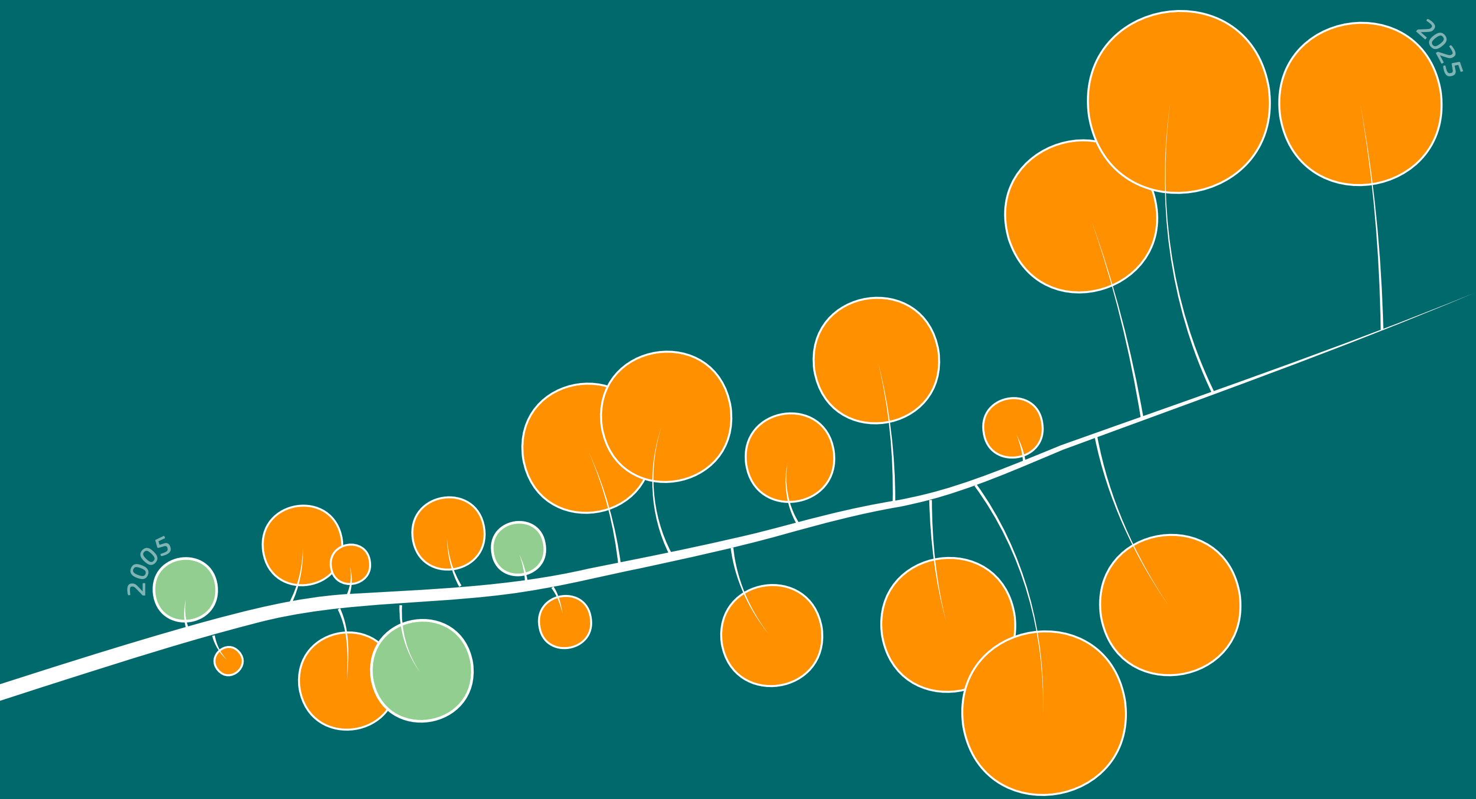
EUROPEAN STATE OF THE CLIMATE

REPORT 2025



PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

Climate Change Service climate.copernicus.eu

IMPLEMENTED BY ECMWF

WORLD METEOROLOGICAL ORGANIZATION

The data behind the art

The cover art of the European State of the Climate 2025 provides an entry point to a vast and multifaceted report. Vivid colours and simple shapes hint at scientific data without overwhelming viewers, inviting closer engagement with the report and the science behind it.

Using ERA5 data, the visualisation depicts the annual temperature anomaly for Europe over the past 20 years. The data were first displayed as a scatterplot, where each dot corresponds to a year and its size is proportional to the magnitude of the anomaly. The chart was then gradually deconstructed: dots morph into leaves, while a trend line becomes a thinning branch symbolising the fragile equilibrium we live in and the biodiversity loss we witness. Yellow and green indicate years with positive and negative temperature anomalies, respectively. While communicating the warming trend across Europe, this symbolic organic form also hints at the biodiversity themes explored in the report.

