

Thermal Trace: health-related weather and climate monitoring

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What is thermal stress?

And how do we monitor it?

What is thermal stress?

- There is close link between **human well-being** and the environment
- Thermal stress refers to the **negative impacts** on the body from **extreme thermal conditions**
 - e.g. heatwaves and cold spells are associated with **increased mortality and morbidity**, especially in vulnerable population groups
- Heat stress is the **leading cause of weather-related deaths** and exacerbates underlying illnesses
- Heat stress and health impacts are **rarely a result of temperature alone**

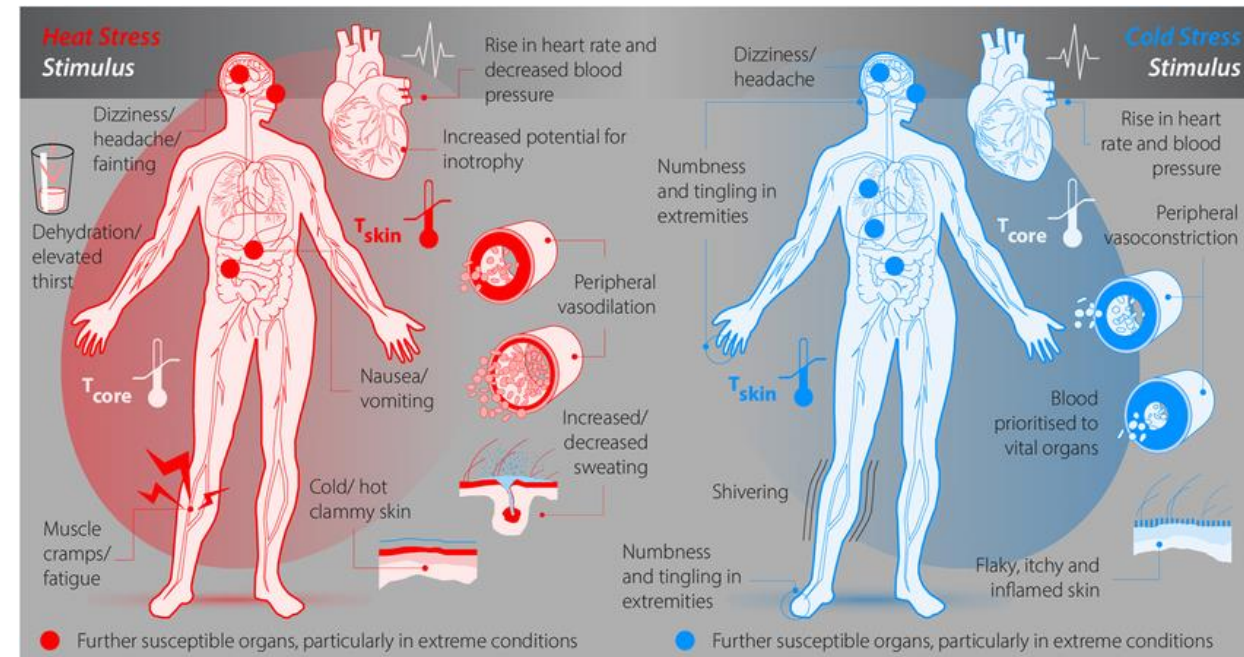


Image from Santos Nouri et al., 2023, *Theoretical and Applied Climatology*

How can we monitor thermal stress?

- At ECMWF, operational forecasts are produced for a range of heat and cold stress indices
 - As covered in Claudia's presentation in this session!
- For our climate monitoring activities, we're primarily monitoring the **Universal Thermal Climate Index (UTCI)**:
 - Represents a **feels-like temperature** (°C)
 - Accounts for **temperature, humidity, wind speed, solar radiation** and **how the human body responds** to different thermal environments
 - **10 categories** of **heat** and **cold** stress
 - **ERA5** dataset of **UTCI** available (first published in 2020; Di Napoli et al., 2021)
 - **ERA5-HEAT** provides hourly, global, gridded UTCI from 1940 to near-real-time

