Determining Unreported Deaths Due to Extreme Temperature Events: 2020-2024

Navigating and preparing for the everchanging future

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General Assembly
Friday, August 1, 2025

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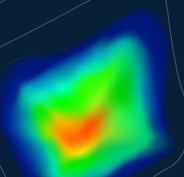
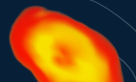




01 INTRODUCTION

Addressing Death Reporting Gaps

Known Issue

Especially in context of climate change

Critical

To quantify the extent to understand True Scale of the problem

Key Questions:

How much data is missing?

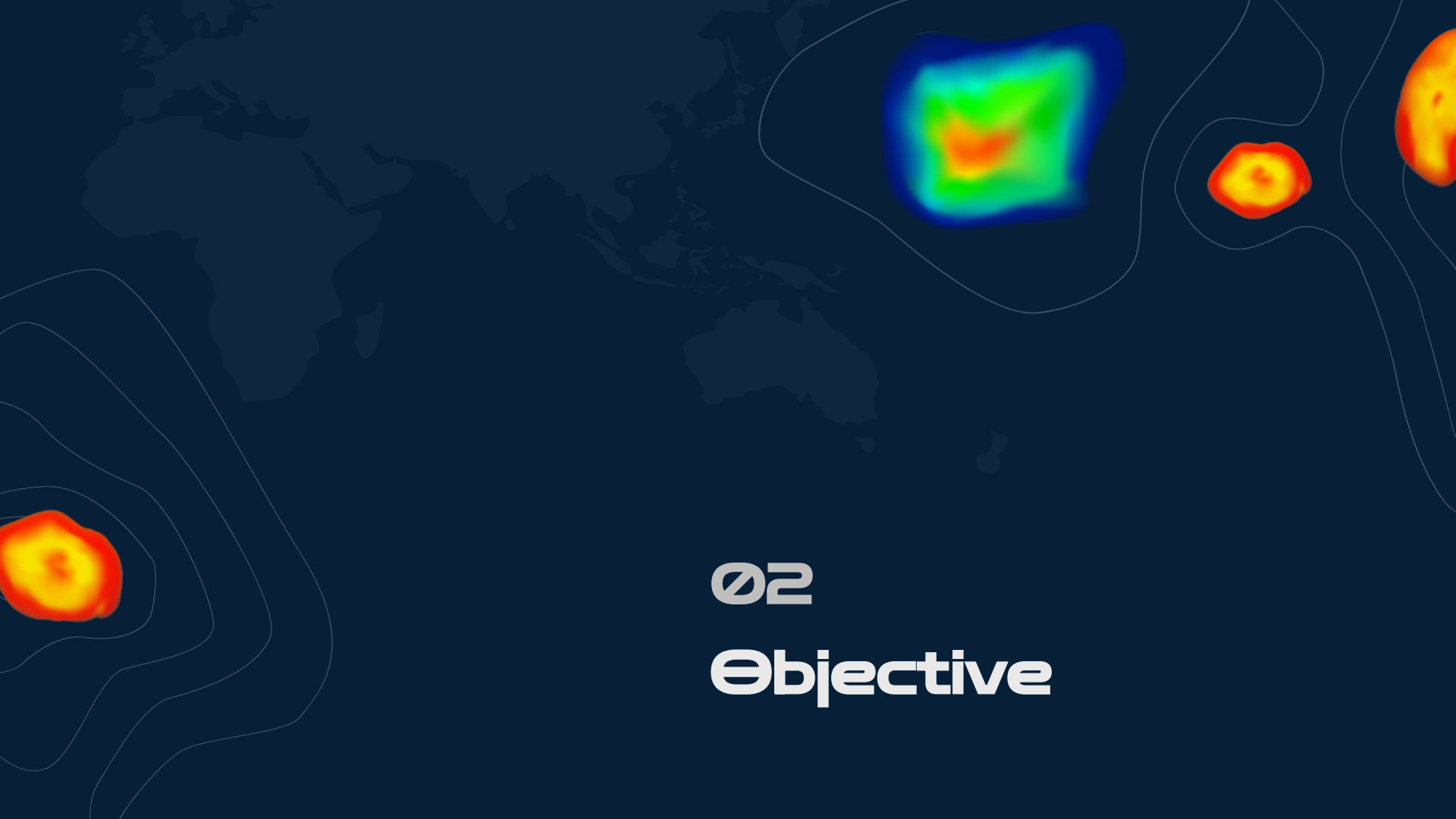
How significant is the underreporting?

No Clarity

On the magnitude means effective solutions can't be developed or implemented

Current Data Limitations

Highlights the need for improved metrics and methods



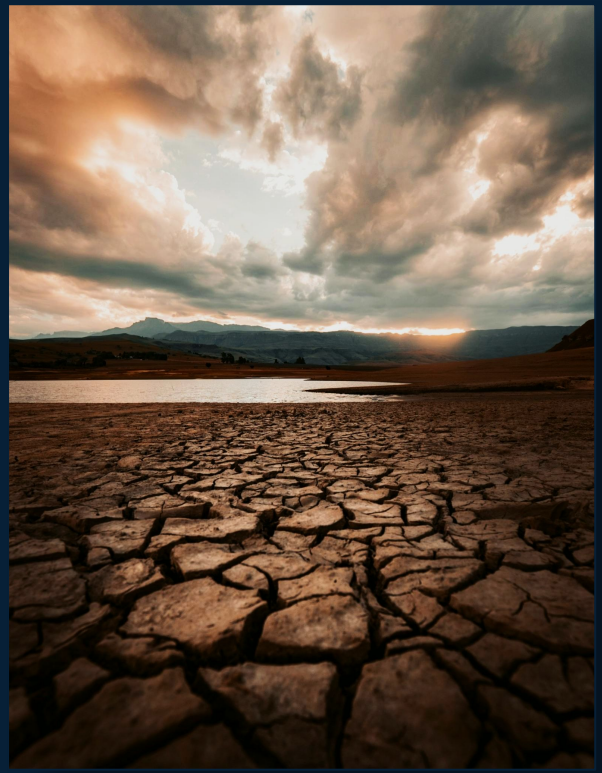
02

Objective

How big of a problem is the missing deaths due to extreme temperature?

Given that extreme temperature events are likely to increase with increasing global temperatures, we want to identify:

- extreme temperature events that resulted in minimal deaths and injuries
- at risk countries or under-reporting countries to model
- The approximate minimum number of deaths due to unreported extreme temperature events in locations compared to data available independently for regions/locations.



