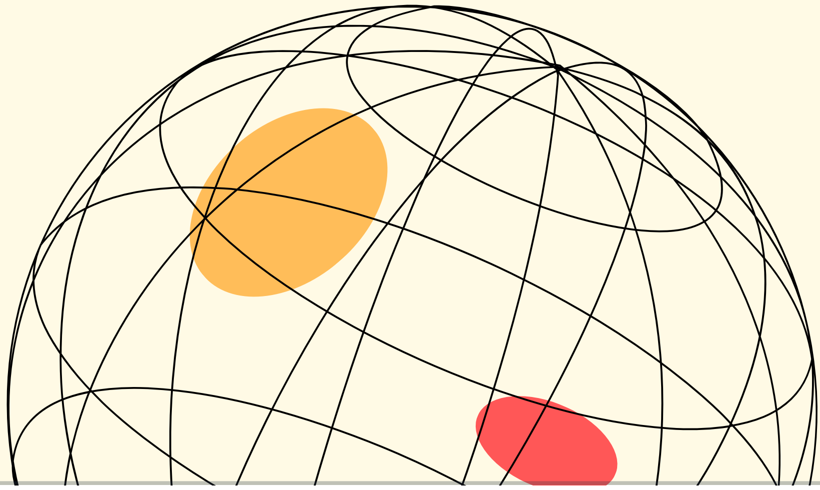
How Climate Change Feels Around the Globe

Spiced Academy

14 August 2023

Radek Kříček



Let us explore the effects of climate change on populations across the world.

We will be focusing on the percentage of populations exposed to extreme heat.

Motivation

"Climate crisis is worsening and developing countries are particularly affected."

What percentage of people has direct experience with extreme heat?

Does this number change over time?

How much is it related to the global temperature anomaly?

Is there a clear link between wealth and heat exposure of populations?

"Climate crisis is worsening and developing countries are particularly affected." - this is what we often hear but let us set some more specific questions to explore.

Temperature anomaly = how much has the temperature changed compared to the average over a period in the past.

We will use GDP per capita as a measure of wealth.

Datasets

872,695 data points
(Extreme temperature)

Based on Maes, M., et al. (2022), "Monitoring exposure to climate-related hazards: Indicator methodology and key results", OECD Environment Working Papers, No. 201, OECD Publishing, Paris.

374,792 data points
(Historical population)

There are three sources for the data: national statistics offices, Eurostat and the United Nations.

Most of the data come from OECD - population exposures, historical populations of countries.

Datasets

BETTER POLICIES FOR BETTER LIVES

872,695 data points
(Extreme temperature)

374,792 data points
(Historical population)