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Welcome to the European State of the Climate (ESOTC) 2025

This annual flagship report is published by the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF) and the World Meteorological Organization (WMO). ECMWF is a research institute and 24/7 operational service producing global weather predictions, and implements C3S, which provides climate monitoring and forecasting for the globe, Europe and the Arctic, on behalf of the European Commission. The WMO is the UN authoritative organisation that collates, monitors and predicts weather, climate and water resources, and provides related services at national, regional and global scales through its 193 Members, the national meteorological and hydrological services.

The ESOTC provides descriptions and analyses of climate conditions in Europe in the previous year, covering variables from across the Earth system, key events and their impacts, and a discussion of climate policy and action with a focus on biodiversity. It also provides updates to the long-term evolution of key Climate Indicators. The report is the result of a collaborative effort involving around 100 scientists, and colleagues across Europe and the rest of the world. Together they analysed around 45 datasets, reported on about 45 different climate variables or indices, and reviewed, designed and published the ESOTC 2025.

Since the 1980s, Europe has been warming twice as fast as the global average.

Globally, 2025 was the third-warmest year on record.[1] Each of the past 11 years has been among the 11 warmest on record, and the past three years were the three warmest. The current level of global warming is estimated to be around 1.4°C above the pre-industrial level. If warming continues at the current rate, the Paris Agreement's limit of 1.5°C for long-term global warming could be reached by the end of this decade, more than a decade sooner than predicted when the Agreement was signed.

Atmospheric concentrations of the greenhouse gases carbon dioxide and methane continued to increase.

Since the 1980s, Europe has been warming twice as fast as the global average, making it the fastest-warming continent on Earth.

1 Based on ERA5 and six other datasets. A further two datasets indicate 2025 was the second-warmest year.

Heatwaves are becoming more frequent and severe. Glaciers in all European regions continue to melt. Changes in precipitation patterns, including an increase in the intensity of the most extreme events, have been observed.

In 2025, annual temperatures were above average across almost the entire continent (at least 95%). Prolonged heatwaves were experienced from the Mediterranean to the Arctic Circle. Other aspects of the climate showed strong contrasts, for example, northwestern and central Europe were much sunnier than average for the year as a whole, while the Iberian Peninsula was cloudier and wetter than average. Sea surface temperatures for the European ocean region were the highest on record, with marine heatwaves across Europe's seas, while snow cover was the third lowest on record. Explore the report to find out more.

As well as this PDF version, the report is available online with interactive charts, a key events map, a summary, and a graphics gallery that includes a range of additional figures and data download options: climate.copernicus.eu/ESOTC/2025

To cite this report:

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To explore all visuals (including supplementary figures) and download the associated datasets, please visit the ESOTC 2025 Graphics Gallery online.

To explore details on the datasets and methods, visit the 'About the data' section online.

Perspectives on the European State of the Climate

The European State of the Climate report shows, once again, that climate change is a reality for Europe, underlining the importance of an independent, world-class Earth observation system. Copernicus provides the information we need to guide the decisions that will shape a more resilient, more sustainable and stronger future for Europe.

ANDRIUS KUBILIUS
Commissioner for Defence and Space,
European Commission

Europe is warming twice as fast as the global average, with far-reaching repercussions on socioeconomic wellbeing and on ecosystems and biodiversity. The European State of the Climate report, produced jointly by WMO and Copernicus, provides reliable scientific insights to help European policymakers meet the growing challenges to both people and planet.

CELESTE SAULO
Secretary-General,
WMO

At ECMWF, we are proud to deliver the Copernicus Climate Change Service on behalf of the European Commission and, in partnership with WMO, publish the European State of the Climate. The 2025 report shows a continent warming rapidly and experiencing more frequent extremes. The evidence we provide helps decision-makers take action to protect lives, infrastructure and biodiversity.

FLORIAN PAPPENBERGER
Director-General,
ECMWF

Key messages

Europe in 2025

- **Almost the entire continent*** saw **above-average annual temperatures** and several northern European countries recorded their warmest or second-warmest year.
- The continent saw its **second most severe heatwave** on record, while sub-Arctic Fennoscandia experienced its **longest heatwave** on record.
- **Wildfire** burnt area and fire emissions both reached **record levels**.

* 95–99.99% depending on the dataset and domain considered.

- The annual **sea surface temperature** for the region was the **highest** on record.
- A **record 86%** of the region** experienced at least **'strong' marine heatwave** conditions.

** Excluding ice-covered areas.

- **Glaciers** in all regions saw a **net mass loss**.
- The **Greenland Ice Sheet** lost around **139 gigatonnes** of ice.
- End-of-season **snow cover** extent and mass were both the **third lowest** on record.