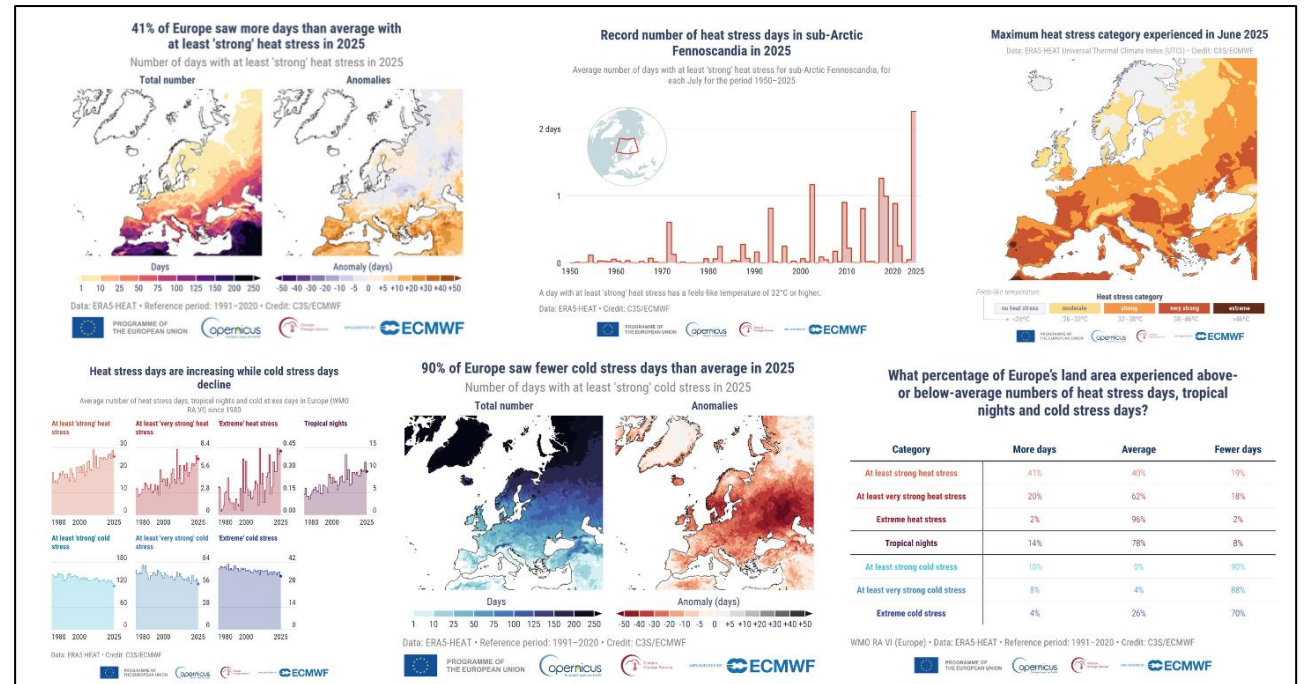


Thermal stress categories

UTCI Range (°C)	Thermal stress category	
Above 46	Extreme heat stress	
38 to 46	Very strong heat stress	
32 to 38	Strong heat stress	
26 to 32	Moderate heat stress	
9 to 26	No thermal stress	
0 to 9	Slight cold stress	
-13 to 0	Moderate cold stress	
-27 to -13	Strong cold stress	
-40 to -27	Very strong cold stress	
Below -40	Extreme cold stress	

