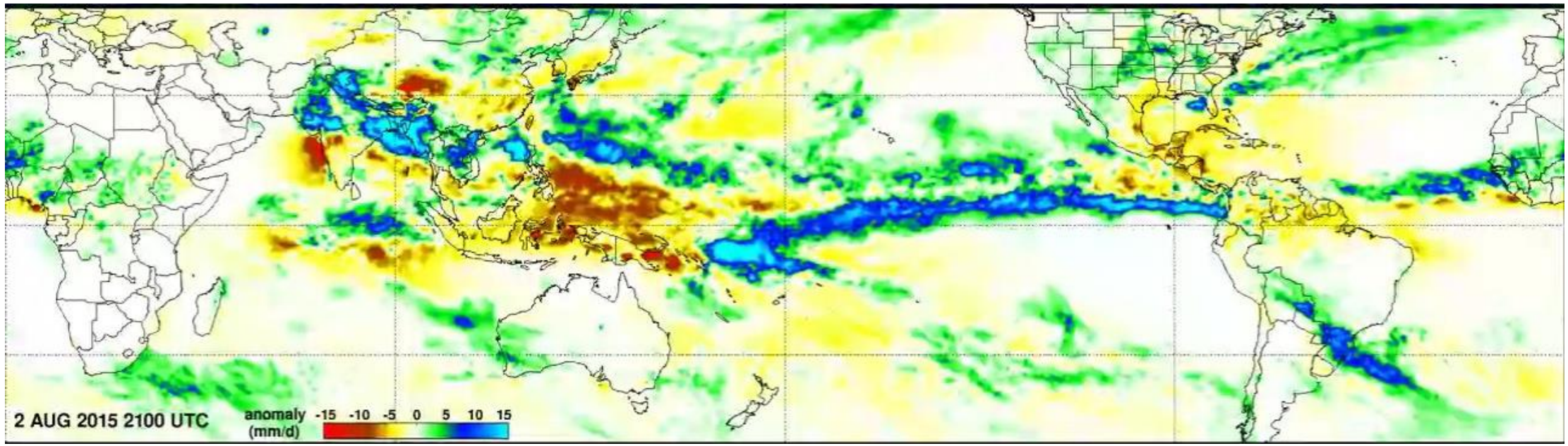


Session 05
Climate anomalies

Proyectos en ingeniería de datos e inteligencia artificial

What you will learn

In this session, you will explore the concept of climate anomalies and learn how to leverage it using several climatological fields from climate reanalysis.

The problem

Imagine we are analyzing the average monthly temperature in Madrid for July. We want to determine whether **July 2024** was warmer or cooler than usual.

The problem

Temperature in Madrid (July)																													
1940	**1941**	**1942**	**1943**	**1944**	**1945**	**1946**	**1947**	**1948**	**1949**	**1950**	**1951**	**1952**	**1953**	**1954**	**1955**	**1956**	**1957**	**1958**	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**
23,0	25,8	25,0	24,5	25,0	25,7	25,0	25,2	23,2	25,6	26,8	24,1	23,7	24,7	24,9	24,9	22,4	24,0	23,3	24,9	23,9	24,3	23,9	23,5	24,3	23,2	23,6	26,0	24,6	25,5
1970	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
25,6	23,6	24,5	23,9	24,9	25,8	24,2	21,0	25,2	24,8	23,9	24,8	25,1	25,7	26,3	26,8	26,1	24,4	23,7	26,7	26,7	25,7	25,4	25,1	27,9	26,9	25,9	23,5	26,7	27,1
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**					
24,5	25,0	25,1	25,9	25,4	26,1	27,3	24,5	24,9	26,2	27,5	24,7	25,4	26,8	24,8	29,0	27,6	26,4	25,9	27,8	28,0	25,1	28,4	26,9	27,3					

Units: Degrees Celsius

Source: ERA5 reanalysis

The approach

Using climate anomalies

What are climate anomalies?