- The year saw strong **regional contrasts** in **hydrological conditions**.
- It was **one of the three driest years** for soil moisture since 1992.
- Annual **river flow** was **below average** in **70%** of rivers.
- **Storms and flooding** affected some areas, but overall **extreme precipitation and flooding** were **less widespread** than in recent years.

- **Renewables** supplied **nearly half** (46.4%) of the continent's electricity, with **solar power** reaching a **new contribution record** of 12.5%.

Climate policy and action: biodiversity

- **Biodiversity is vital** for a sustainable future. **Climate change** is a major cause of its **degradation**.
- Climate change and biodiversity are **strongly connected** within **European policy** and frameworks.
- The **European Biodiversity Strategy 2030** aims to protect and restore biodiversity. By the end of 2025, around **half** of the Strategy's **recommended actions** were in place or completed, with many of the remainder underway.

Contents

The **standard reference period** for climatological averages used is 1991–2020, unless stated otherwise.

Winter refers to December 2024 to February 2025.

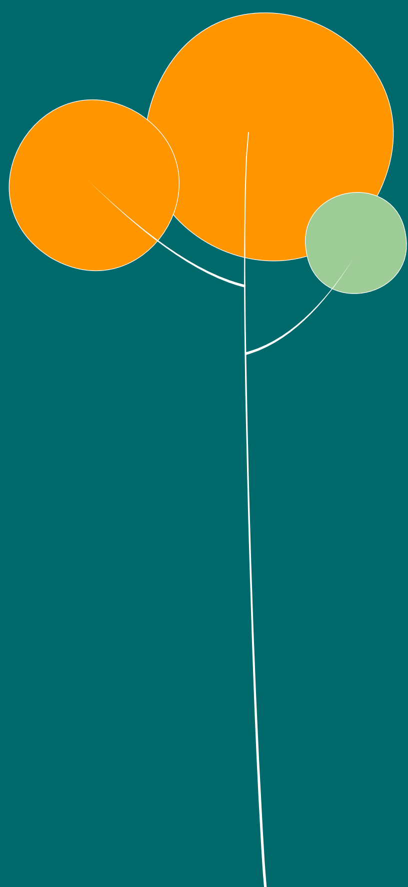
C3S supports the adaptation and mitigation policies of the European Union, while the **WMO Regional Office for Europe** serves its 50 Member States, covering Europe, Greenland, the South Caucasus and part of the Middle East. They therefore cover overlapping domains. As the size and climatic zones of the two domains differ, variations in statistics are expected. Some statistics are reported for both domains.

Maps showing the domains are on page 167.

This report contains information from the **Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6)**. Published in stages between 2021 and 2023 and compiled by scientists around the globe, AR6 looks at past, present and future climate change and its impacts based on data from more than 66,000 sources published before January 2021.

1.

Why is Europe warming so quickly?

