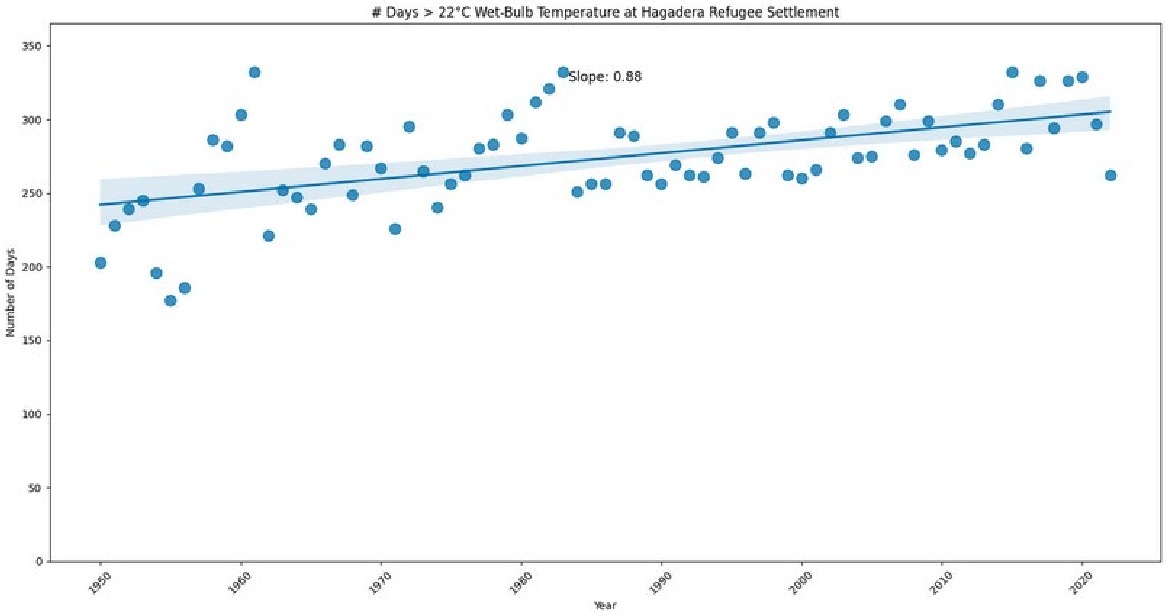


Part 2:
Concluding Thoughts & Summary

What Did We Learn Today?

- Importance of studying heat exposure for vulnerable populations
- Understanding of different extreme heat metrics
- How to process gridded climate data efficiently
- How to extract heat metrics for refugee camps





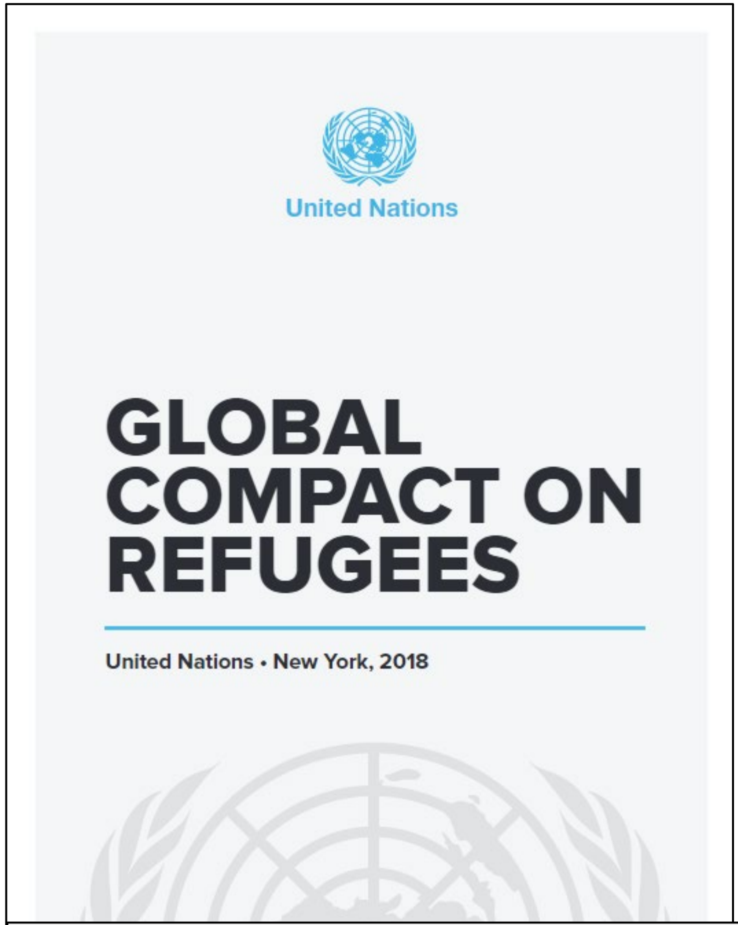
How Can We Go Forward with this Analysis?