Parameters: Years 2020-2024

Extreme Heat Events

Temperatures above 97.5%/2.5 standard deviation above the mean

Location specific

2+days

Extreme Cold Events

Temperatures below 2.5%/2.5 standard deviation above the mean

Location specific

2+days

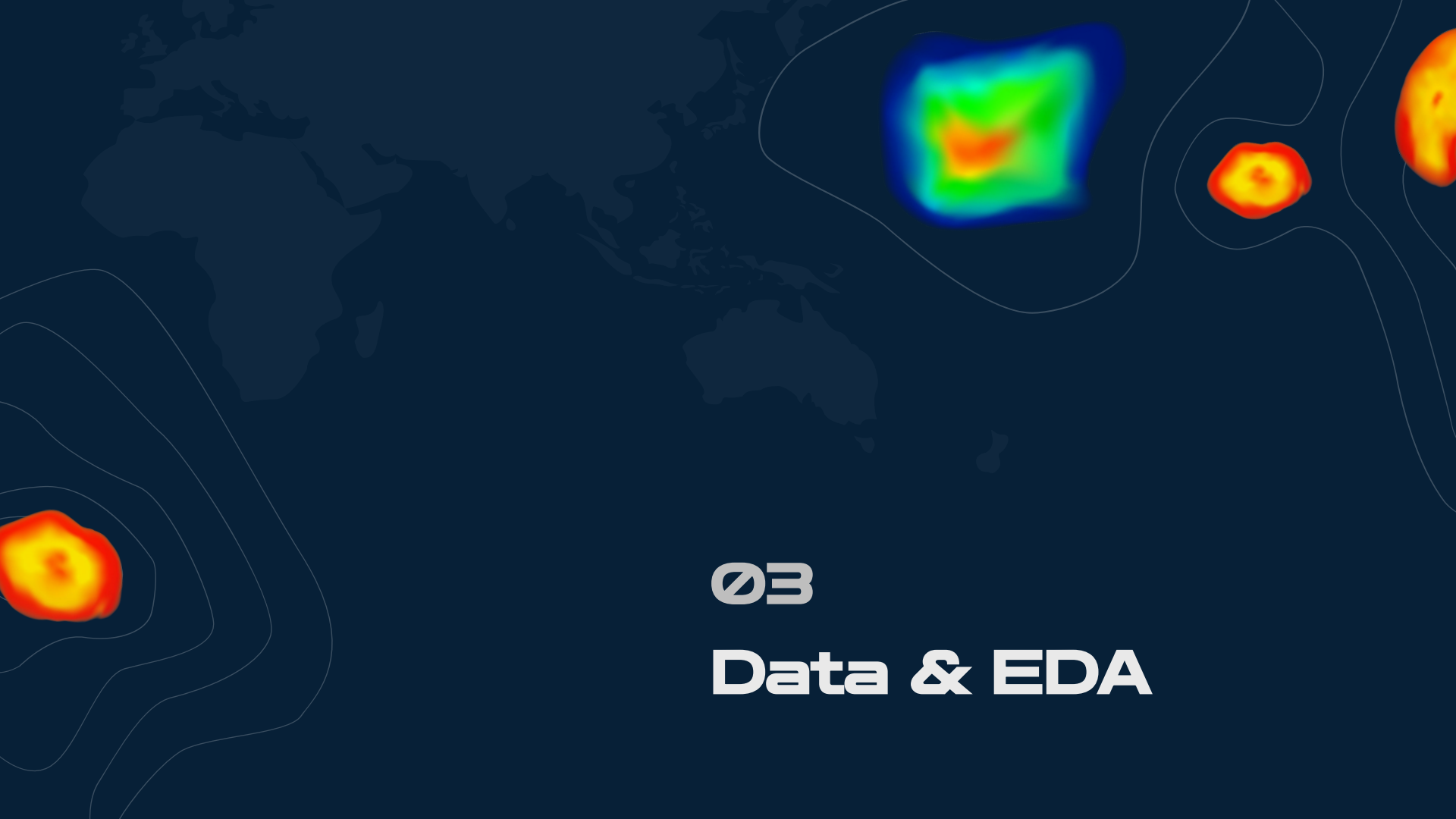
Identification of Under-reported Countries

Africa and Middle East

These regions have been mentioned in publications

Data Comparison

Temperature data individually available for locations/regions reporting and not reporting



03

Data & EDA

EM-DAT
The International Disaster Database

Centre for Research on the Epidemiology of Disasters (CRED), Brussels, Belgium

Copernicus Climate Change Service information (2025)

temperature grid: ERA5 reanalysis data

UN Statistics Division (2024)

Population Census, 1985-2023 (Our World in Data)