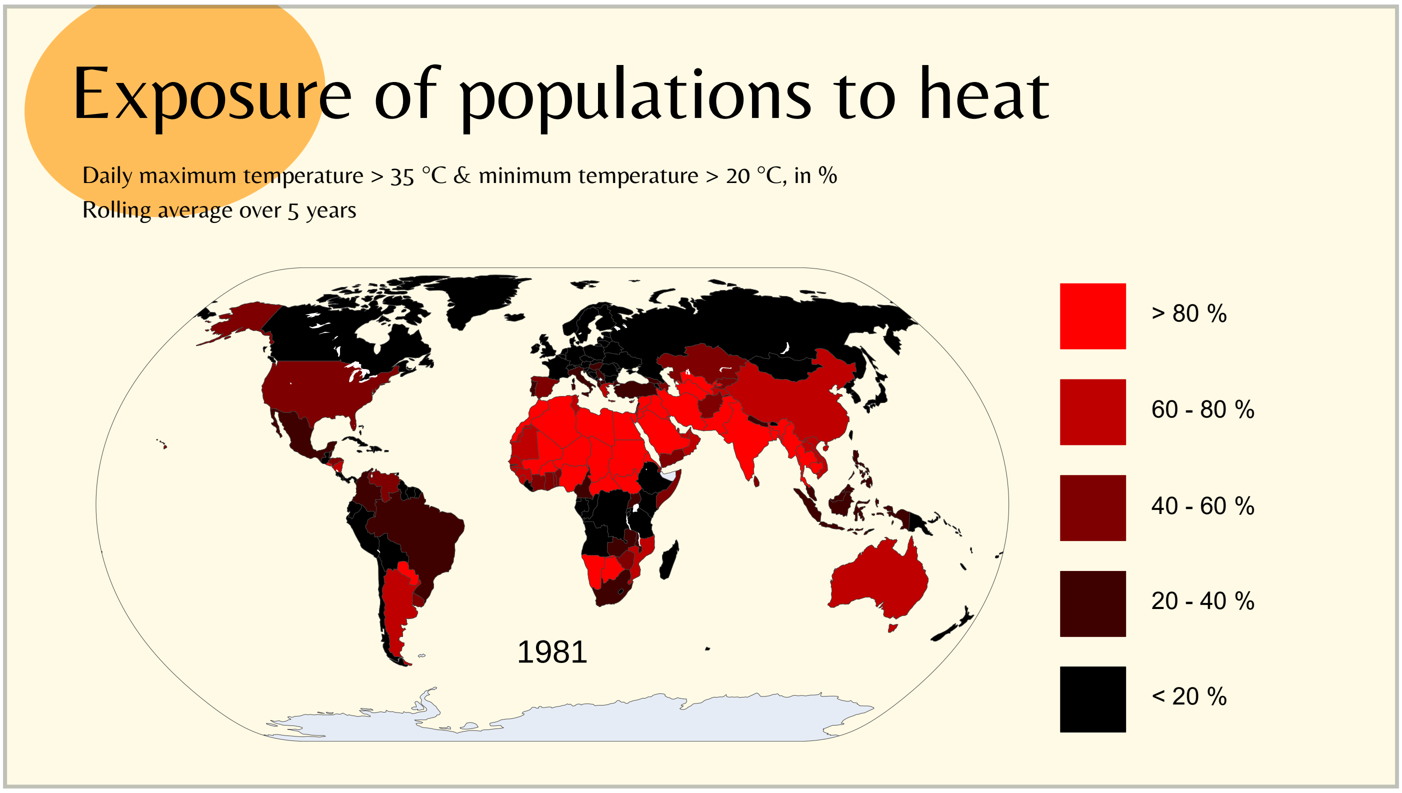
Monthly data 1880 - 2023
(Temperature anomaly)

Tables of Global and Hemispheric Monthly Means and Zonal Annual Means,
Combined Land-Surface Air and Sea-Surface Water Temperature Anomalies (Land-Ocean Temperature Index, L-OTI).

1060 data points
(GDP per capita)

The National Accounts Section of the United Nations Statistics Division.

I also used data from NASA (temperature anomaly) and UN (GDP per capita).



First, we must define extreme heat. The data from OECD show population exposures to very hot days and tropical nights, when temperature does not sink below 35 degrees Celsius during the day, resp. 20 degrees of Celsius in the night.

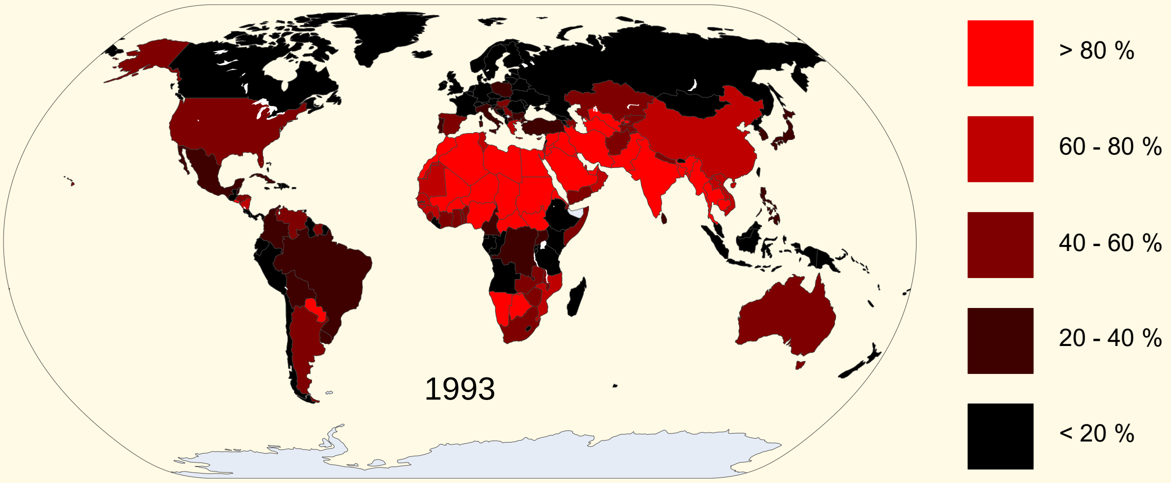
To suppress random fluctuations, I mostly use rolling average of exposure values over 5 years.

