



Observer: ESOTC 2023 - Europe experienced an extraordinary year of extremes with record-breaking heatwaves, wildfires, floods, and drought

EUROPEAN STATE OF THE CLIMATE

2023



Since the 1980s, Europe has been warming twice as fast as the global average, becoming the fastest-warming continent. This is due to several factors, including the proportion of European land in the Arctic, which is the fastest-warming region on Earth. Europe's fast warming is also caused by changes in atmospheric circulation which cause more frequent summer heatwaves. Glaciers are melting, and there are changes in the pattern of precipitation. An increase in extreme rainfall is leading to catastrophic events, such as the widespread flooding seen in Italy, Greece, Slovenia, Norway and Sweden in 2023. Meanwhile, southern Europe has suffered from widespread droughts and wildfires. Overall, the frequency and severity of extreme events is increasing. Estimates indicate economic losses from weather- and climate-related events in Europe reached €13.4 billion in 2023. Millions of people were affected, and at least 151 lives were lost in due to flooding, storms, and wildfires.

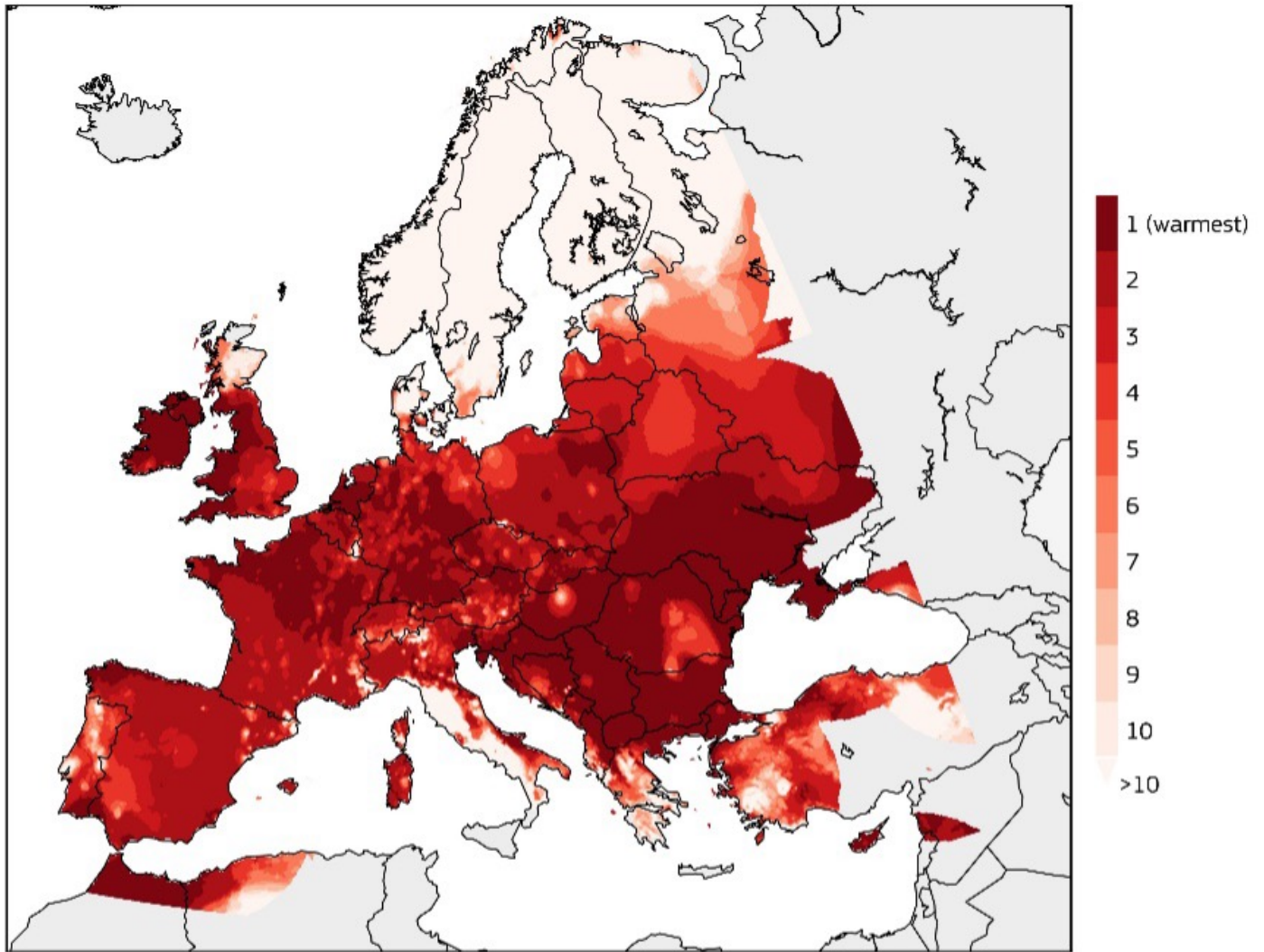
The seventh edition of the European State of the Climate (ESOTC) covers conditions during 2023 and, for the first time, was produced jointly by the [Copernicus Climate Change Service \(C3S\)](#) and the [World Meteorological Organization \(WMO\)](#). The report presents a detailed analysis of climate conditions, key events, and their impacts across the continent. It is a crucial resource for understanding the current climate situation. ESOTC 2023 also provides valuable insights into climate policy and action, particularly in the context of human health, and updates of the C3S Climate Indicators that describe the long-term evolution of several key variables that are used to assess the global and regional trends of our changing climate.