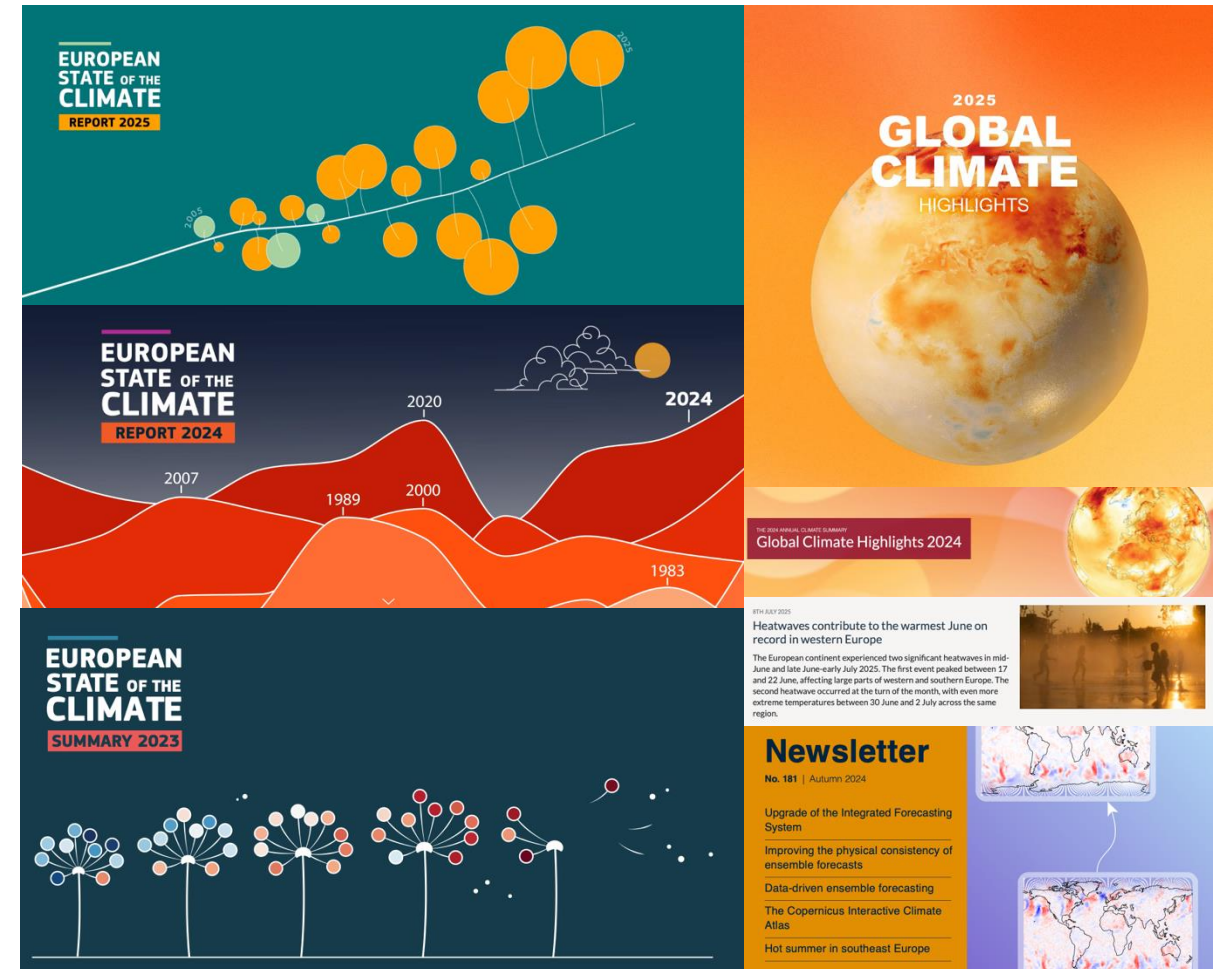
Thermal stress monitoring diagnostics

- Number of **heat / cold stress days**
- Max / min **feels-like temperature**
- Peak heat / cold stress **category**
- Feels-like temperature **anomalies**
- **Area affected**
- Event maps for **heatwaves**



How are these used?

- **European State of the Climate (ESOTC)** reports
 - Annually since ESOTC 2019
- **Global Climate Highlights** reports
 - Annually since GCH 2024
- Ad-hoc reports e.g. articles following **heatwaves**
 - (C3S news, ECMWF newsletter, C3S monthly bulletin)
- **Research**
- Development of **climate services**
- **Supports** work of other organisations