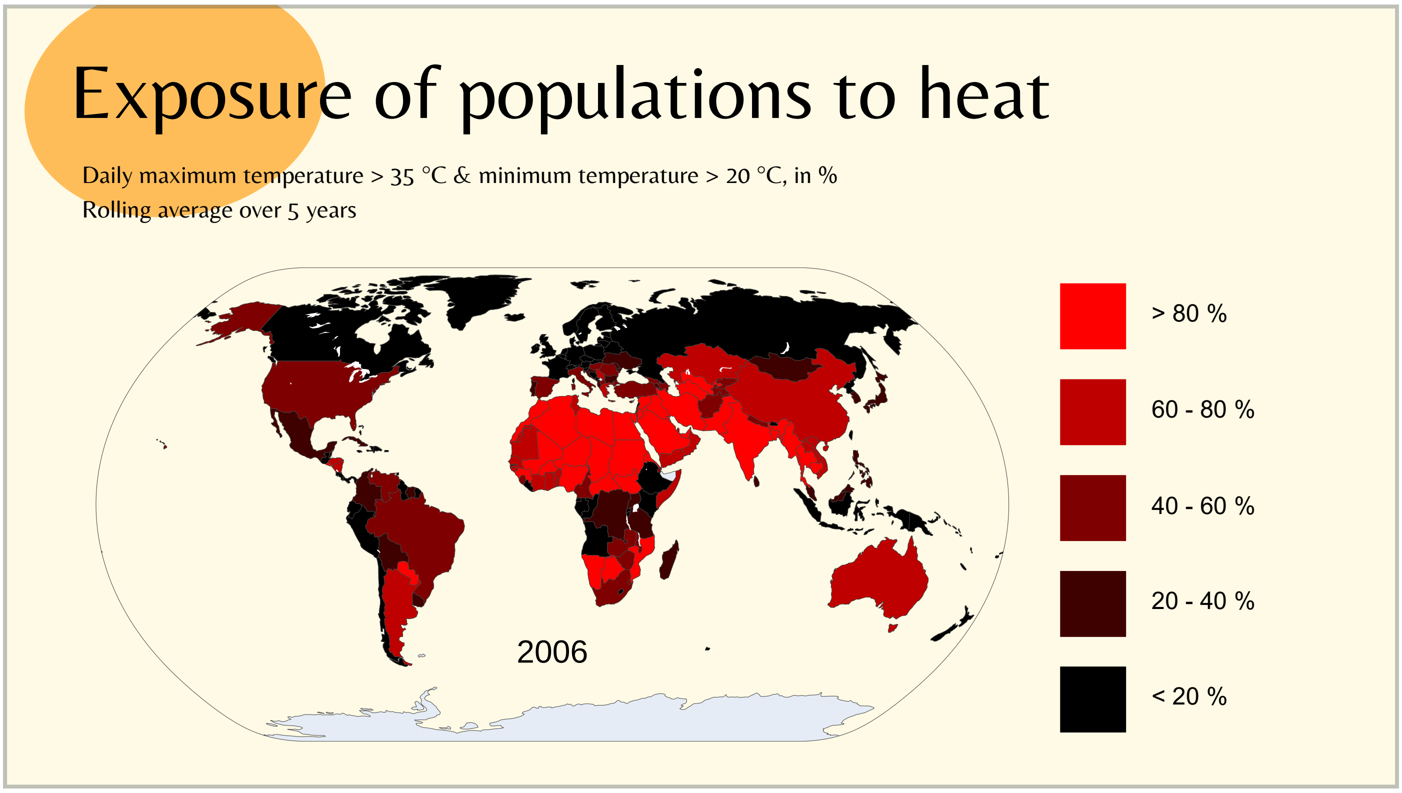
In the beginning of 80s, large parts o the globe were still very dark in this map.

Meaning that almost no people in those countries had experience with extreme heat.