Commenting on the report's significance, Carlo Buontempo, Director of C3S, said: *'Climate data, information, and insight have never been as important as they are now. And the information contained in this report will certainly be extremely valuable in taking stock of our current vulnerability and informing our future action.'*

Rising temperatures and adverse health impacts

Ranking of annual average surface air temperatures in 2023

Data: E-OBS • Credit: KNMI/C3S/ECMWF



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The report shows that 2023 was the joint warmest or second warmest year on record in Europe. Temperatures were around 1.0°C above average, and around 2.5°C above the pre-industrial levels.

For most of Europe, 2023 ranked among the top ten warmest years, with southeastern Europe and parts of western and central Europe experiencing their warmest year on record. Also, temperatures remained above average for 11 months, with September being the warmest September on record.

The year also saw a record number of days with 'extreme heat stress', equivalent to a 'feels-like' temperature exceeding 46°C. On 23 July, 41% of southern Europe experienced 'strong', 'very strong' or 'extreme' heat stress at the peak of a heatwave.

In Europe, heat-related mortality has risen by approximately 30% in the past two decades, with an increase recorded in 94% of European regions monitored.

'We see the adverse health impacts related to extreme events and the need to strengthen climate

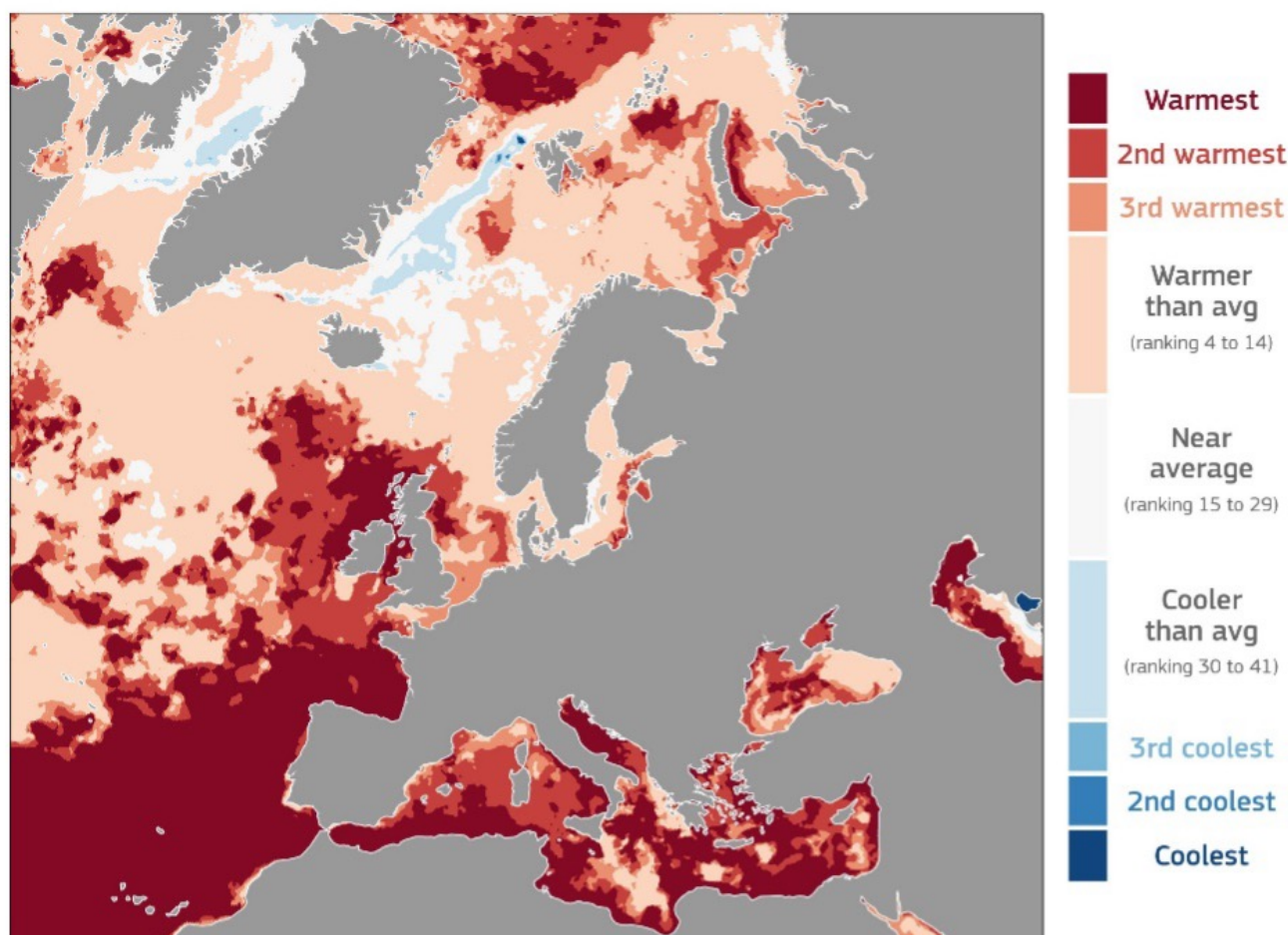
resilience in the health sector,' said Elisabeth Hamdouch, Deputy Head of Unit at the Directorate General for Defence Industry and Space (DEFIS) at an ESOTC media briefing.

Record-breaking sea surface temperature

Ranking of sea surface temperatures in 2023

Data: ESA SST CCI Analysis v3.0 • Data period: 1980–2023 (44 years)