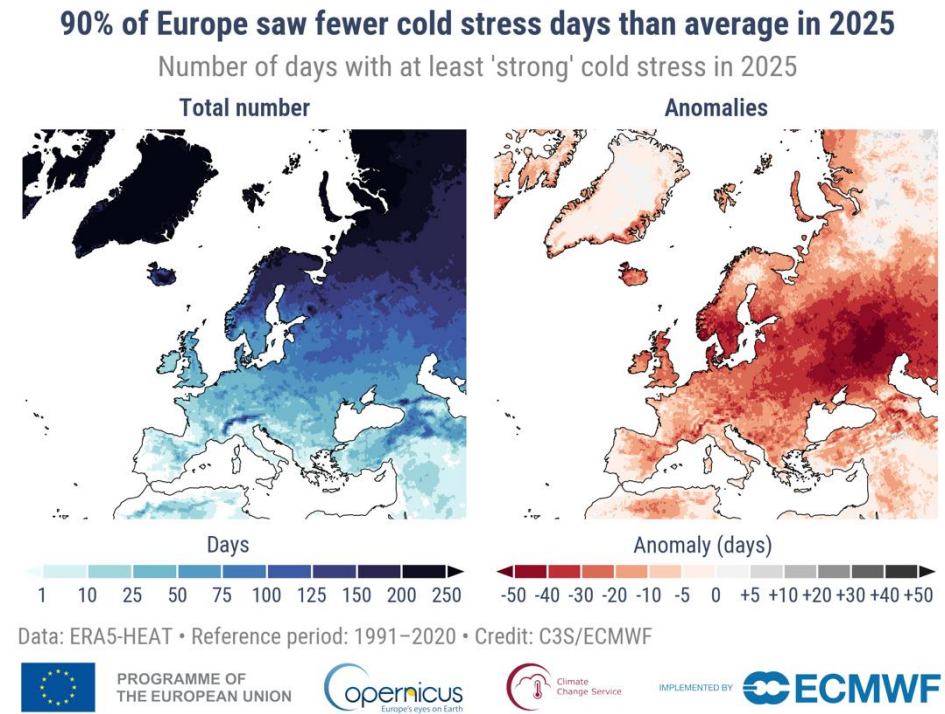


European State of the Climate

Thermal stress in Europe in 2025

 climate.copernicus.eu/ESOTC

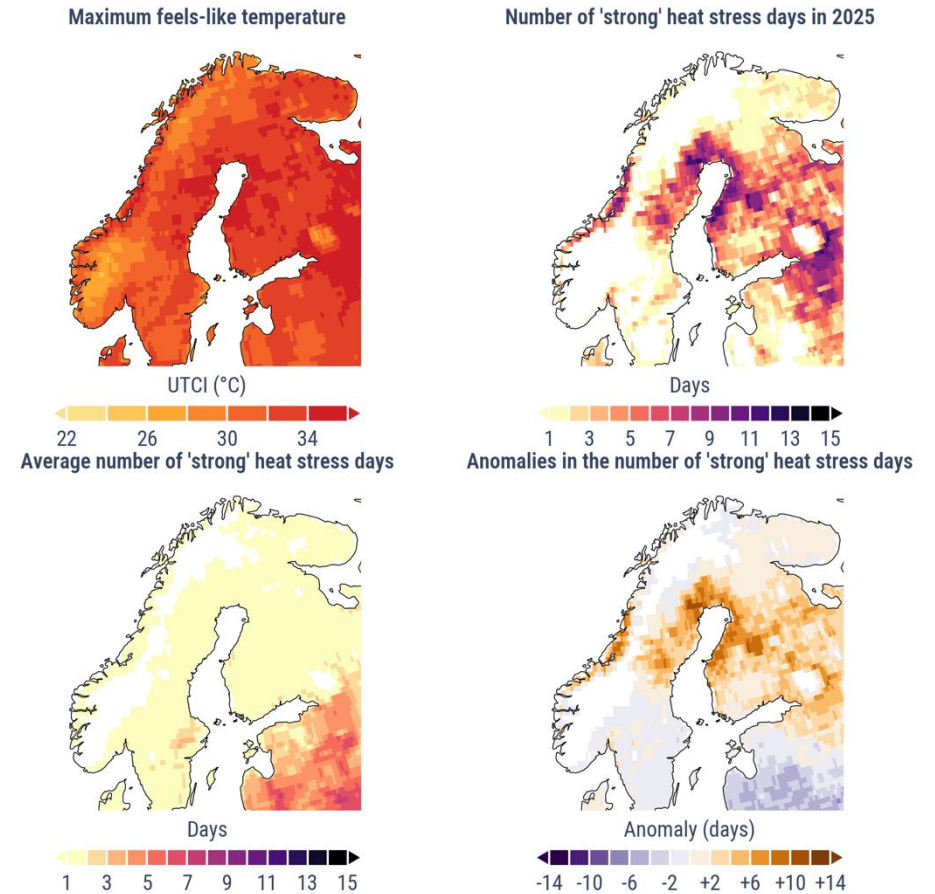
- In 2025, **41% of Europe** saw **more days than average** with at least **‘strong’ heat stress**
- **90% of Europe** saw **fewer** days than average with at least **‘strong’ cold stress**
- There was a **record low** number of cold stress days in Europe



Thermal stress in Europe in 2025

- **Sub-Arctic Fennoscandia typically experiences up to two ‘strong’ heat stress days per year**, but in July 2025 saw almost **two weeks** at this level during the region’s **longest and more severe heatwave on record**
- The region average of 12 days is a record by a large margin – almost **double the previous record** set in 2018
- **Feels-like temperatures** widely reached 33–34°C, and in some locations up to 36°C
- To see almost two consecutive weeks of strong heat stress in sub-Arctic Fennoscandia highlights the impact of climate change and the potential for hazardous heat in regions where it has historically been rare or non-existent