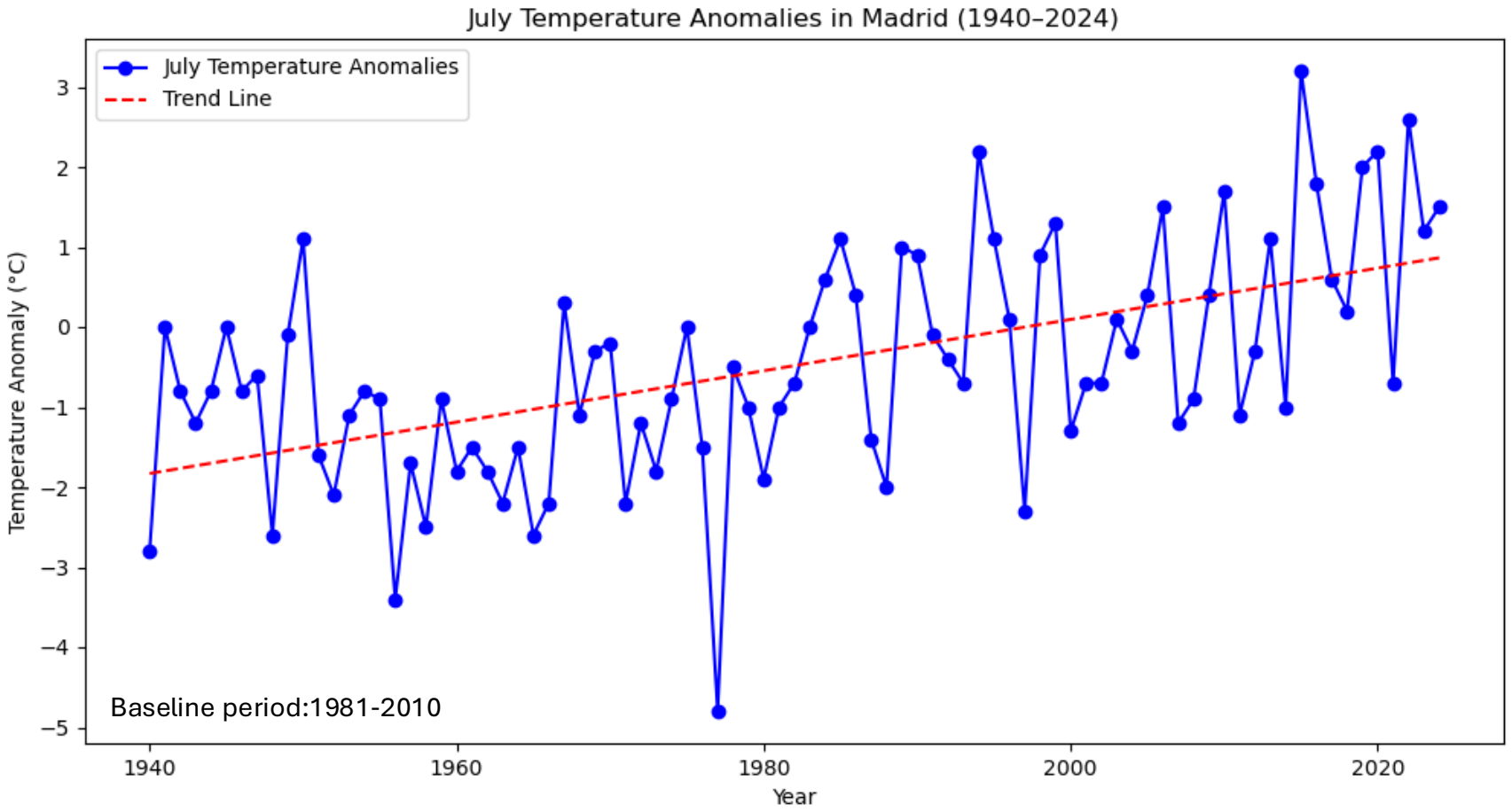
A climate anomaly is the difference between an observed value and a long-term average.

What are climate anomalies?

Anomaly = actual – long-term average

What are climate anomalies?