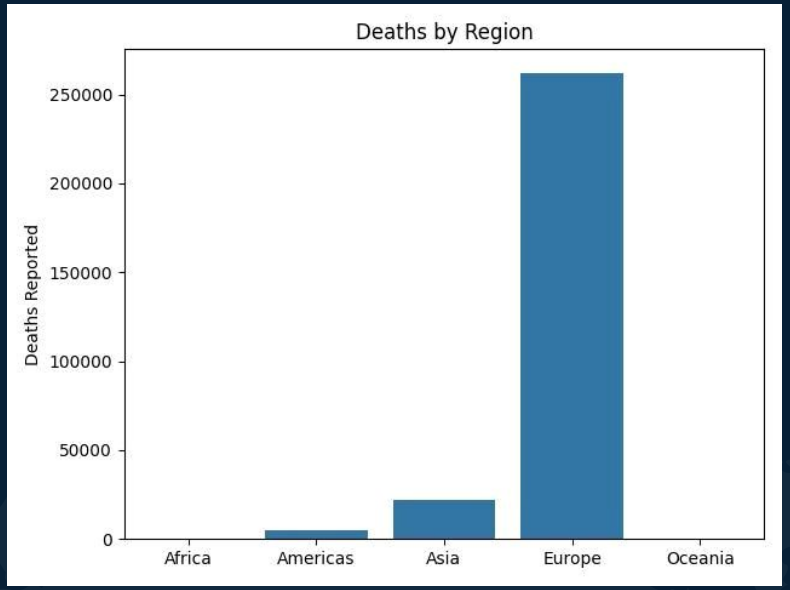
Identifying Extreme Temp Events

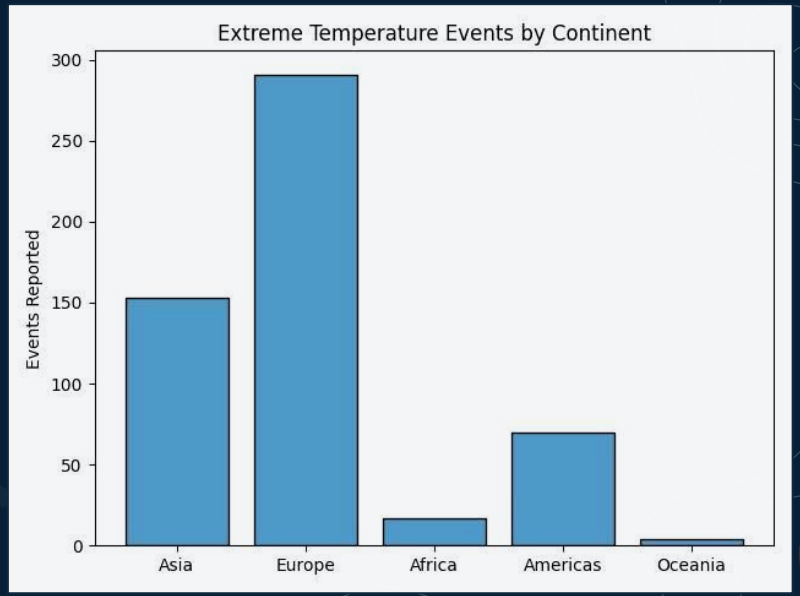
Calculated standard dev, duration &
compared with recorded events