Record-breaking heat stress in Fennoscandia in July 2025



Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF

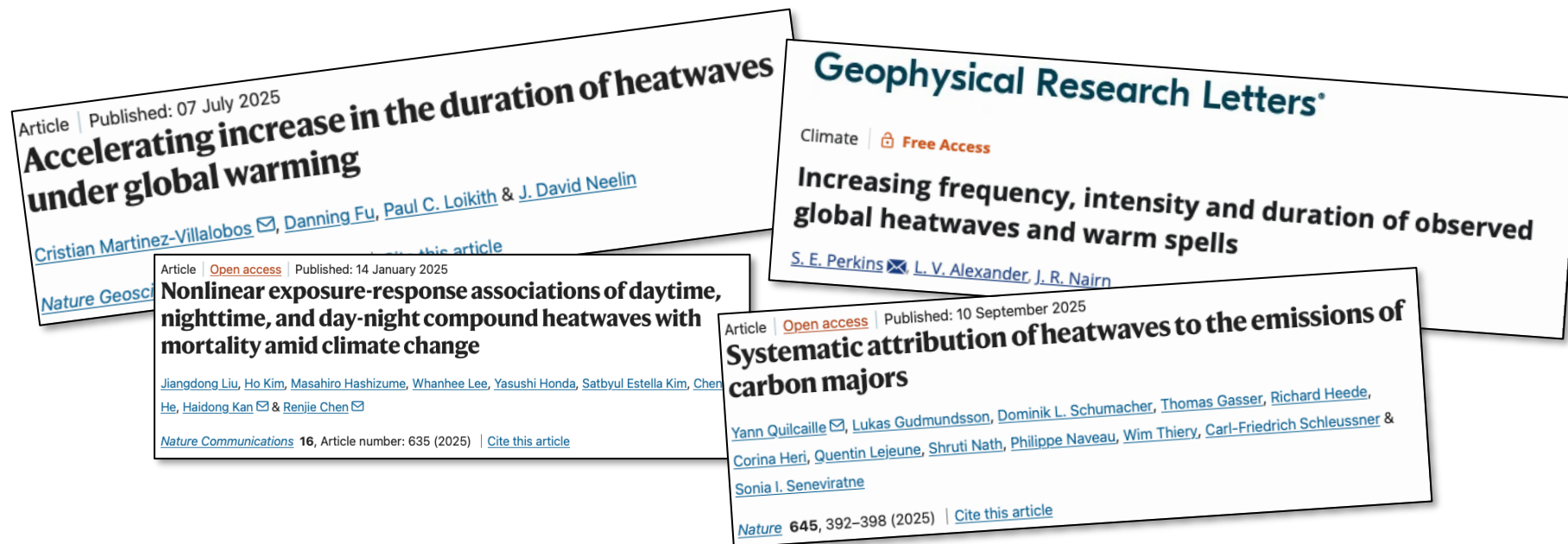
Research

Global heat stress intensification and its expanding footprint on the human population

Rebecca Emerton, Julien Nicolas, Anna Lombardi, Claudia Di Napoli, *Nature Climate Change*, in press (coming soon)

Heatwaves are becoming more frequent, longer and more severe

- Climate change is further increasing the risk of heat-related illness and death
- One quarter of heatwaves between 2000 and 2019 were virtually impossible without climate change
- Beyond heatwaves, many people worldwide are also exposed to chronic heat
- **How do these changes translate into trends of heat as experienced by the human population?**