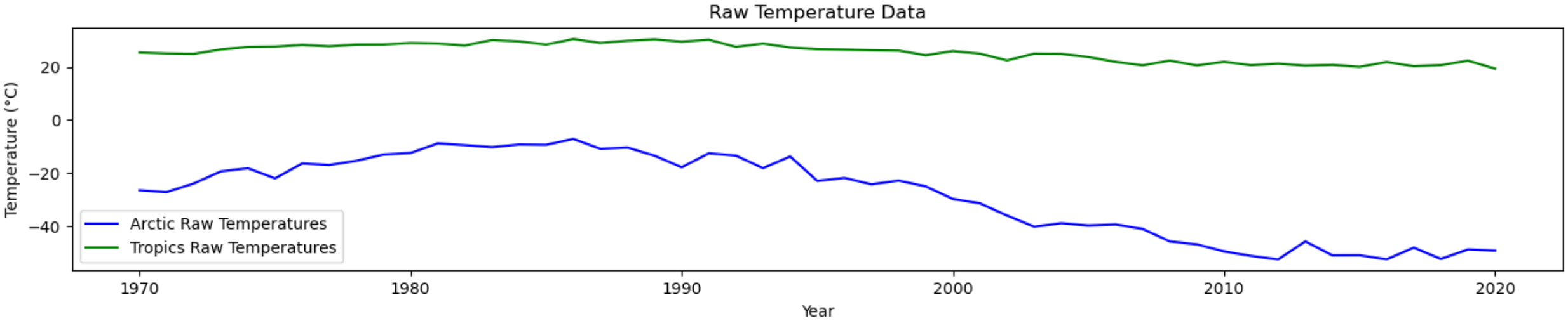
- **Positive anomaly**. Higher than the reference value
- **Negative anomaly**. Lower than the reference value

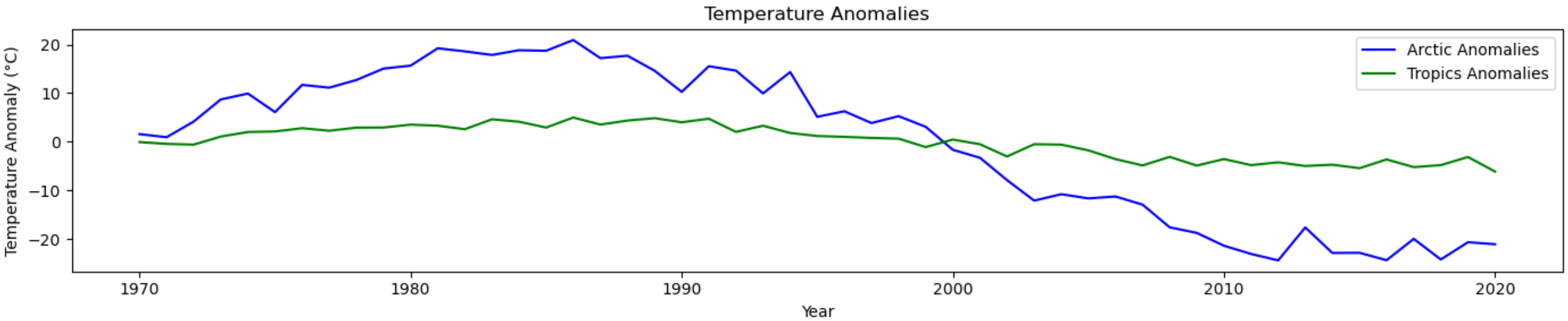

July Temperature Anomalies in Madrid (1940–2024)
July Temperature Anomalies
Trend Line
Temperature Anomaly (°C)
3
2
1
0
−1
−2
−3
−4
−5
1940
1960
1980
2000
2020
Year
Baseline period:1981-2010

Why use climate anomalies?

- Better comparison of different baseline climate regions
- Clearer trend visualization
- More accurate for global analysis

[redacted]


Raw Temperature Data
Temperature (°C)
20
0
−20
−40
Arctic Raw Temperatures
Tropics Raw Temperatures
1970
1980
1990
2000
2010
2020
Year


Temperature Anomalies
Temperature Anomaly (°C)
20
10
0
−10
−20
Arctic Anomalies
Tropics Anomalies
1970
1980
1990
2000
2010
2020
Year

Why use climate anomalies?