Exposure of populations to heat

Daily maximum temperature > 35 °C & minimum temperature > 20 °C, in %
Rolling average over 5 years

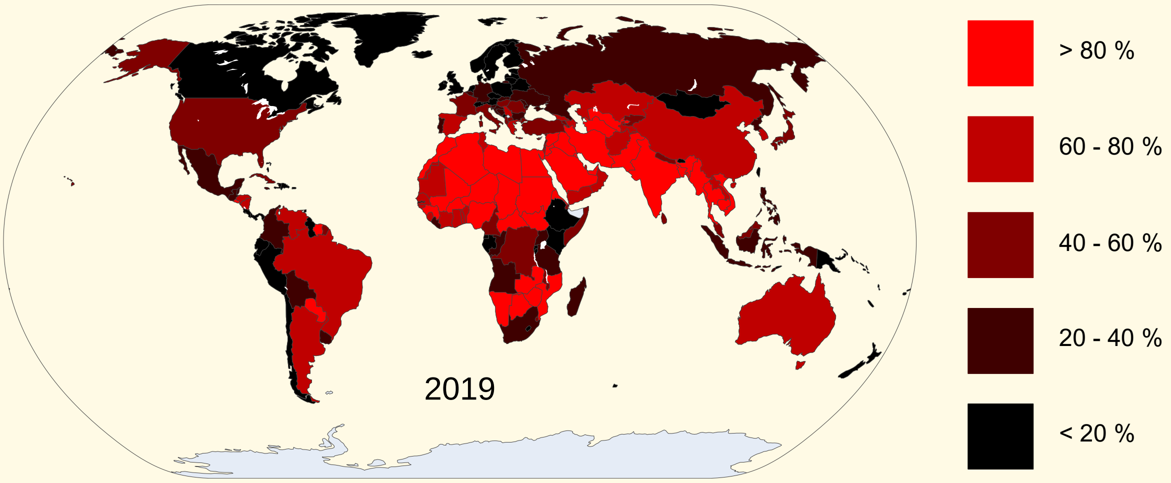




Situation slowly changes in time.

Exposure of populations to heat

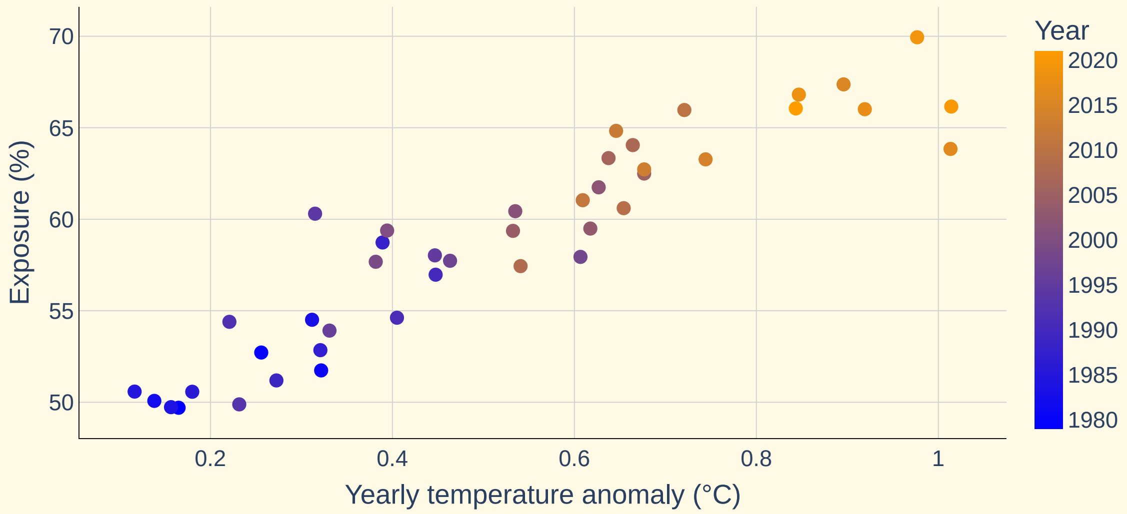
Daily maximum temperature > 35 °C & minimum temperature > 20 °C, in %
Rolling average over 5 years



In recent past, significant percentage of people in the Americas, Europe or China have experienced extreme heat.