Using ERA5 to assess heat stress trends across the globe

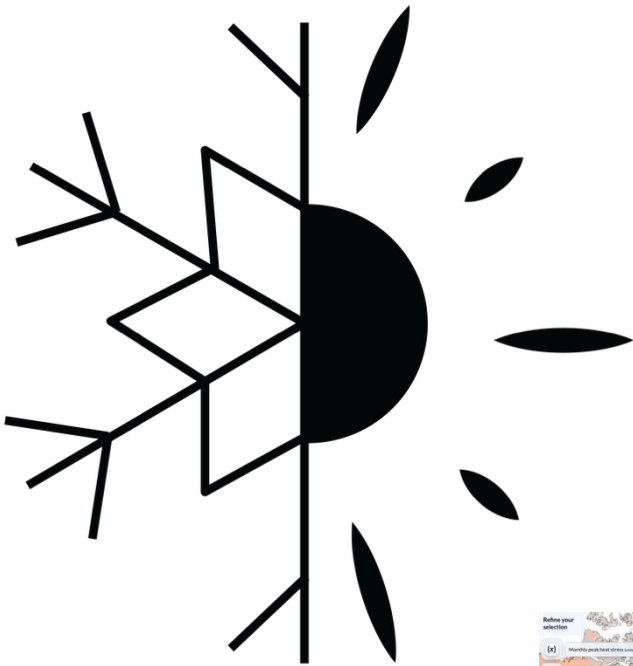
- Using the hourly UTCI data from ERA5-HEAT, we assessed heat stress globally since 1950
- Daytime extremes, nocturnal heat and compound day-night events – how have they changed over time?
 - (high nighttime temperatures amplify health risks by limiting recovery, and increasing mortality)
- How much of the global population is exposed to extreme heat, and how has this changed?



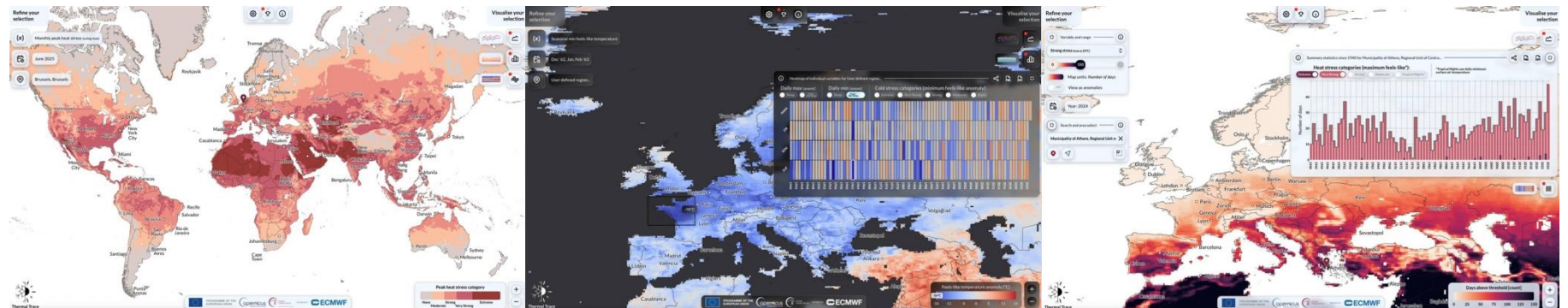
Climate services development

Introduction to Thermal Trace

Matt Menary, Rebecca Emerton, Anna Lombardi, Chiara Cagnazzo, Chris Barnard, James Varndell



- A free, interactive tool for exploring heat/cold stress worldwide
- Maps, time series, anomalies, data downloads
- Processed thermal stress statistics in the Climate Data Store
 - Search for [ERA5-HEAT](#)
- Launched in August 2025
- Developed to assist weather and climate monitoring: quick, intuitive access without needing to download data



What are you interested in?

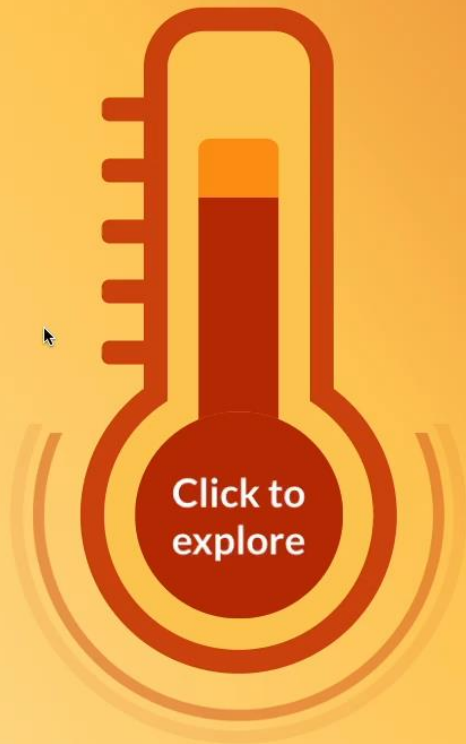
 Cold stress



Heat stress



Climate changes and extremes impact human health.
Trace cold and heat stress with this interactive map.



Thank you!

Join the ***Live Demo*** session at **14:00 today** in the **lecture theatre** for a guided exploration of our latest apps:

Weather Replay, Thermal Trace, Extremes ERA, Prismera

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www.ecmwf.int