- Camp and settlement-level data provide localized insights with more specificity than nationwide assessments.
  - Integration with refugee population and demographics data would amplify the value the analysis since heat risk varies with age and sex.
  - Understanding the built environment and shelter conditions with specific refugee camps and settlements would also be helpful to assess mitigation strategies.

- Refugee populations may or may not have similar exposure to dangerous heat compared to nearby non-refugee (host) populations.
  - Better understanding regional challenges will help inform the timing and type of humanitarian action for refugees, such as in-place mitigation or adaptation or resettlement.

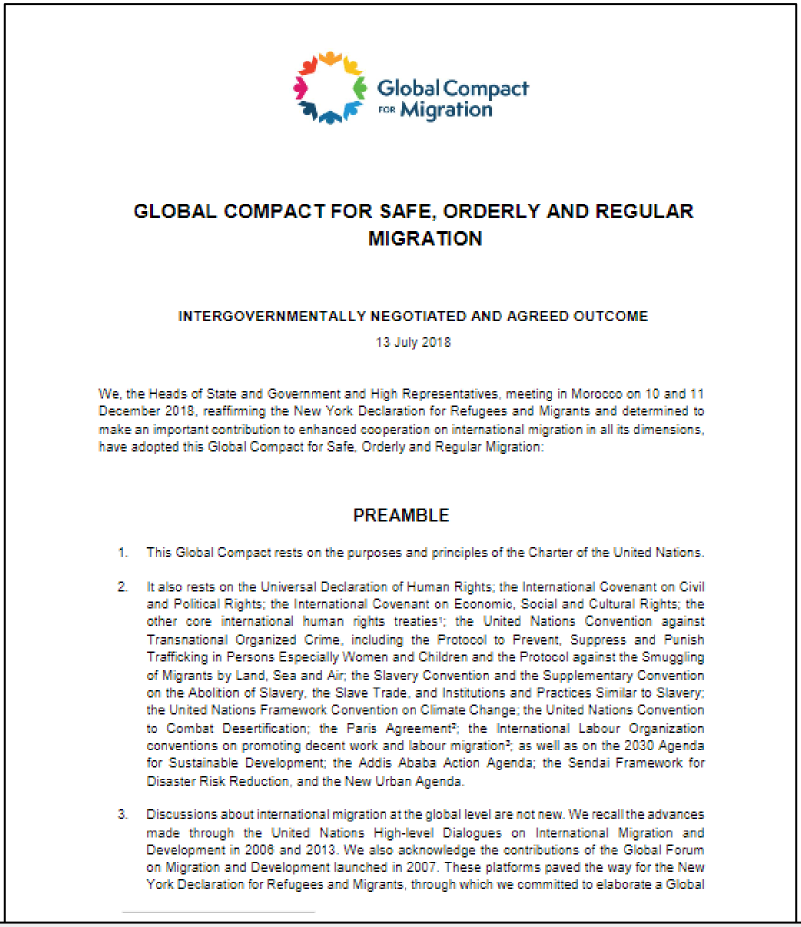
- Needs and solutions for addressing extreme heat are not uniform across refugee settings.
  - Different approaches to providing adequate water and food supplies and access to medical care may be more appropriate in different settings.
  - An assessment like what we've done here helps ensure that these decisions are more likely to be made using the same criteria, considerations, with an awareness of limitations.