Exposure vs temperature anomaly

Daily maximum temperature > 35 °C & minimum temperature > 20 °C
Deviations from 1951-1980 mean temperature



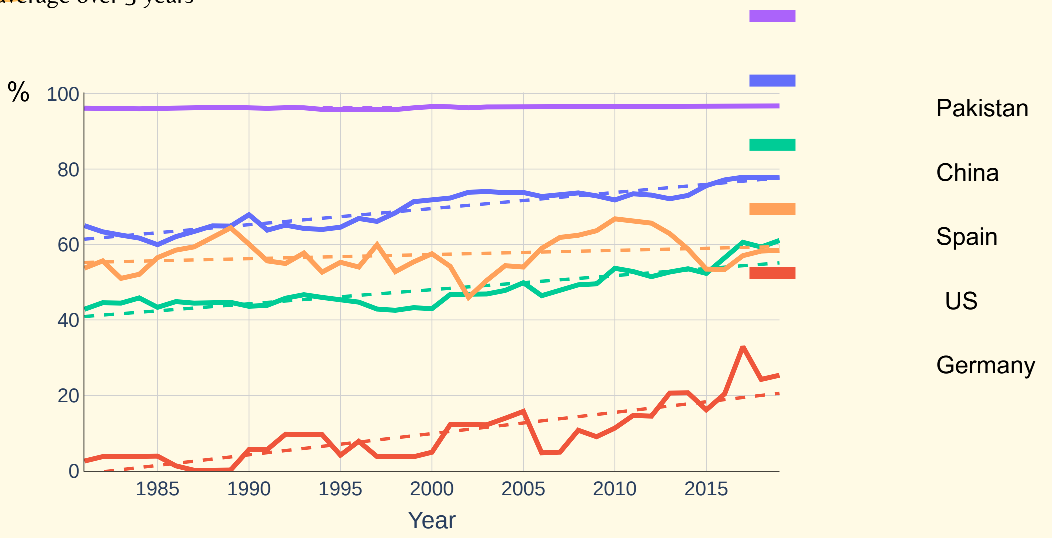
The exposure rose of almost 20 % due to the increase of global temperatures of about 1 degree Celsius.

The trend seems to be slightly slowing down lately, but the forecasted increase in global temperatures might still mean a lot more people exposed to extreme heat.

The global exposure was calculated using the historical populations of countries.

Exposure of populations to heat

Daily maximum temperature > 35 °C & minimum temperature > 20 °C
Rolling average over 5 years

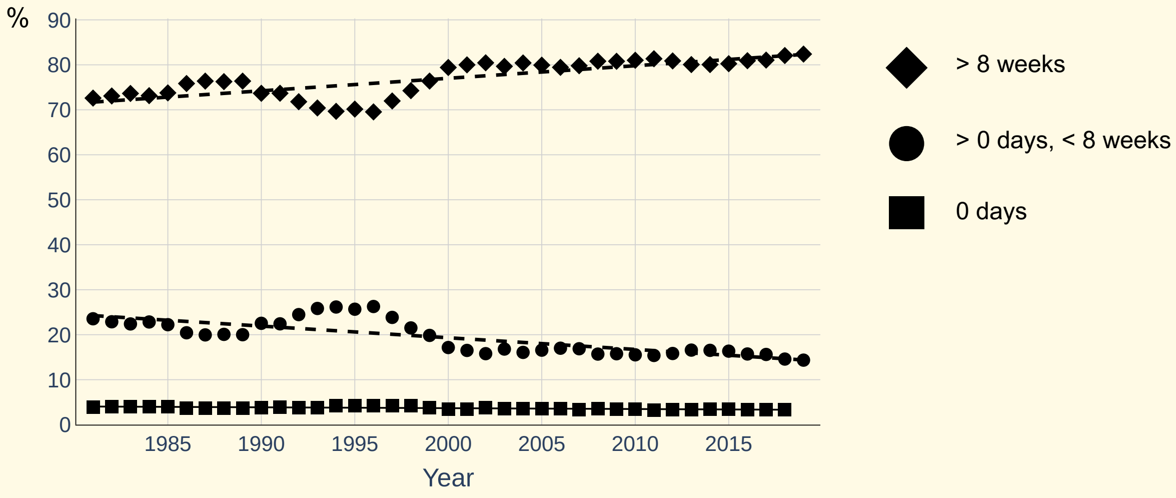


We can easily observe increases in almost any country in the world.

Now, have a look at Pakistan. It seems there is not much happening in countries which had very hot climate from the beginning.