Narrowed to 2020-2024

Era 5 - just too large
from 1950 to last wk down to 1 degree

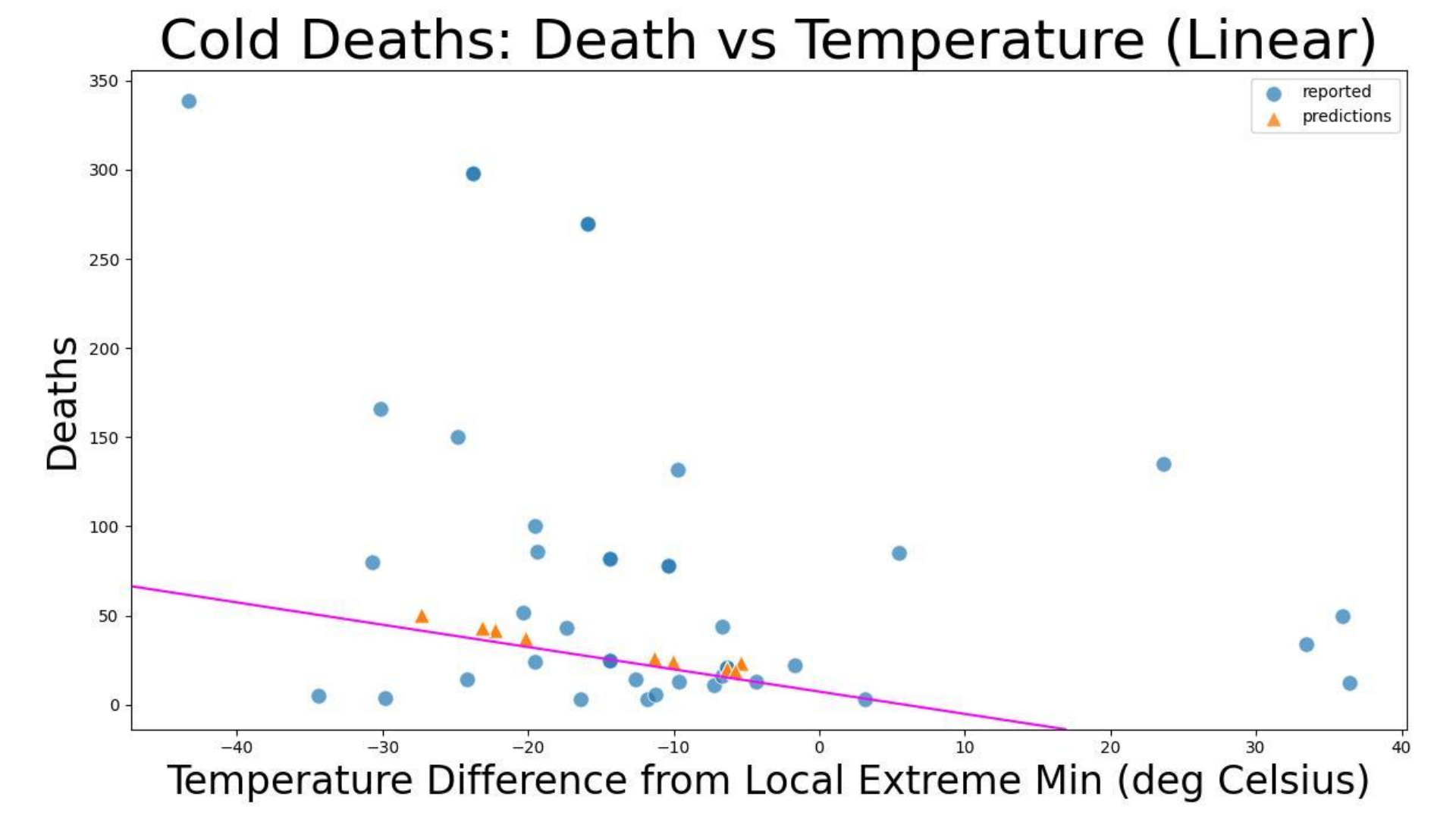
Underreported Regions

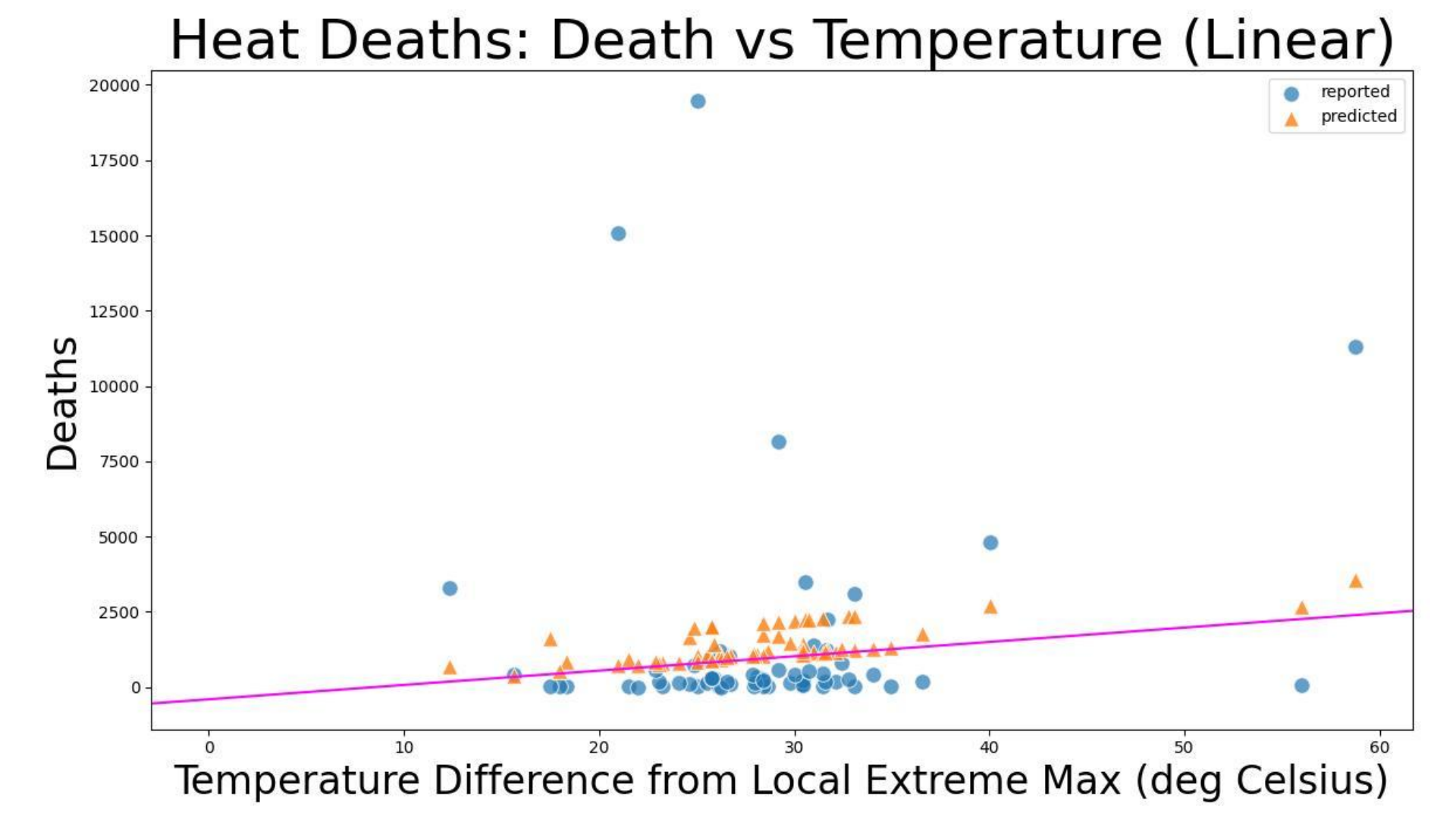




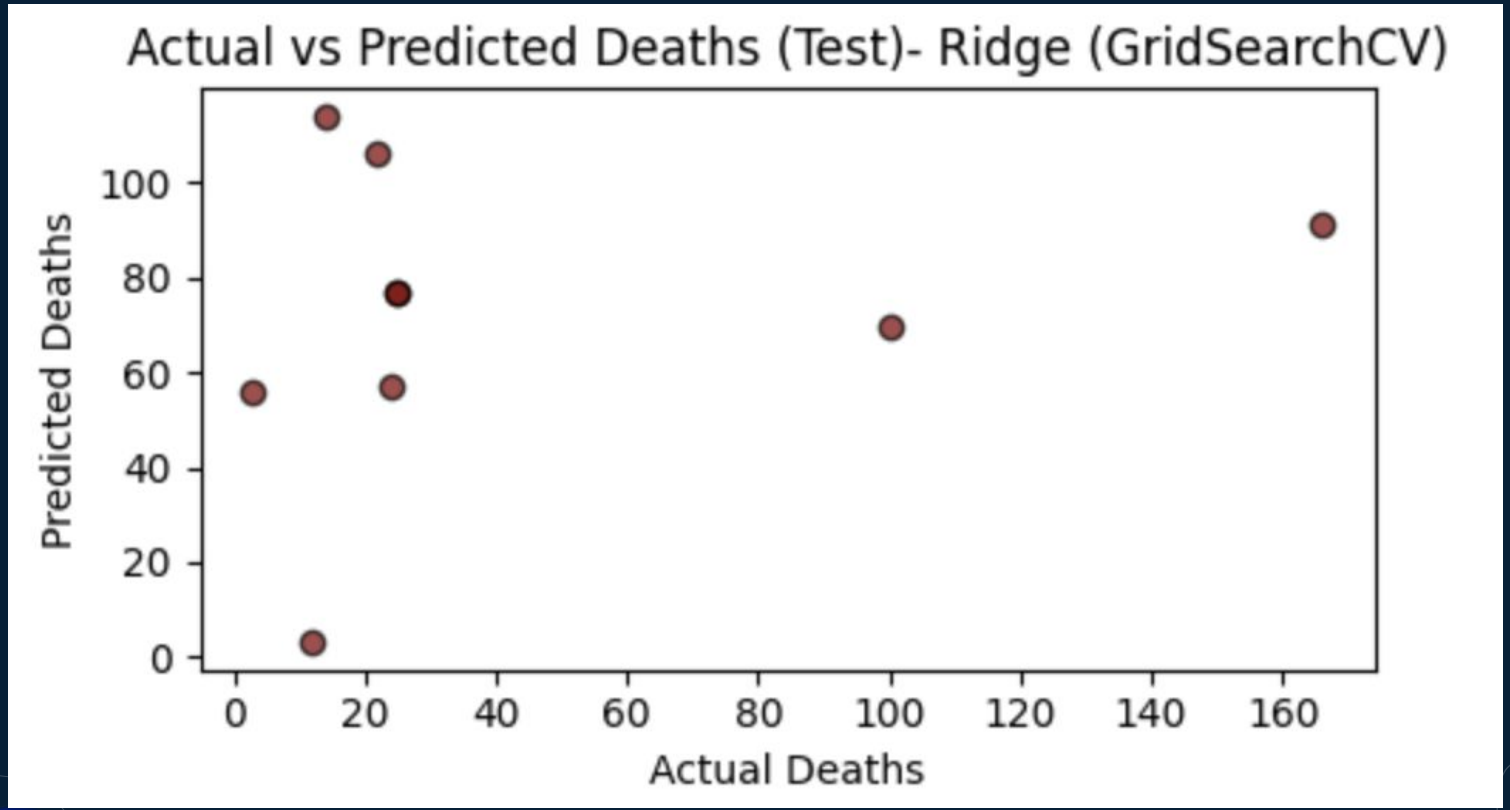
04

Model & Approach

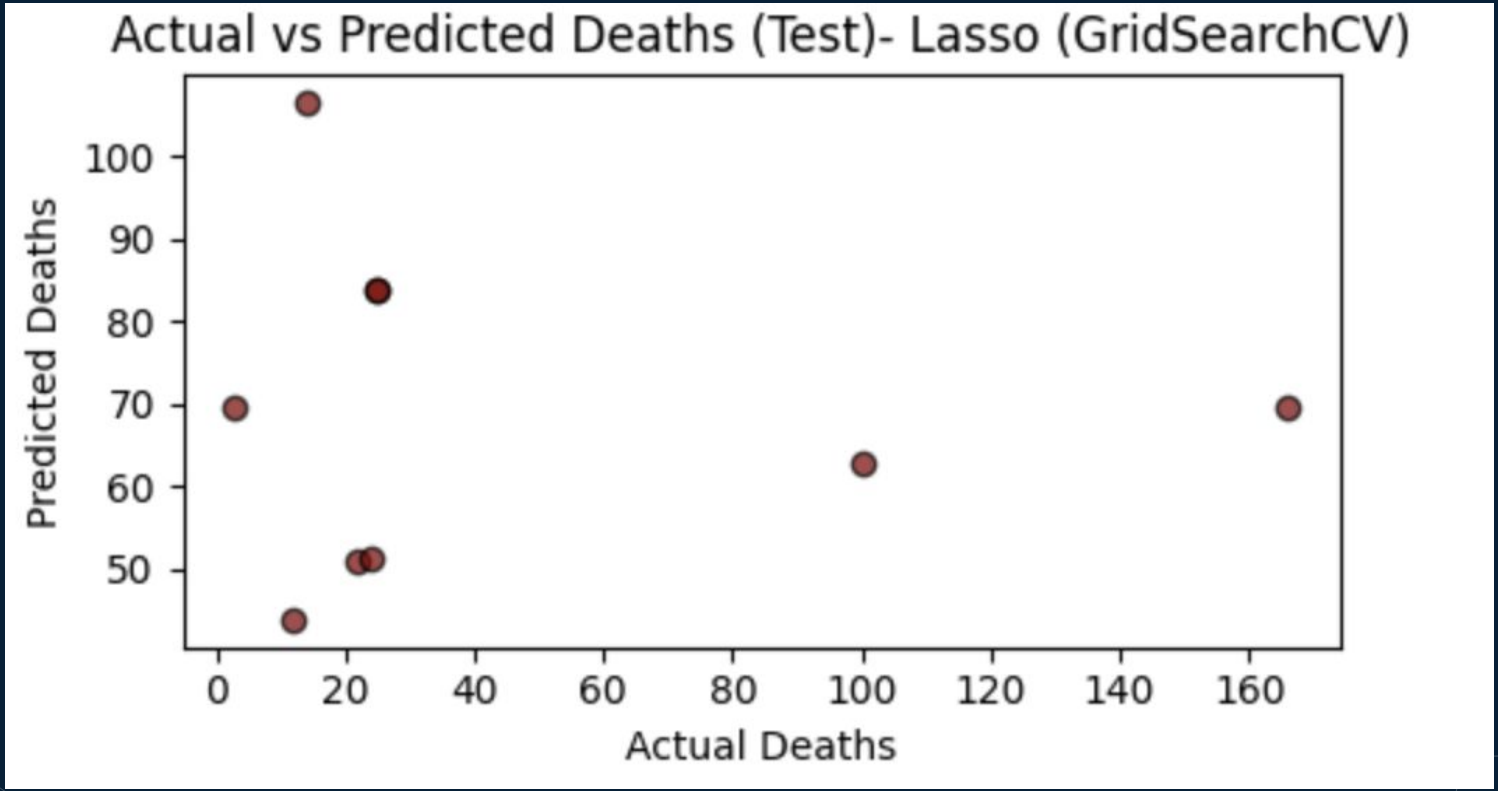

Cold Deaths: Death vs Temperature (Linear)
reported
predictions
Deaths
Temperature Difference from Local Extreme Min (deg Celsius)
350
300
250