Ultimately, these data could inform the next generation of policies to better protect refugees from extreme heat.


United Nations

GLOBAL COMPACT ON REFUGEES

United Nations • New York, 2018


Global Compact FOR Migration

GLOBAL COMPACT FOR SAFE, ORDERLY AND REGULAR MIGRATION

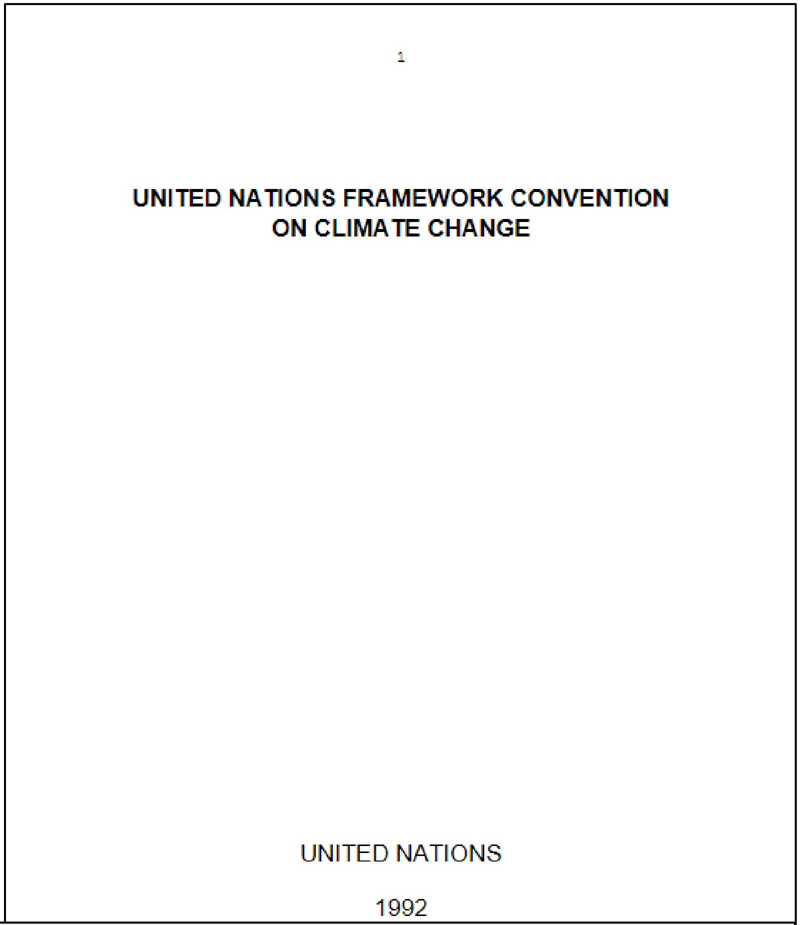
INTERGOVERNMENTALLY NEGOTIATED AND AGREED OUTCOME

13 July 2018

We, the Heads of State and Government and High Representatives, meeting in Morocco on 10 and 11 December 2018, reaffirming the New York Declaration for Refugees and Migrants and determined to make an important contribution to enhanced cooperation on international migration in all its dimensions, have adopted this Global Compact for Safe, Orderly and Regular Migration:

PREAMBLE

1. This Global Compact rests on the purposes and principles of the Charter of the United Nations.
2. It also rests on the Universal Declaration of Human Rights; the International Covenant on Civil and Political Rights; the International Covenant on Economic, Social and Cultural Rights; the other core international human rights treaties[1]; the United Nations Convention against Transnational Organized Crime, including the Protocol to Prevent, Suppress and Punish Trafficking in Persons Especially Women and Children and the Protocol against the Smuggling of Migrants by Land, Sea and Air; the Slavery Convention and the Supplementary Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery; the United Nations Framework Convention on Climate Change; the United Nations Convention to Combat Desertification; the Paris Agreement[2]; the International Labour Organization conventions on promoting decent work and labour migration[3]; as well as on the 2030 Agenda for Sustainable Development; the Addis Ababa Action Agenda; the Sendai Framework for Disaster Risk Reduction, and the New Urban Agenda.
3. Discussions about international migration at the global level are not new. We recall the advances made through the United Nations High-level Dialogues on International Migration and Development in 2006 and 2013. We also acknowledge the contributions of the Global Forum on Migration and Development launched in 2007. These platforms paved the way for the New York Declaration for Refugees and Migrants, through which we committed to elaborate a Global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UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

UNITED NATIONS

1992

None of these current policy frameworks considers the effects of climate change on refugees.