Credit: ESACCI/EOCIS/UKMCAS/C3S/ECMWF



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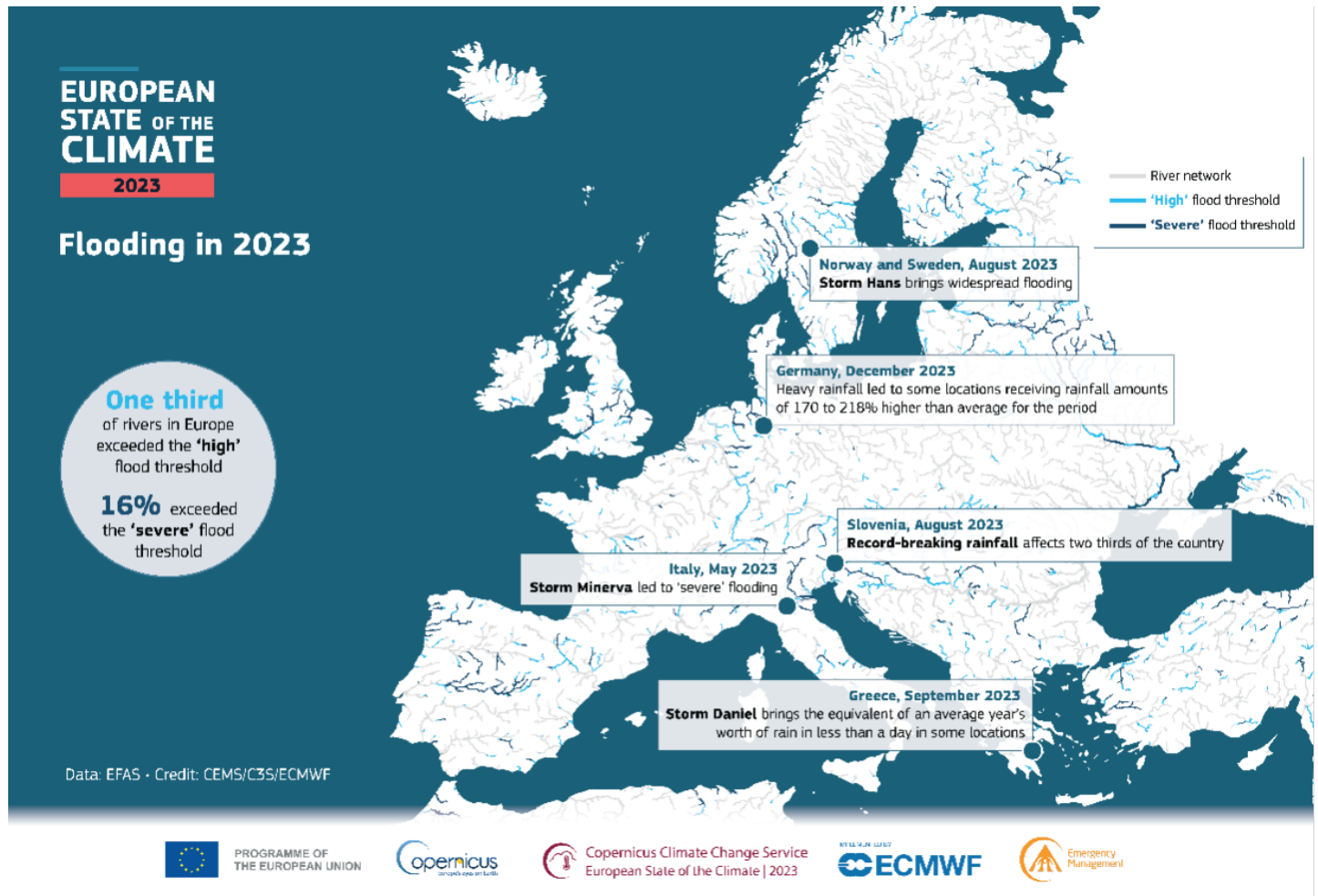
The report shows that the average sea surface temperature (SST) for European seas was the warmest on record for the year as a whole.

In June, the Atlantic Ocean west of Ireland and surrounding the United Kingdom experienced a record-breaking marine heatwave, categorised as 'extreme' and, in certain regions, even 'beyond extreme', with SSTs soaring as high as 5°C above average.

In July and August there were marine heatwaves in the Mediterranean Sea, during which SSTs reached up to 5.5°C above average in some areas, indicating 'extreme' conditions. August also

witnessed the onset of another marine heatwave in the Atlantic Ocean, west of the Iberian Peninsula.