200
150
100
50
0
−40
−30
−20
−10
0
10
20
30
40


Heat Deaths: Death vs Temperature (Linear)
reported
predicted
Deaths
20000
17500
15000
12500
10000
7500
5000
2500
0
0
10
20
30
40
50
60
Temperature Difference from Local Extreme Max (deg Celsius)

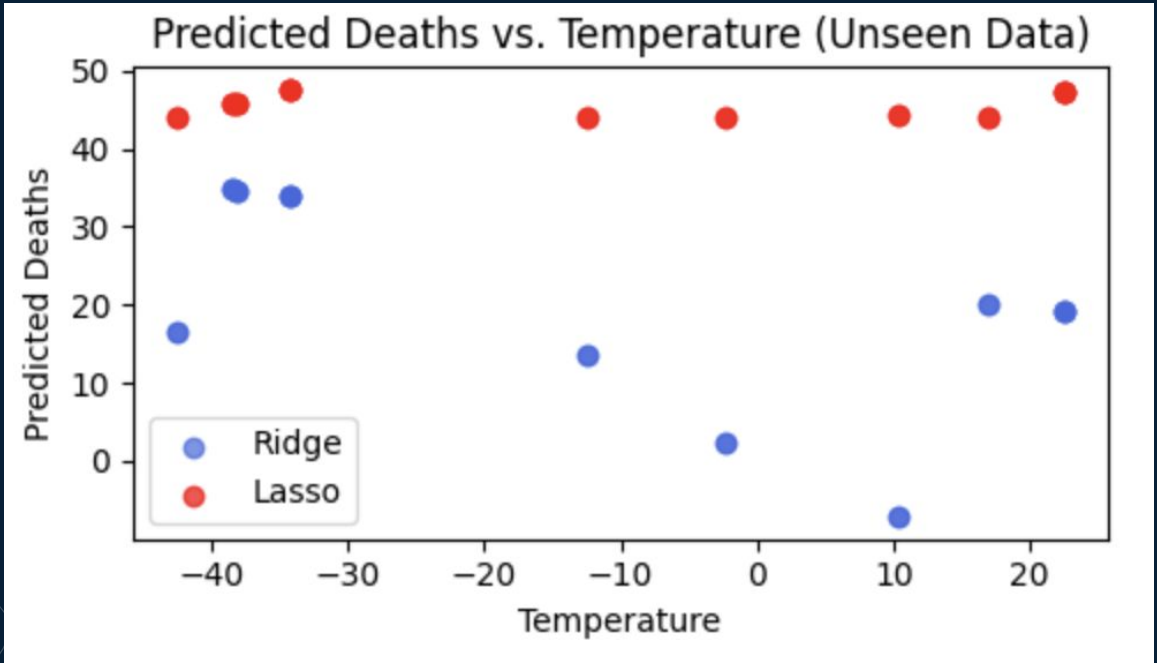
Ridge & LASSO


Actual vs Predicted Deaths (Test)- Ridge (GridSearchCV)
Predicted Deaths
0
20
40
60
80
100
Actual Deaths
0
20
40
60
80
100
120
140
160