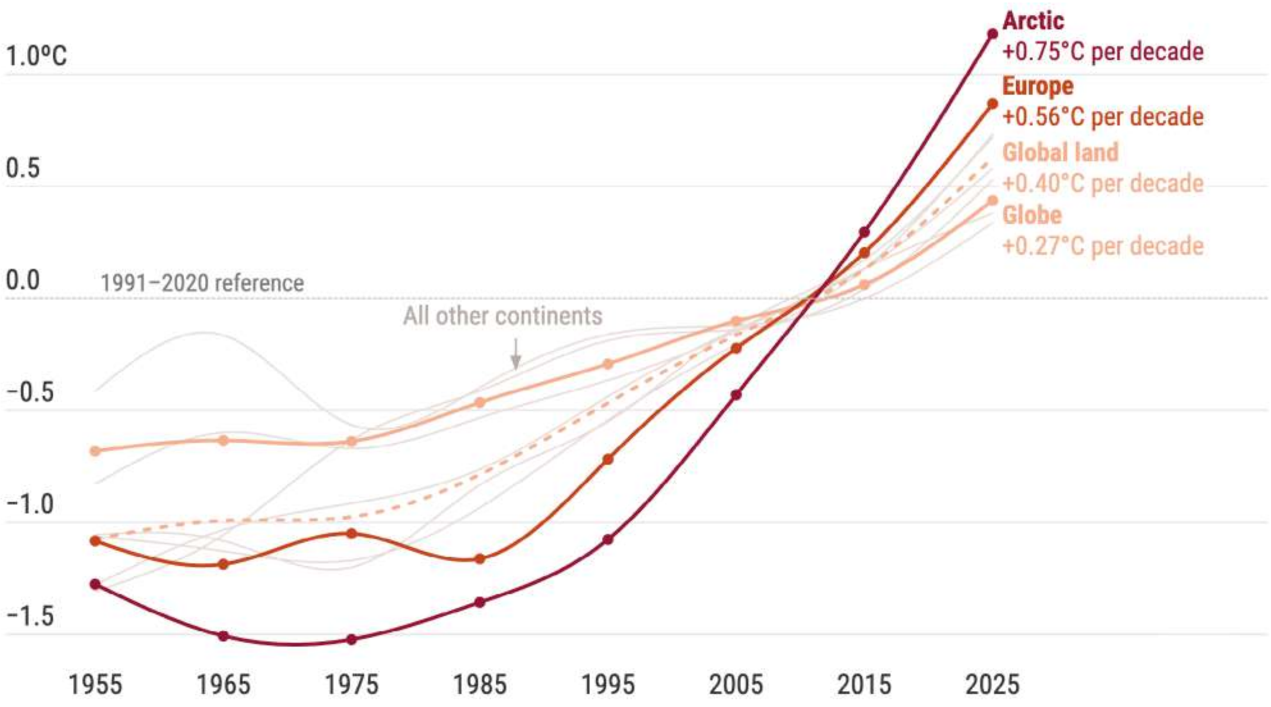


The global average temperature continues to increase, but not all regions are warming at the same rate. Almost all land areas are experiencing temperature increases, though the rate varies. The fastest warming is observed in northern high latitudes, particularly the Arctic, as well as in central and eastern Europe and the Middle East. Land areas are warming faster than the ocean.

Changing weather patterns, increasing solar radiation, reduced air pollution, decreasing snow cover and geography are all factors contributing to this trend.

Europe is the fastest-warming continent

Temperature anomalies for the globe, global land, each of the seven continental regions and the Arctic, alongside the rate of increase



Temperature increases per decade for other continents are: **Asia** 0.46°C, **North America** 0.42°C, **Africa** 0.36°C, **Antarctica** 0.34°C, **Central and South America** 0.27°C, **Australasia** 0.23°C. Values are for land only except for the global average. Rates of increase per decade are estimates for the last 30 years (1996–2025).

Figure 1.1. Anomalies in average temperature over the globe, each continent based on the IPCC regions, and the Arctic, shown as ten-year averages relative to the average for the 1991–2020 reference period. Values are for land only, except for the global average. Linear trends are indicated for the last thirty years (1996–2025). Data: ERA5. Credit: C3S/ECMWF

Over the past thirty years, the global average temperature has increased by around 0.27°C per decade.[2] Europe is the fastest-warming continent, with temperatures rising by approximately 0.56°C per decade since the mid-1990s, more than double the global average. Other continents have been warming at rates between 0.23°C per decade (Australasia) and 0.46°C per decade (Asia). The fastest-warming region on Earth, however, is the Arctic, where temperatures are increasing by around 0.75°C per decade.

Compared to pre-industrial levels (1850–1900), the global average temperature has increased by around 1.4°C, according to the Climate Indicator for temperature, which is based on the latest five-year averages. The exceptional temperatures of 2023–2025 meant that, based on ERA5,[3] this was the first three-year period on record in which the global average temperature exceeded 1.5°C above the pre-industrial level.

Europe has warmed by around 2.5°C compared to pre-industrial levels.

The Paris Agreement, adopted in 2015 by 196 parties, aims to hold the long-term increase in global average temperature to well below 2°C above pre-industrial levels and preferably below 1.5°C. Ten years after the signing of the Agreement, the Global Climate Highlights 2025 report indicates that the last 11 years were the 11 warmest on record. If warming continues at the same rate as over the last 30 years, the globe could reach 1.5°C of long-term warming by the end of this decade. In Europe, warming since pre-industrial levels is around 2.5°C and in the Arctic it is 3.2°C, based on the latest five-year averages.

Why does the rate of warming vary?

While the long-term rise in global average temperature is mainly caused by increasing greenhouse gas emissions, the uneven rate of warming around the globe is influenced by a combination of factors. Land warms faster than the ocean. This is because water can absorb more heat and can cool through evaporation, while land has limited moisture for this process. Air over the ocean typically contains more moisture, which affects how temperature changes with height and helps limit surface warming, whereas drier land warms more quickly. Changes in wind patterns

2 The linear trends are calculated using ordinary least-square regression. This does not imply that the temperature changes are themselves linear.

3 Other datasets may vary. See the WMO Global State of the Climate and C3S Global Climate Highlights for more information.

and atmospheric circulation can also lead to regional differences. The amount of cloud-producing aerosols, and air quality, can also have an impact. For example, in more polluted areas, higher concentrations of atmospheric aerosols reduce the amount of solar radiation that reaches the surface. This can partially offset the warming caused by increased greenhouse gases.

Europe is the fastest-warming continent, warming more than twice as fast as the global average.

Why is Europe the fastest-warming continent?