Record river flows and widespread flooding



In 2023, Europe faced many flood events across the continent, affecting an estimated 1.6 million people.

In May, for example, Italy experienced widespread flooding, during which 23 rivers burst their banks. This led to 36,000 people being evacuated and tragically resulted in 15 deaths. In August, two-thirds of Slovenia was flooded, leading to the evacuation of 8,000 individuals and the loss of six lives. Norway and Sweden also suffered flooding in August, aggravated by the partial collapse of a hydroelectric power plant in Norway.

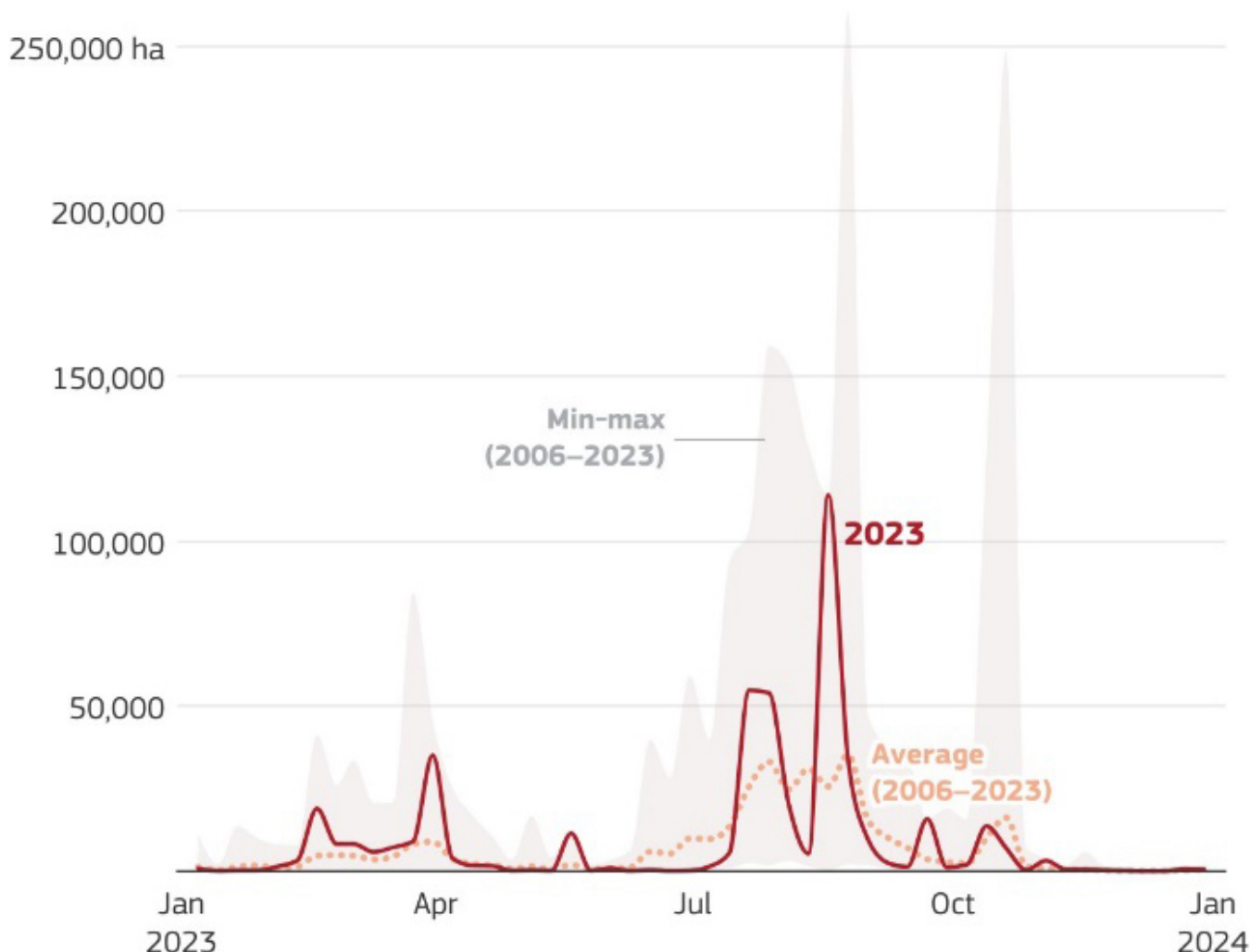
September brought record-breaking rainfall and flooding to Greece, Bulgaria, and Turkey. This led to 17 casualties in Greece, eight in Turkey, and four in Bulgaria. Around 700 square kilometres of Greek territory were flooded, with some areas receiving an average year's worth of rainfall in just one day.