Ridge & LASSO

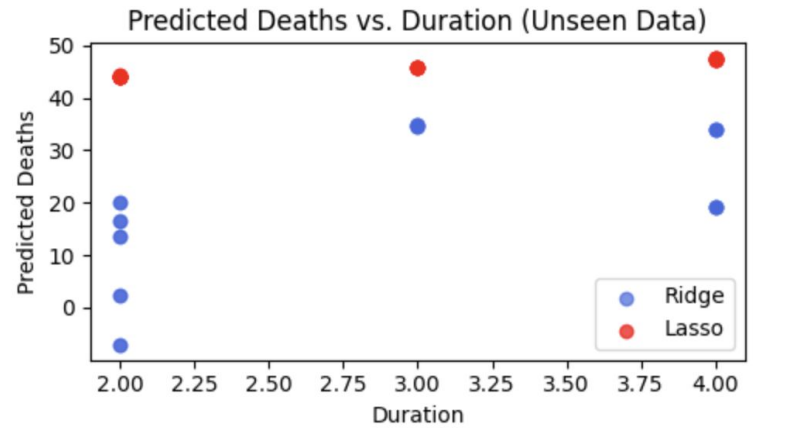

Actual vs Predicted Deaths (Test)- Lasso (GridSearchCV)
Predicted Deaths
100
90
80
70
60
50
0
20
40
60
80
100
120
140
160
Actual Deaths

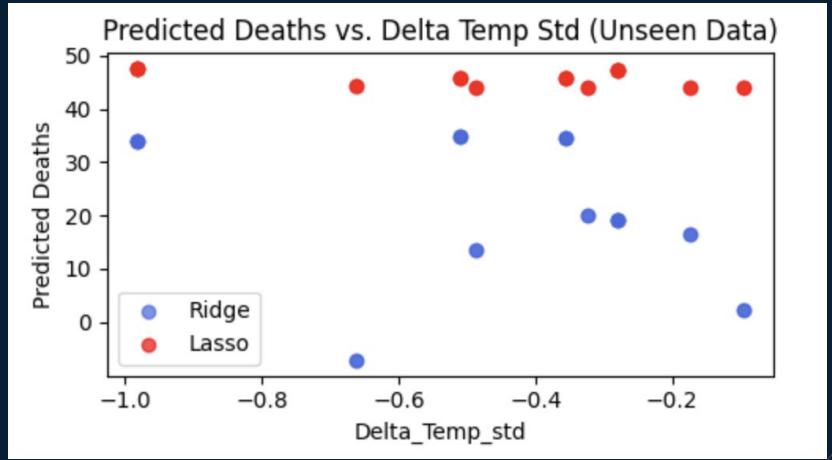
Ridge & LASSO



No pattern!

Ridge & LASSO


Predicted Deaths vs. Duration (Unseen Data)
Predicted Deaths
Duration
Ridge
Lasso
50
40
30
20
10
0
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00


Predicted Deaths vs. Delta Temp Std (Unseen Data)
Predicted Deaths
Delta_Temp_std
Ridge
Lasso
50
40
30
20
10
0
−1.0
−0.8
−0.6
−0.4
−0.2

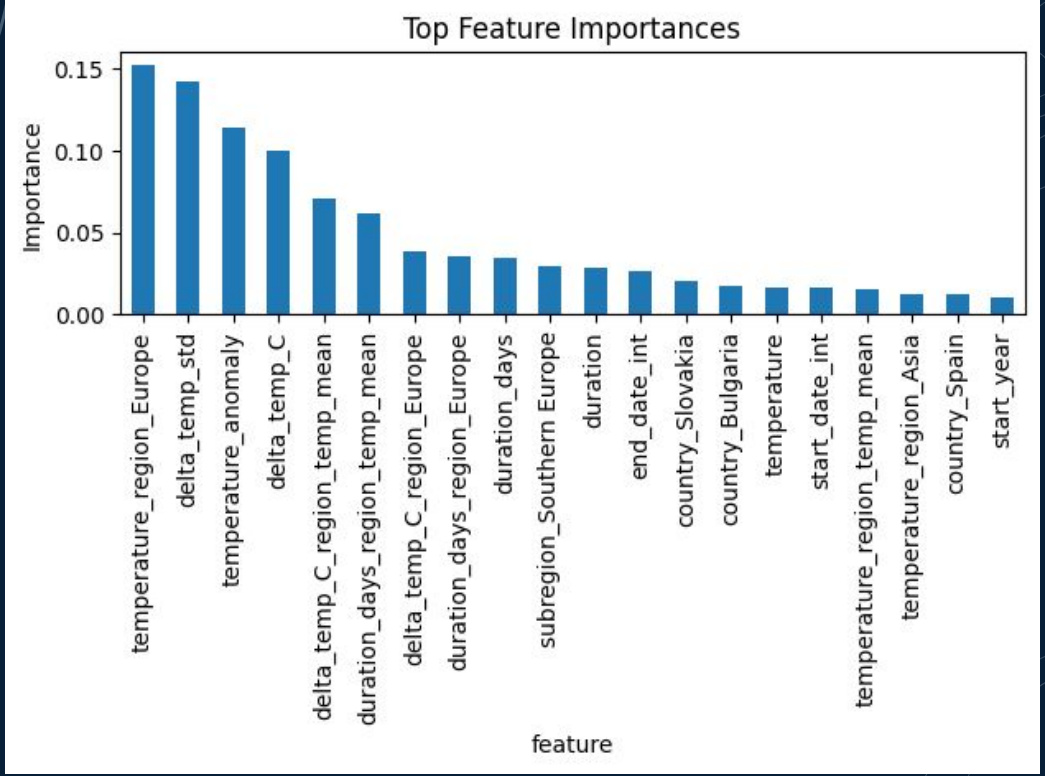
Random Forest

- Model explains a large share of variance in training (R^2=0.86), moderate on test data (R^2=0.50).
- Indicates reasonable predictive power for identifying likely underreporting.