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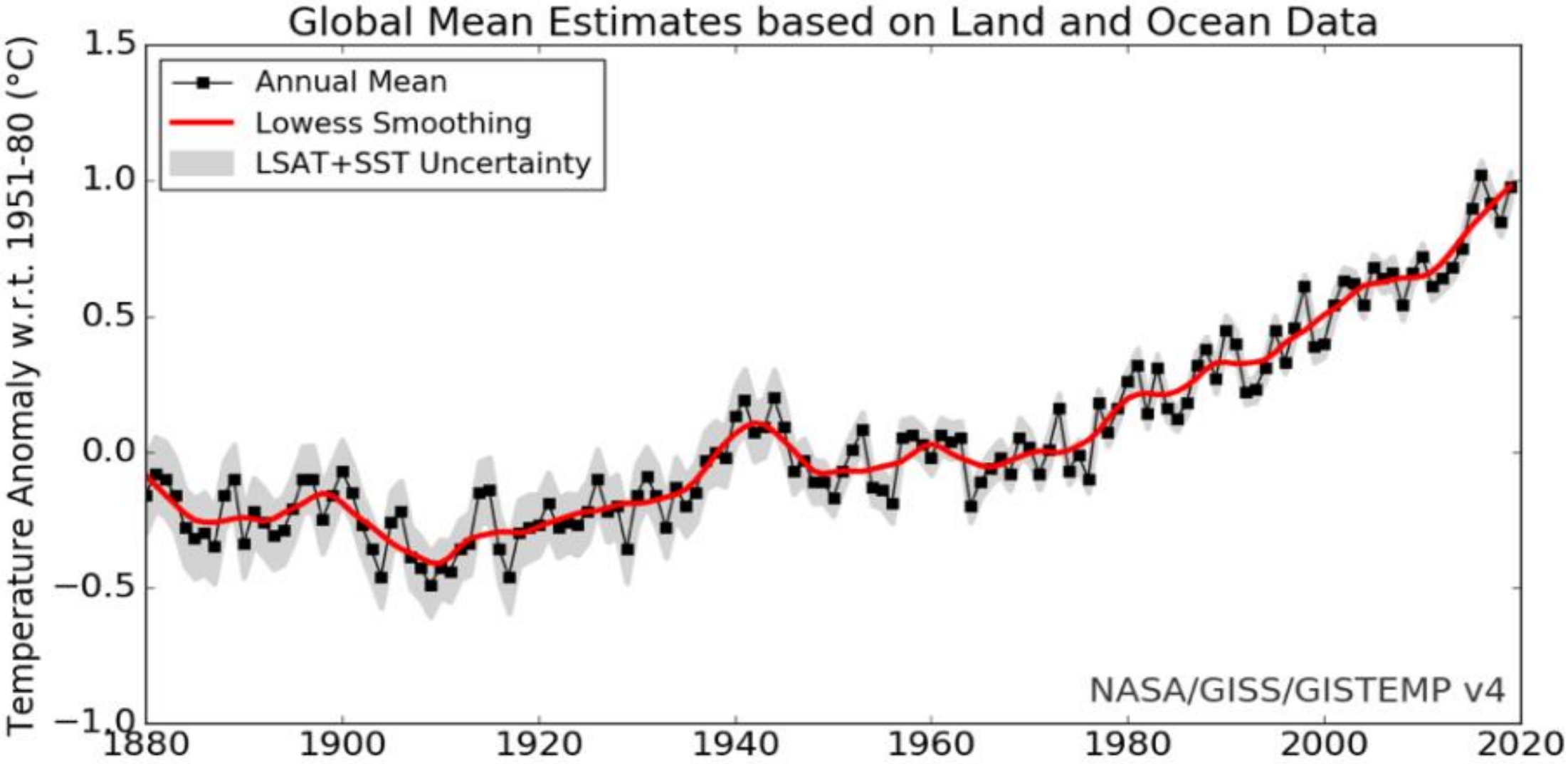
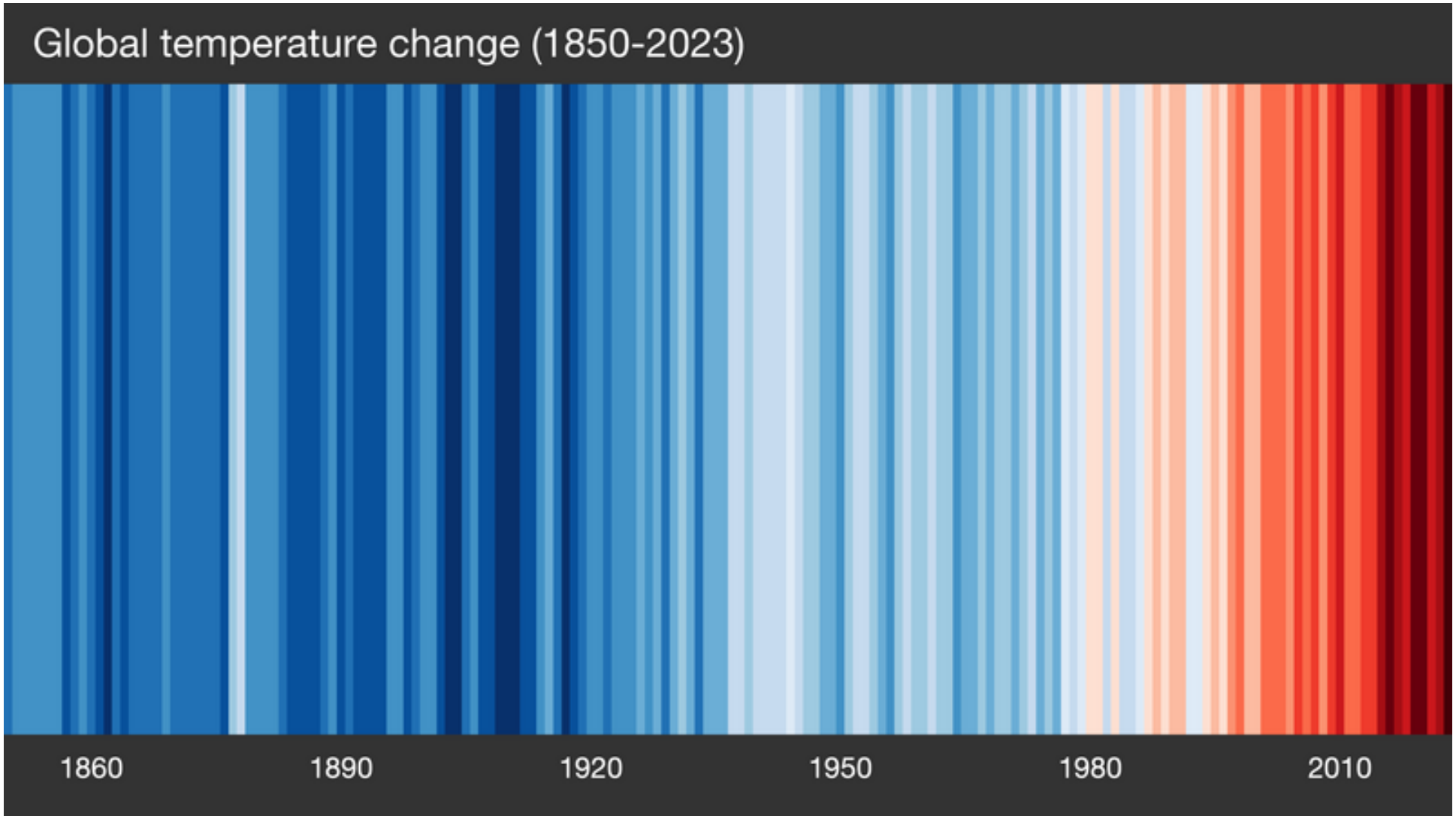