The report provides a detailed analysis of several of the largest flood events in Europe in 2023, and a [new interactive webpage](#) provides information on many more extreme events across the continent and their impacts.

The largest wildfire ever recorded in the EU

Burnt areas in European Union countries in 2023

Weekly data, in hectares



Data: European Forest Fire Information System (EFFIS) • Credit: EFFIS/CEMS



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The data in ESOTC 2023 also shows that the fire season started earlier than average, with significant fires in Mediterranean mountain ranges, like the Pyrenees, in February. Subsequent dry conditions led to large fires, particularly in the Iberian Peninsula, exacerbated by below-average precipitation and lower-than-average soil moisture in March and April. 'Extreme' fire danger was observed in northern Europe in early summer, followed by similar conditions in the south during July and August, culminating in the EU's largest recorded fire, scorching 96,000 hectares in Alexandroupolis, Greece.

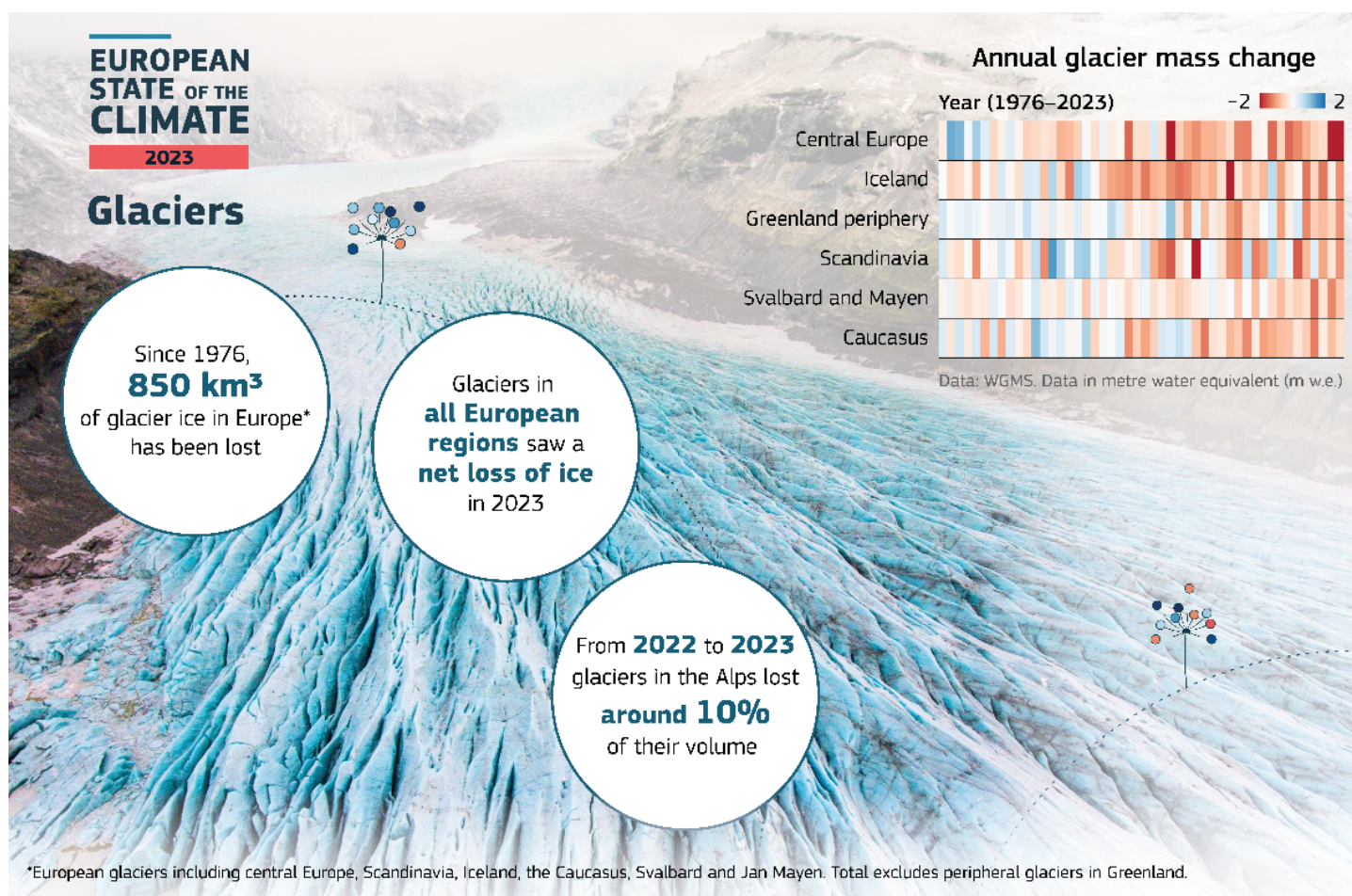
The 2023 wildfire season in the EU saw the fourth-largest burnt area on record, totalling around 500,000 hectares.