Since the 1980s, Europe has been the fastest-warming continent, at more than twice as fast as the global average. Several factors contribute to this trend:

- Changing weather patterns: Shifts in atmospheric circulation have favoured more frequent and more intense summer heatwaves [R1.1]. This report highlights that the number of heat stress days is increasing, and 2025 saw extreme heatwaves from the Mediterranean to the Arctic Circle, including Europe's second most severe heatwave on record.
- Reduced air pollution: Aerosols can reduce the amount of solar radiation reaching the surface. Since the 1980s, stricter air quality regulations have reduced emissions, and therefore aerosol concentrations, across Europe. Cloud cover is also reduced as pollution decreases.
- Decreasing snow cover: As temperatures increase, snow cover across Europe has been declining, reducing the albedo – the amount of solar radiation reflected back into space – and leading to more rapid warming. More information can be found in the 'Snow' section.
- Geography: Parts of Europe extend into the Arctic, the fastest-warming region on Earth.

How does the rate of warming vary across Europe?

The rate of warming varies by season. In Europe, spring has warmed more slowly than other seasons. Winter has warmed most rapidly across much of central and eastern Europe, while summer has warmed most rapidly across western Europe. Within Europe, the rate of temperature change also varies with some regions warming more rapidly than others. For example, eastern and southeastern Europe, and parts of central Europe including the Alps, are warming faster (0.5–1°C per decade over the last 30 years) than western and southwestern Europe and Fennoscandia (generally 0.2–0.5°C per decade). Iceland shows warming of up to 0.4°C per decade in the east and localised cooling of up to 0.2°C per decade in the west over the last 30 years. This is linked to an area of cooling over the northern North Atlantic, sometimes referred to as the North Atlantic 'warming hole' or 'cold blob'. This area of cooling has mitigated warming in Iceland since around 2011 [R1.2]. In the 30 years before this, Iceland had seen warming of around 1.5°C per decade. Svalbard, in the European Arctic, is one of the fastest-warming places on Earth, warming at a rate of 1.5–2°C per decade over the past 30 years.

The rate of warming varies across Europe, with the fastest warming in eastern and parts of central Europe, and the European Arctic.

The rate of warming varies across Europe

Linear trend in annual surface air temperature for 1996–2025

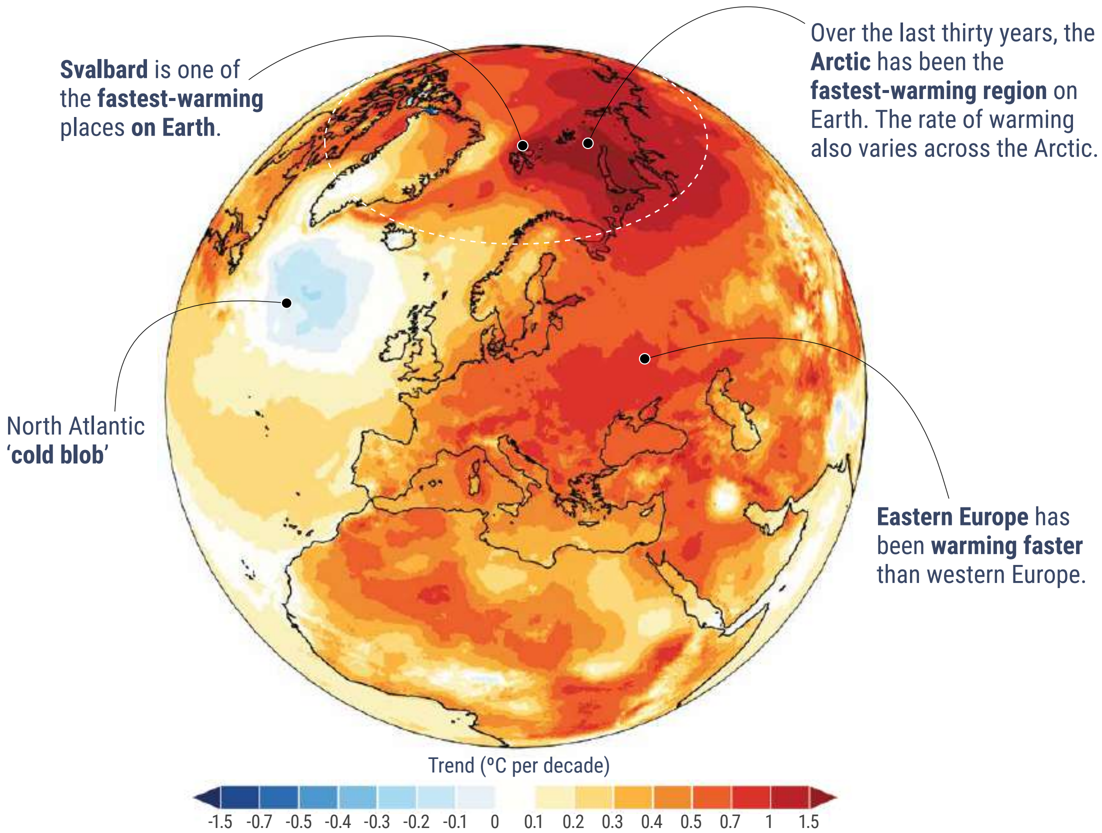


Figure 1.2. Trend in annual surface air temperature (°C/decade) for 1996–2025. Data: ERA5. Credit: C3S/ECMWF.