The mean global annual surface temperature from 1880-2019 with 95% confidence interval. The red line is a LOWESS smoothing equivalent to a 5-year moving average. **Source**: GISTEMP.



https://wmo.int/es/node/25831

Warming Stripes for the GLOBE from 1850-2023.
Data: Berkeley Earth, NOAA, UK Met Office, MeteoSwiss, DWD, SMHI, UoR, Meteo France & ZAMG.

Why use climate anomalies?

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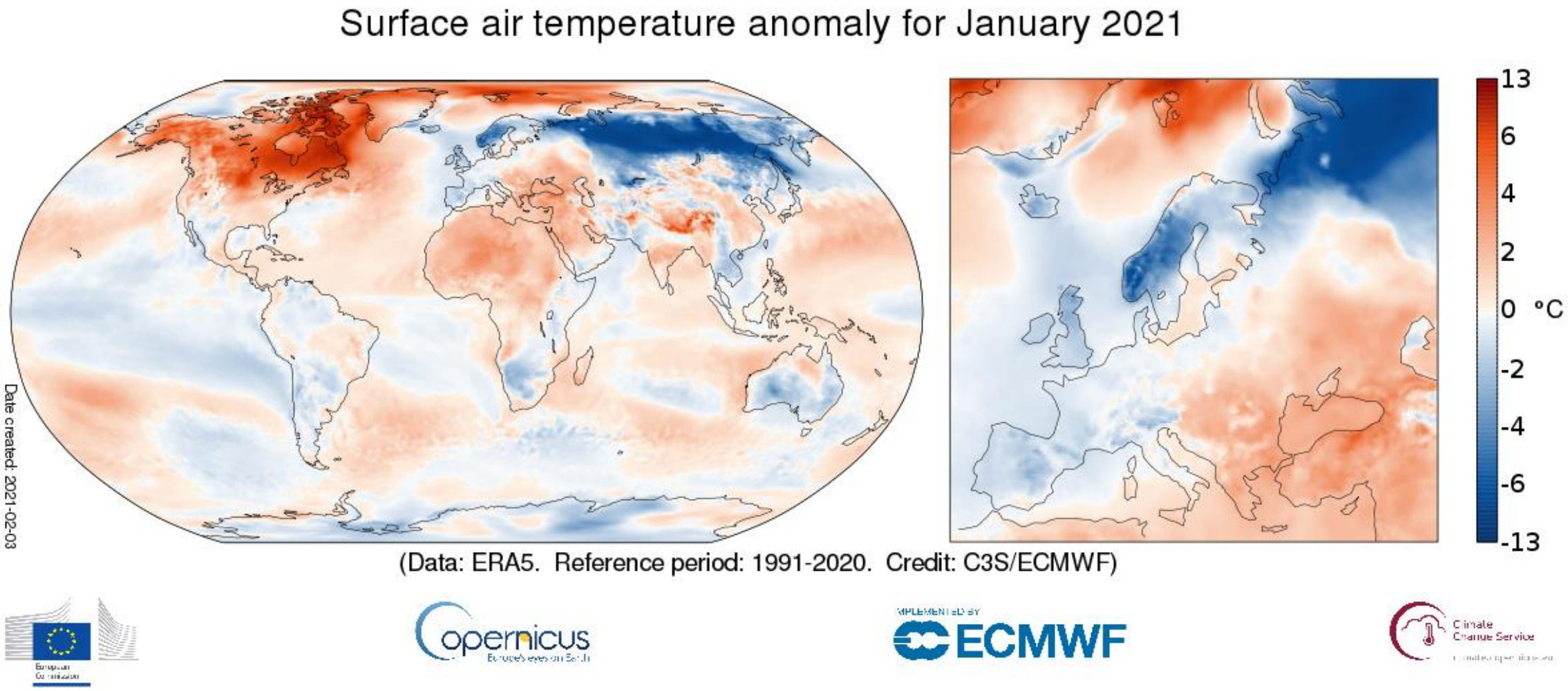


The surface air temperature anomaly for January 2021 compared to the 1991-2020 reference period.
Source: Copernicus Climate Change Service, ECMWF.

Climate anomalies in a nutshell

Climate anomalies offer a clearer, more consistent, and more meaningful way to analyze and compare climate data across time and space.

The baseline period

WMO. 30-year *“normal”* period [1991-2020]

Other common baseline periods. 1850-1900 [preindustrial]; 1961-1990 [historical*]; 1981-2010 [present].