Europe's record renewable energy use

In 2023, a record proportion of actual electricity generation in Europe was from renewable sources, at 43%, compared to 36% in 2022. Climate-driven electricity demand was above average in southern Europe due to cooling required during exceptional summer temperatures, and in Scandinavia, where cooler-than-average temperatures in several months led to increased demand for heating.

For the year as a whole, the potential for solar photovoltaic power generation was below average in northwestern and central Europe and above average in southwestern and southern Europe and Fennoscandia (geographical peninsula in Europe which includes the Scandinavian and Kola peninsulas, mainland Finland, and Karelia). The potential for run-of-river hydropower generation was above average across much of Europe, linked to above-average precipitation and river flow. Increased storm activity from October to December resulted in above-average potential for wind power production.

Changing snowfall patterns and glacier loss



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In 2023, much of Europe experienced fewer days with snow than average. Many locations in Fennoscandia, however, saw a near-average or higher-than-average number of snow days.

With some exceptions, Europe generally saw a well-below-average number of days with snow during winter, and a near-average or below-average number during spring. In the Alps in winter, just three regions saw more days with snow than average, while most saw far fewer than average.

Since the 1800s, glaciers worldwide have been shrinking, and those in the Alps are no exception. In 2023, they lost even more ice due to a lack of snow in winter and warmer-than-average summer temperatures. The report reveals that glaciers in the Alps lost about 10% of their volume in the two years from 2022 to 2023.

Arctic heatwaves and wildfires

Since the 1990s, the Arctic has been warming at a rate well above the global average. For Arctic land, the report shows that 2023 was the fifth warmest year on record. The five warmest years on record for Arctic land have all occurred since 2016. Svalbard is one of the fastest-warming places on Earth. In 2023, the average summer temperature there was the highest on record, linked in part to below-average sea ice cover and above-average SSTs. In Greenland, below-average temperatures in May and June led to the delayed onset of the ice sheet melt season. In July and August, however, heatwaves led to substantial summer melt and greater-than-average annual ice loss despite the late start to the melt season.