Pakistan: different durations

Daily maximum temperature > 35 °C & minimum temperature > 20 °C
Rolling average over 5 years

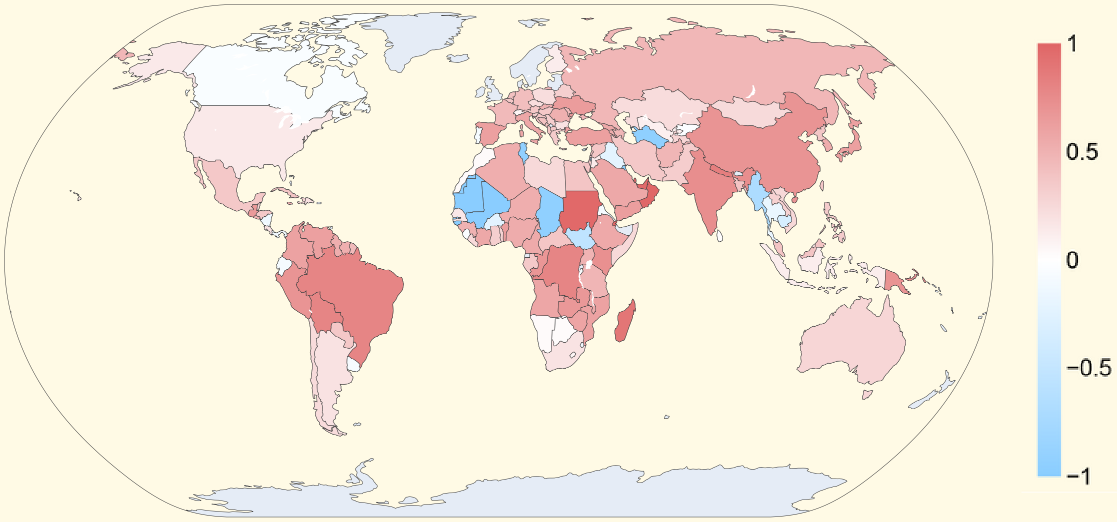


However, if we dive deeper and check exposure to heat for different time periods, we can see that also here the situation is worsening.

The percentage of people who experience heat for more than 8 weeks per year is steadily rising.

Correlation exposure vs time

Daily maximum temperature > 35 °C & minimum temperature > 20 °C



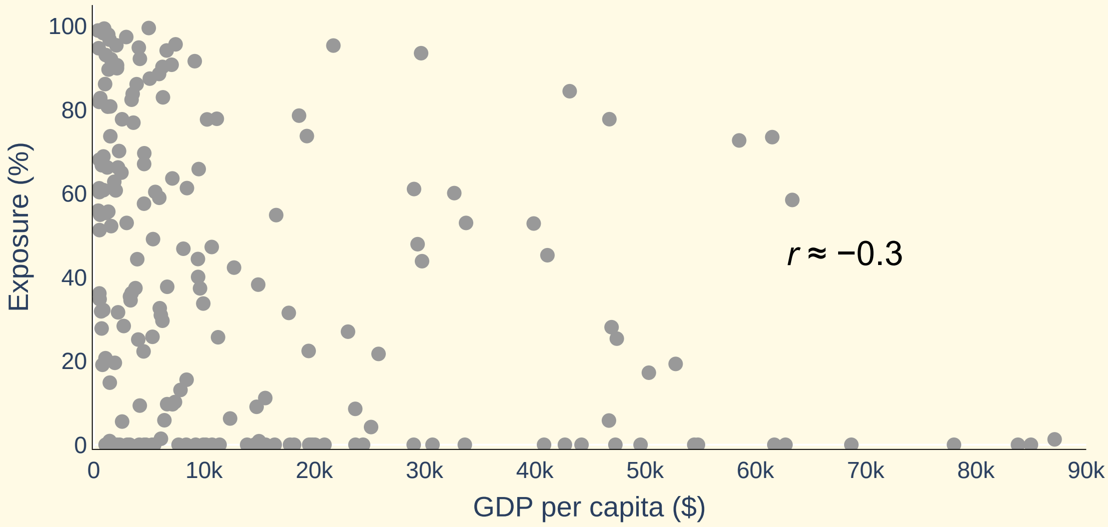
Mostly, heat exposure rose in time with several exceptions.

The reason for the exceptions is impossible to tell from the data, but it might be caused by reporting or by demographic changes.

For example, more people can move to cities outside of desert areas, changing the exposure value.

What countries have in common

Exposure to heat + GDP per capita, average values from 2017 to 2021



In this scatter plot, each dot represents one country.

The values are averages from between 2017 to 2021.

By calculating the correlation coefficient, we can see that on average the exposure slightly decreases with higher GDP per capita.

To have better idea about similarities between countries, I used an automatic algorithm to split them into groups (k-means clustering).