Data from Svalbard highlight the rapid warming in the European Arctic. Consecutive summers from 2022 to 2024 saw new record high temperatures, in 2024 reaching 2.6°C above average for Svalbard as a whole and 2.9°C above average at Svalbard Airport, a location where temperature measurements extend back to 1899. 2025 saw the fourth warmest summer on record, just slightly cooler than that of 2022.

Svalbard is one of the fastest-warming places on Earth

Summer temperature anomalies at Svalbard Airport

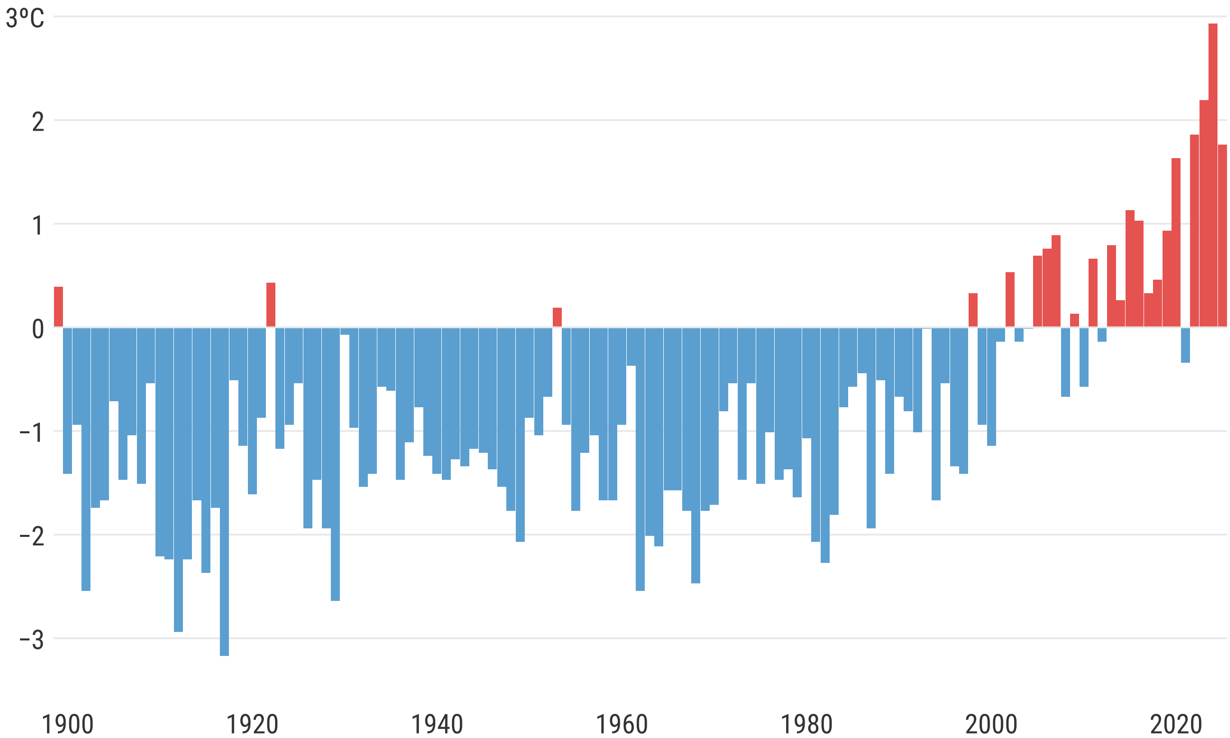


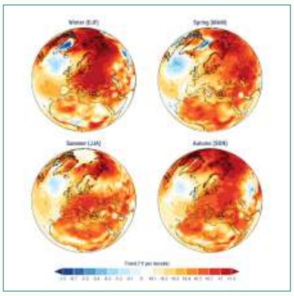
Figure 1.3. Surface air temperature anomalies for summer at Svalbard Airport from 1899–2025. All anomalies are relative to the average for the 1991–2020 reference period. Data: In situ observations at Svalbard Airport. Credit: Met Norway/C3S/ECMWF.

Why is the Arctic warming so quickly?