In 2023, the Arctic and sub-Arctic regions saw high levels of wildfire activity, and the second-highest carbon emissions from wildfires on record. The majority of high-latitude wildfires occurred in Canada between May and September, contributing to the highest total annual emissions for the western Arctic on record. In July, the prevailing weather conditions transported smoke from Canadian wildfires to Greenland, possibly contributing to a significant melt event as ash deposits cause increased susceptibility to solar radiation.

The sea ice extent in the Arctic was lower than average for most of the year. In March, it was the fifth lowest on record, and in September, it was the sixth lowest.

The global picture

From June to December, each month was warmer than the same month in any previous year. It was the first year in which every day saw temperatures that were at least 1°C higher than the pre-industrial level. Almost half of the days were 1.5°C higher, and two days reached 2°C above the pre-industrial level.

The amount of heat stored in the oceans also hit a record high. The transition from La Niña to El Niño, and conditions in the Indian Ocean, contributed to an increase in global upper ocean heat content from 2022 to 2023.-

Global sea levels continued to rise, reaching new record highs in the first six months of the year. And they're rising faster than before, with potentially significant impacts for coastal areas.

Greenhouse gases such as carbon dioxide and methane, which trap heat in the atmosphere, continued to increase. They reached levels not seen in hundreds of thousands of years. Methane levels increased much more than the 2010s average increase, while the increase in carbon dioxide levels was comparable to the records from previous years.

Glaciers worldwide lost a considerable amount of ice in 2023—around 600 gigatonnes of water, which is equivalent to about five times the amount of ice contained in all of central Europe's glaciers. This loss raised sea levels by 1.7 mm, the largest annual increase due to glacier melt on record.

Antarctic sea ice reached record-low extents for the time of year during eight months of 2023, and reached a record minimum in February, with a monthly value 33% below average. Arctic sea ice extent remained below average through most of the year.

Commenting on the report's findings, Celeste Saulo, Secretary-General of the World Meteorological Organization (WMO), said: *'The climate crisis is the biggest challenge of our generation. The cost of climate action may seem high, but the cost of inaction is much higher. As this report shows, we need to leverage science to provide solutions for the good of society.'*

Climate policy and action

Andrew Ferrone, Head of the meteorological department at the Administration of Technical Agricultural Services (ASTA) in Luxembourg, said: *"The World Health Organization's (WHO) European regional office declared the climate crisis a public health emergency in July 2023, recognising the escalating adverse health impacts of extreme weather events."*

Since 1970, extreme heat has been the leading cause of weather- and climate-related fatalities in Europe. 23 of the 30 most severe heatwaves have occurred since 2000, and five in the last three years. Between 55,000 and 72,000 deaths due to heatwaves were estimated in the summers of 2003, 2010 and 2022. An estimate for 2023 is not yet available.

Heat-related mortality has increased by around 30% in the past 20 years in Europe. In their commitments under the Paris Agreement, European countries have prominently emphasised mitigation efforts, but fewer than a quarter have integrated health into their adaptation strategies.

The report highlights that climate services are vital for safeguarding lives, and that tailored climate services for the health sector are effective in increasing resilience. In Europe, 78% of countries provide data services for the health sector, but only 28% provide climate services, and there is room for improvement in customising them to the sector's needs.

Global climate indicators show alarming trends

Climate indicators track essential variables to assess global and regional climate changes. The report shows that greenhouse gas concentrations continue to increase. Carbon dioxide and methane again

reached record levels in 2023. Surface air and sea temperatures have notably increased since pre-industrial times.

The ocean absorbs up to 90% of the excess heat associated with greenhouse gas emissions. Ocean heat content is increasing, primarily in the upper layers.

Glaciers, sea ice, and ice sheets are experiencing significant melt and contributing to rising sea levels. The Greenland and Antarctic Ice Sheets, if entirely melted, could raise global mean sea level by around 65 metres.

For regular updates, follow the C3S [monthly climate bulletins](#).