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 20/06/2024
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 05/07/2024**

- **Certificate of Completion:**
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Contact Information

Trainers:

- Andrew Zimmer
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- ARSET Website
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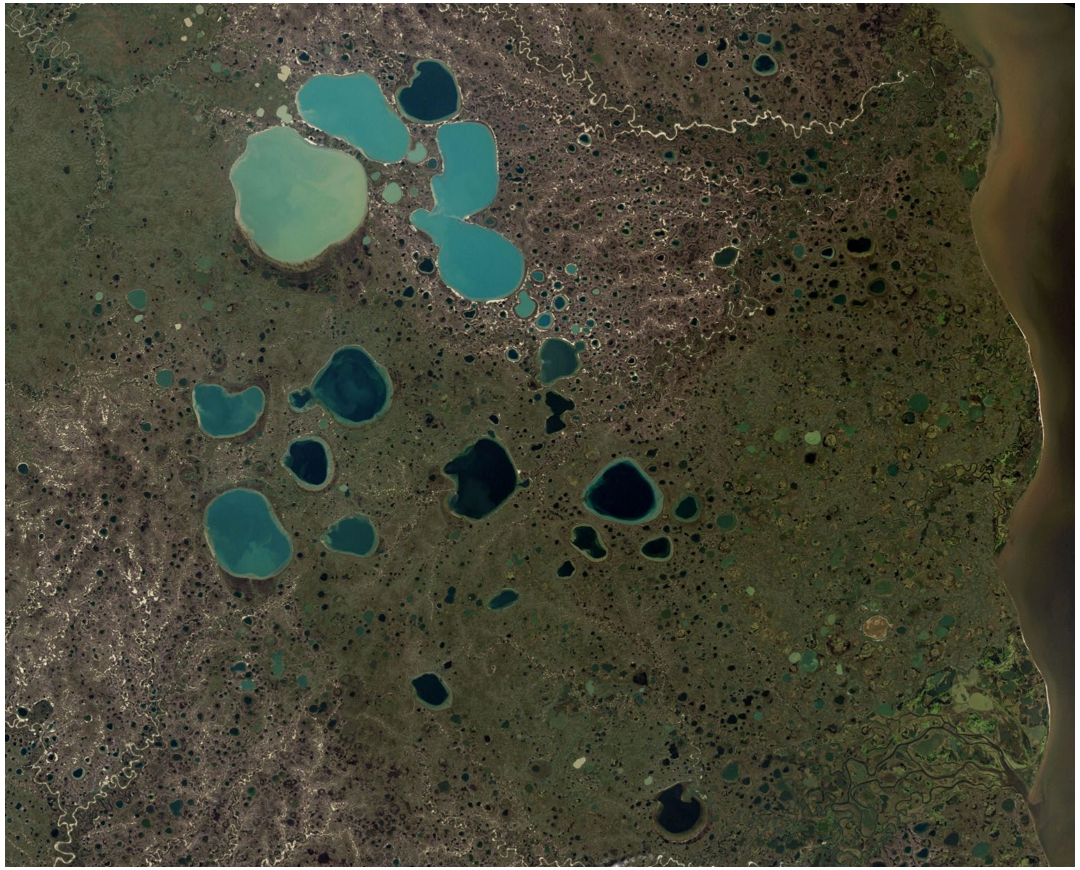
Questions?

- Please enter your questions in the Q&A box. We will answer them in the order they were received.
- We will post the Q&A to the training website following the conclusion of the webinar.



https://earthobservatory.nasa.gov/images/6034/pothole-lakes-in-siberia

APPLIED REMOTE SENSING TRAINING PROGRAM

TRAIN - EMPOWER - ADVANCE

Thank you!