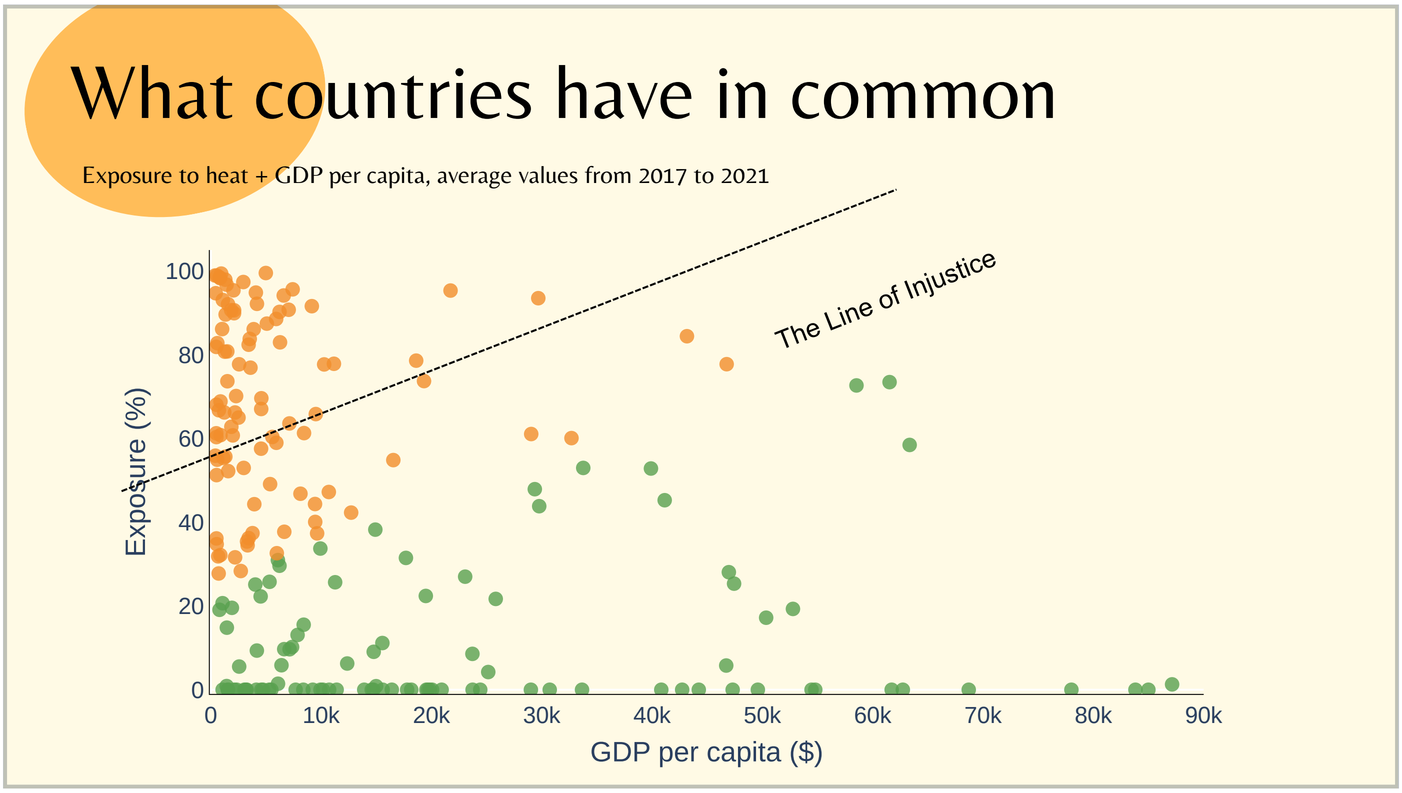
What countries have in common

Exposure to heat + GDP per capita, average values from 2017 to 2021

The result I considered the most insightful was just with two clusters.

The orange group consists of countries, which are poor and at least one fifth of population suffered from heat in the analyzed period and some more wealthy countries where the exposure was in the same time very high.