Since the 1990s, the Arctic has been warming at a rate far exceeding the global average, a phenomenon known as 'Arctic amplification'. This is driven by several interconnected processes and feedback loops:

- Albedo feedback: As the climate warms and snow and ice melt, they reveal darker surfaces underneath, such as the ocean or bare ground. Darker surfaces can absorb more heat in summer and release more heat back to the atmosphere in winter. This accelerates the warming and leads to further melting – a classic feedback loop.
- Convection differences: In the tropics, strong convection, where warm air rises and mixes into the atmosphere, distributes heat vertically. In the Arctic, however, there is little convection as solar heating is weaker, so the heat remains trapped near the surface.
- Lapse rate feedback: In cold regions like the Arctic, air near the ground warms much faster than air higher in the atmosphere, trapping heat near the surface and further accelerating the warming.
- Water vapour transport: Atmospheric circulation patterns move warm, moist air from the tropics towards the poles. As a warmer atmosphere can hold more moisture, the amount of water vapour transported to the poles is expected to increase with climate change, further intensifying Arctic warming.

Supplementary figures



Seasonal temperature trends across Europe

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

2.

Key events

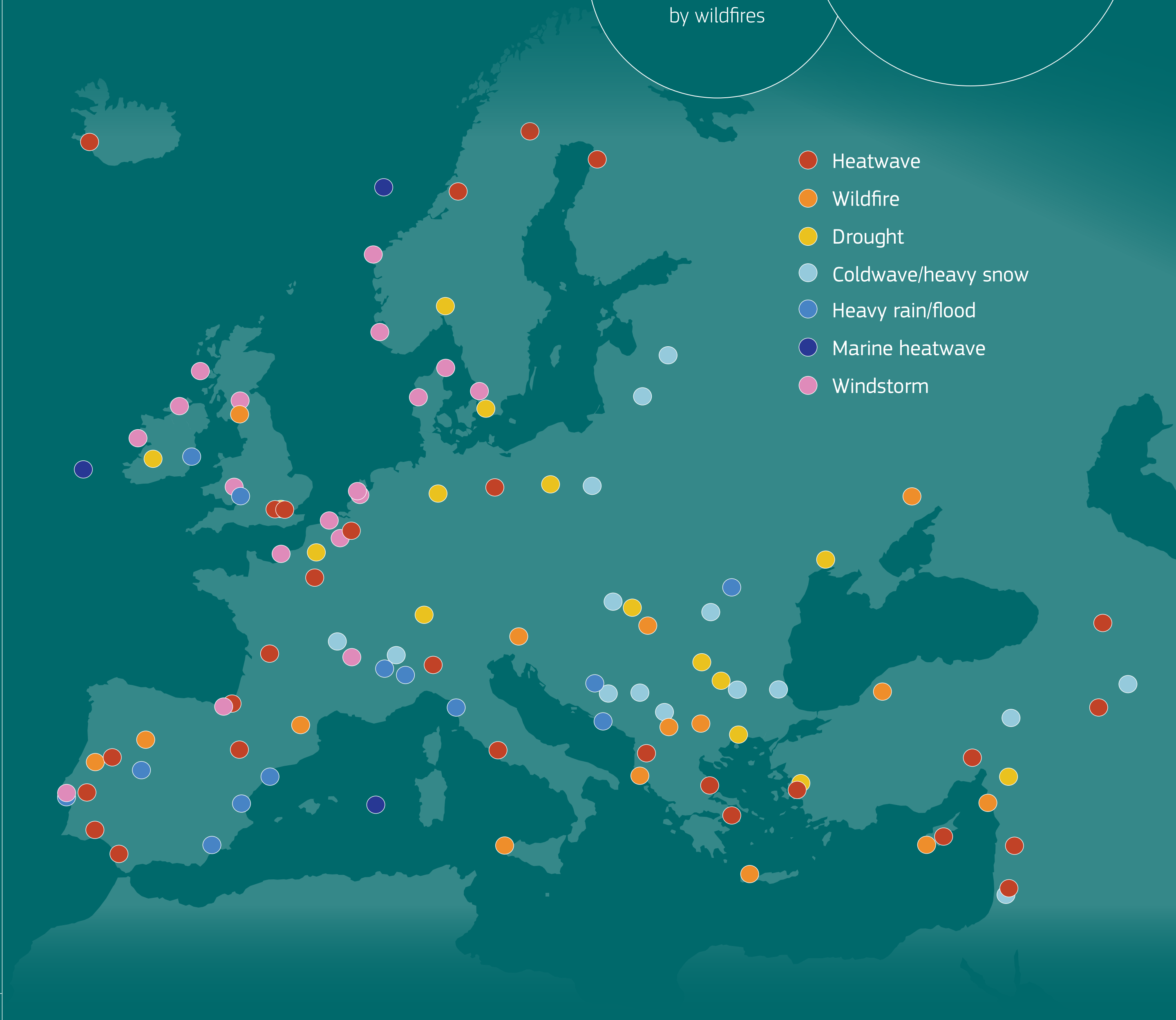
Key events in 2025

- Heatwaves impacted Europe from the Mediterranean to the Arctic Circle.
- Extreme precipitation and **flooding were less widespread** than in recent years.
- Weather and climate events can impact **biodiversity**.