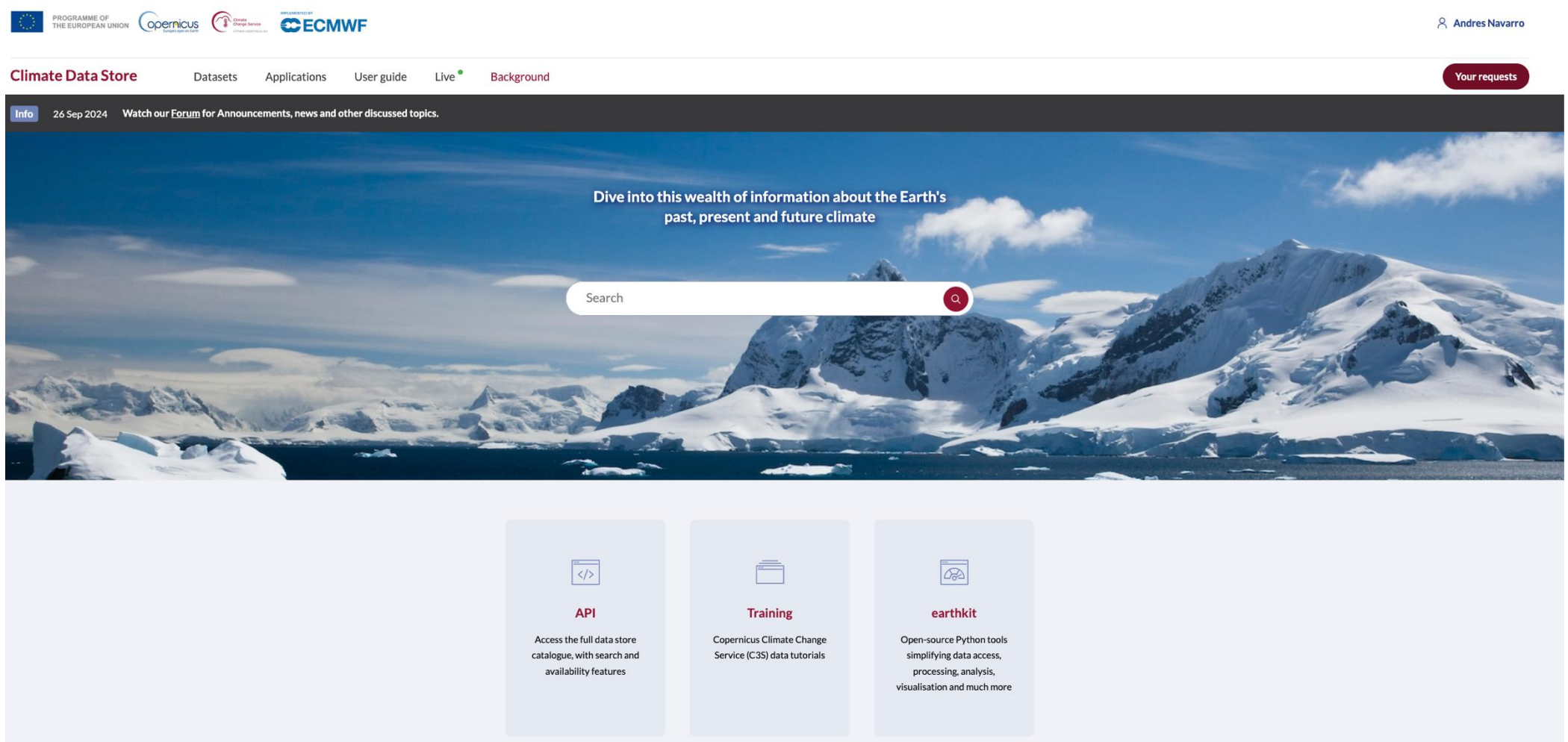
*Pre-satellite era.

Anomalies beyond climate science

- Finance
  - Anomalous trade prices
  - Credit card fraud
- Remote sensing and geosciences
  - Thermal anomalies [forest fire detection]
  - Gravitational anomalies [subsurface water detection]

Assignment.

Climate anomalies for different cities



https://cds.climate.copernicus.eu/

Computing anomalies

1. Get data from *copernicus* [T2m reanalysis 1940-2025]
2. Select the baseline period [e.g. 1981-2010]
3. Compute monthly climatology
4. Compute the anomalies [for the whole period]