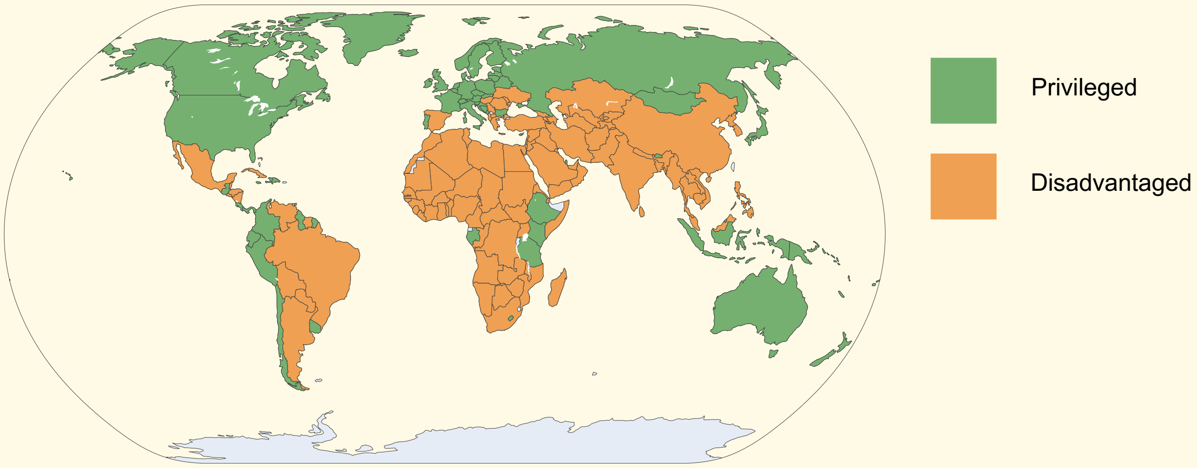
The green group consists of countries with low exposures or wealthy countries with higher exposures, where the material well-being can however often compensate for the inconvenience.



I called the line splitting the two groups The Line of Injustice.

Usually people would probably prefer to live in one of the green countries.

What countries have in common



We can visualize the two groups in a world map.

Let us once more remember that the distinction is a result of purely mathematical metrics we defined in the 2D space of exposure and GDP per capita.

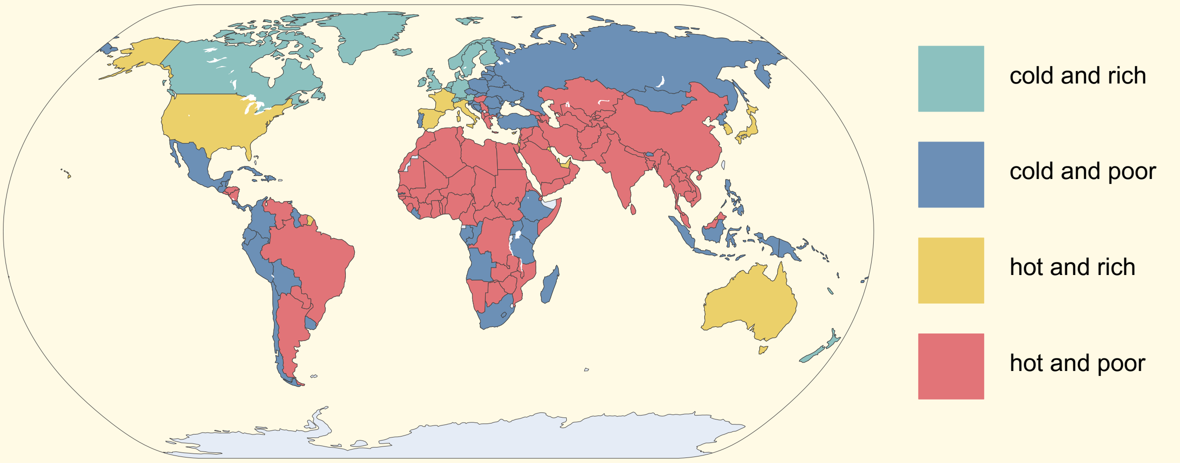
Fine-tuning of the model can be a topic for further discussion.

Is it fair to call some African countries privileged, while some European richer countries are considered disadvantaged?

However, the green African countries reported very low exposures while having higher wealth in regional standards; in the orange European countries it was the opposite.

4 clusters

Exposure to heat + GDP per capita



This is a result of clustering into 4 groups.

It takes more time to grasp the meaning of it but is more descriptive.

Basically, the algorithm split countries into colder and hotter and poorer and richer.

In the same time, the global inequality is still present - cold and rich countries tend to be richer than hot and rich countries, the same with cold and hot poor countries.

Summary

Exposure to extreme heat increases worldwide and within countries.

Warming of ~ 1 °C increased the exposure from 50 to 65 % worldwide.

There is large amount of countries with both high exposure and low income.

Thank for going through the story!