Top predictors of death:

- Regional temperature extremes
- Temperature variability (delta, anomaly, std)
- Duration of event

Geography (Europe, Asia) also significant.



Random Forest

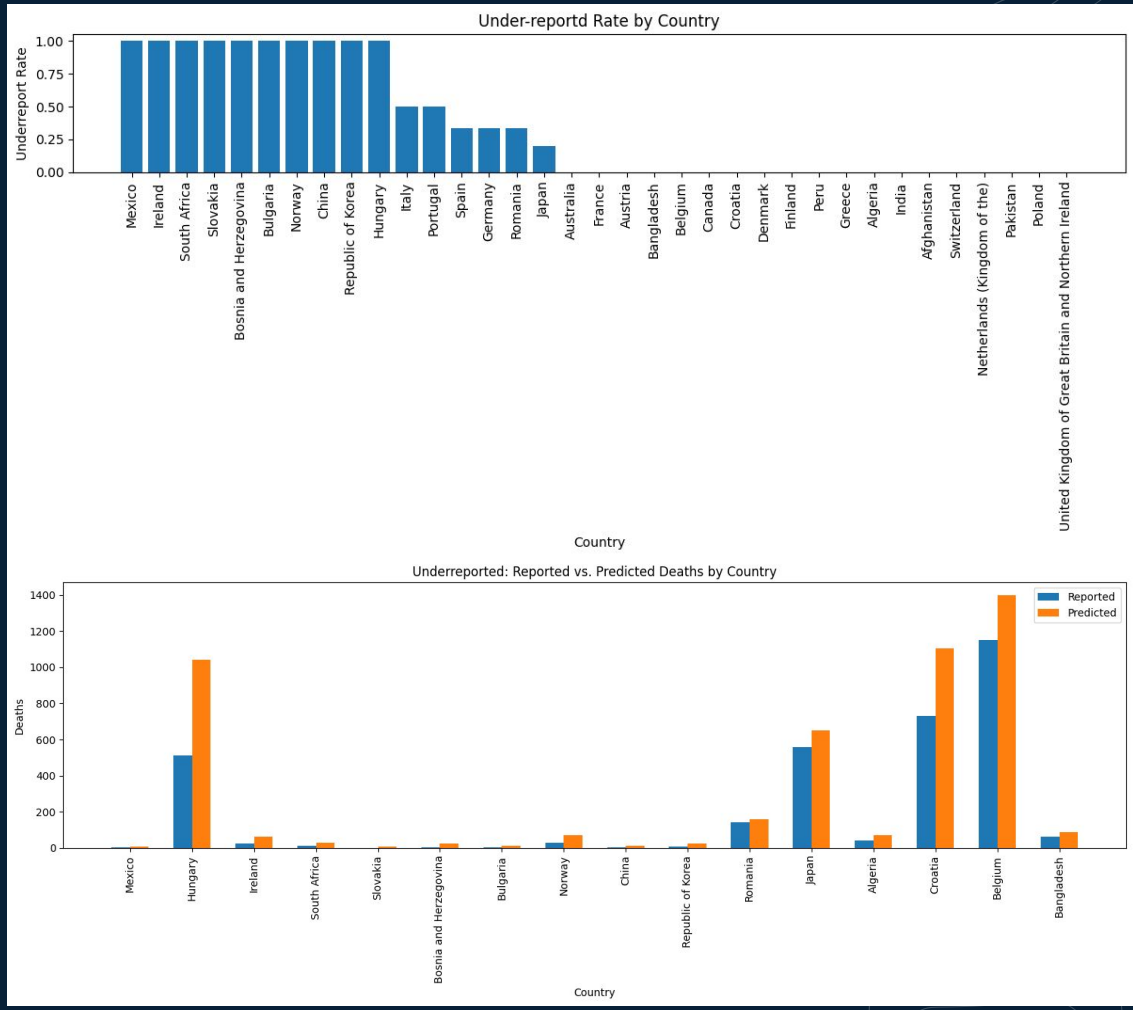
Identifying Anomalies

- Anomaly detection identifies events likely underreported.
- 33 anomalies in training, 8 in test set.
- Events with extreme temperatures but low reported deaths.

Underreport Rate by Country

Mexico, Ireland, South Africa, Slovakia, Bulgaria, China, Korea, Hungary, Norway

This suggests that the true impact of extreme temperature events may be systematically underreported in many countries.



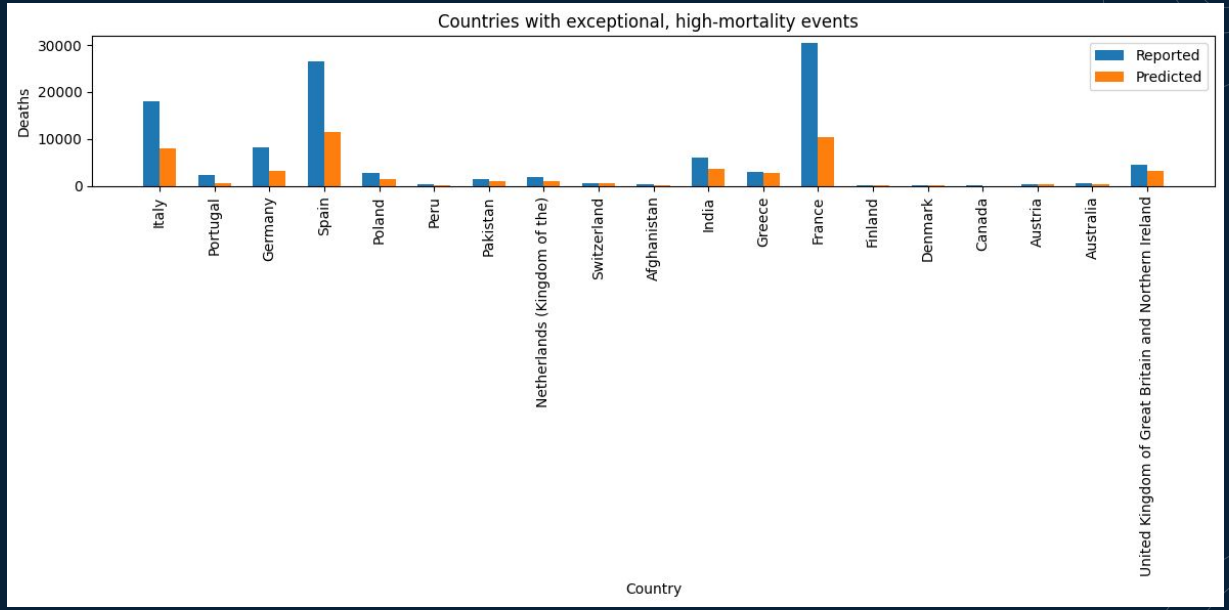
Random Forest

France, Spain, Italy, and Germany have far more reported deaths than the model would predict.

This corresponds to widely recognized heatwaves or disasters, such as the 2003 European heatwave.

The model was trained on global data (where most events are much smaller), so it may underestimate deaths in truly catastrophic events.

For this events in Europe, reported deaths are much higher than what our statistical model would expect. This not only shows good reporting, but also emphasizes the massive scale these disasters can reach

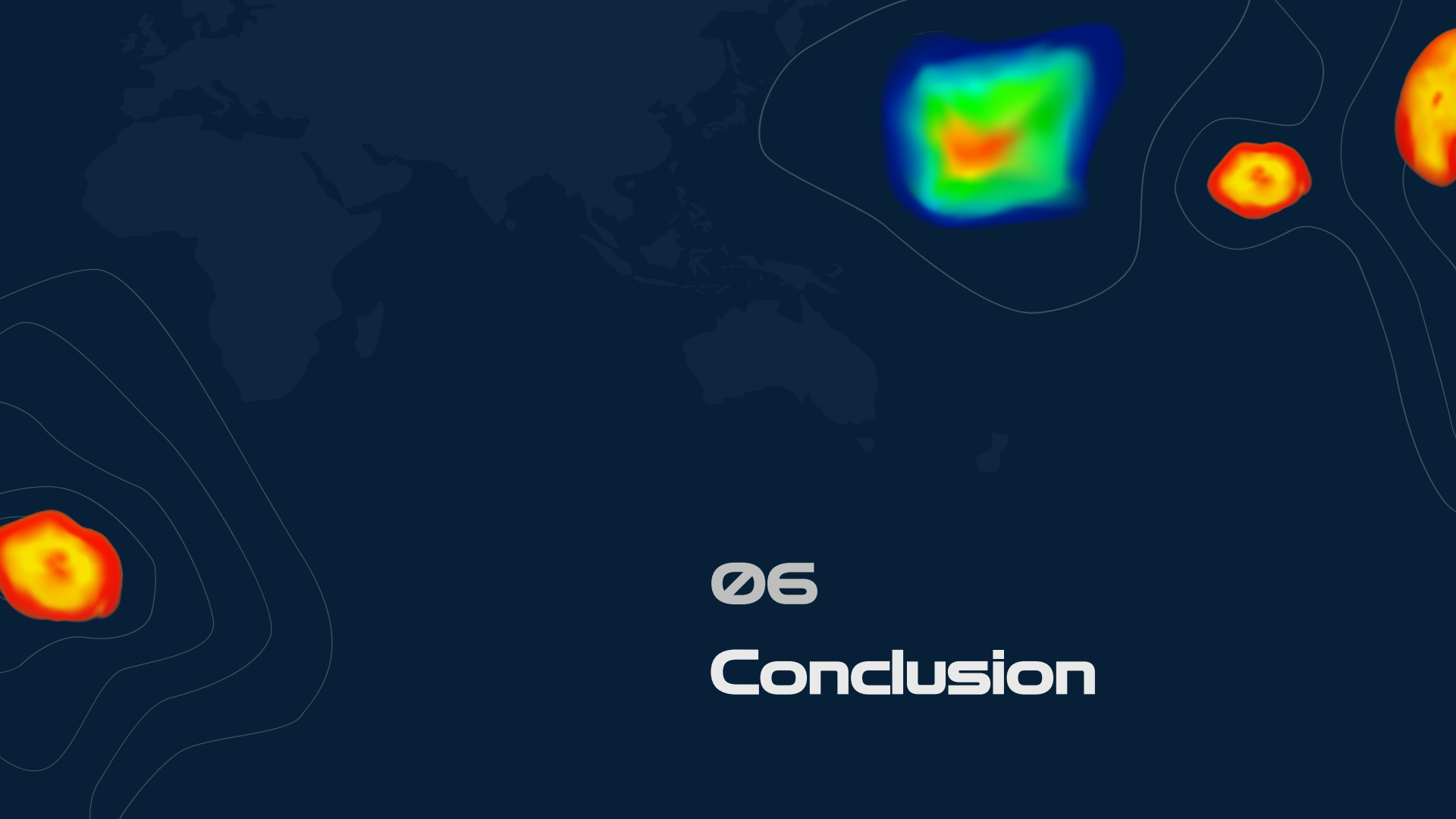


05
Results


> 800
Unreported cold deaths

> 87,000

Unreported heat deaths



06
Conclusion

What's the Issue?

Massive Underreporting

Large scale especially for heat-related deaths

Continents Missing

~2 countries in Africa reporting out of 50+

~Brazil reporting but other countries in South America missing

What Can Be Done?

Spot event individually

Instead of waiting for countries to self-report

Next Step

Again with more time and more data

Need more time to figure out minimal deaths in low-economic countries

What are their policies if any? Or cultural approach to extreme temperatures

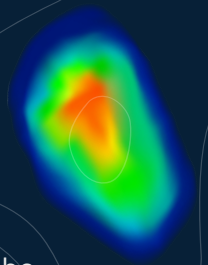
RESOURCES

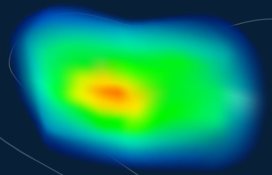
Raw Data

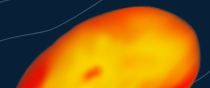
- EM-DAT - The international disaster database - 1900-2025
- 3d rendering of planet earth
- Average monthly surface temperature, Oct 15, 2024
- ERA5 Land hourly time-series data from 1950 to present
- Population census 1985-2023 - UN Statistics Division (2024)

Resesarch

- Mortality risk attributable to high and low ambient temperature: a multicountry observational study
- Hannah Ritchie (2024) - "How many people die from extreme temperatures, and how this could change in the future: Part two"
- United Nations Development Programme
- Heatwaves and Health: Guidance on Warning0System Development







THANKS!

Do you have any questions?