At least
21 lives lost
due to storms and flooding

At least
500
people affected by wildfires

At least
14,500
people affected by storms and flooding



Data for people affected and fatalities according to preliminary estimates for 2025 from the International Disaster Database.

In Europe, 2025 was marked by a range of extreme and notable events, from widespread drought in spring and summer to heatwaves from the Mediterranean to the Arctic Circle, wildfires in southern Europe and storms across the continent. The interactive 'Key events map' provides information on selected extreme events across Europe during the year, largely drawn from national meteorological and hydrological service reports made to the World Meteorological Organization's Regional Climate Centre, and highlights examples of biodiversity conservation initiatives. More information on how some of the key events may have impacted biodiversity can be found in the 'Climate policy and action: biodiversity' section. Below is a summary of some of the key events across Europe in 2025.

Heatwaves

Summer temperatures were above average across much of the continent in 2025, with several heatwaves, two of which ranked among the 30 most severe on record for Europe. July saw Europe's second most severe heatwave on record, lasting 25 days (7–31 July) and affecting a large part of the continent, while August saw the 22nd most severe. Much of western and southern Europe, and Fennoscandia, saw more days than average with heat stress. More information on heat stress can be found in the 'Thermal stress' section.

In June, two significant heatwaves affected large parts of western and southern Europe. Across much of western Europe, including most of Spain, Portugal, France and southern parts of the United Kingdom, the average temperature between the start of the first heatwave and the end of the second heatwave (17 June–2 July) was the highest on record for the time of year. Exceptionally high sea surface temperatures in the western Mediterranean contributed to the intensity of the heatwaves. A detailed analysis of these heatwaves and the high sea surface temperatures is available in a C3S news article. Heatwave conditions also affected central and southeastern Europe in late June and early July in a swathe from northern Italy and Switzerland to Czechia and Slovenia. In Slovenia, a national June temperature record of 38.4°C was set.

In July, sub-Arctic Fennoscandia experienced its most severe heatwave on record, lasting 21 days and with temperatures reaching 30°C close to and within the Arctic Circle. In an average year, this region would see up to two days of 'strong' heat stress,[4] but parts of Fennoscandia saw almost two weeks of strong heat stress in July 2025. More information on this event can be found in the 'Long heatwave in sub-Arctic Fennoscandia' section.

In July and early August, extreme heat also affected southeastern Europe. In Türkiye, temperatures reached 50°C for the first time, with 50.5°C recorded at Silopi on 25 July. In Cyprus, temperatures reached 44.7°C, a new record for July. In Greece, an estimated 85% of the population was affected by extreme temperatures close to or above 40°C, reaching a maximum of 44°C.

August also saw western Europe's third major heatwave of summer 2025. It began in late July in Portugal, spread to Spain on 3 August and reached France on 8 August, before ending on 18 August. During this period, maximum temperatures reached up to 45°C in Spain and 42°C in France. In Spain, it was reported to be the most intense heatwave since at least 1975, while in France it was the second-longest heatwave on record, after the major European heatwave of 2003. The C3S climate bulletin for August 2025 provides additional information about the heatwave in western Europe.

Wildfires

During the year, wildfires in Europe[5] caused at least three deaths and affected around 500 people. In southwestern Europe, large wildfires occurred in southern France, Spain and Portugal in August. Over one week, the fires in northwestern Spain and northern Portugal led to the highest annual total wildfire emissions for Europe in the 23-year record. The United Kingdom also saw its highest total wildfire emissions in the 23-year record, as well as the largest burnt area since monitoring began in 2012. Southeastern Europe experienced a particularly intense wildfire season. For example, Greece saw one of its most severe wildfire outbreaks in recent years, with at least 50 wildfires reported in just 24 hours, and Cyprus had its most destructive wildfire on record in July. More information on wildfires across Europe can be found in the 'Wildfires' section.

4 A day with strong heat stress has a maximum feels-like temperature of 32°C or higher.

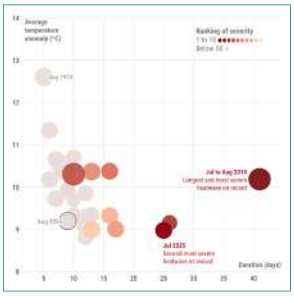
5 According to preliminary estimates for 2025 from the International Disaster Database. Media reports indicate that the impacts of wildfires are likely to be an underestimate. Information on impacts of heatwaves in 2025 is not yet available.

Storms and flooding

At least 21 lives were lost and an estimated 14,500 people were affected by storms and flooding across Europe[5] in 2025. Overall, however, extreme precipitation affected a smaller area than in other recent years, such as 2021, 2023 and 2024, and flooding affected a much smaller share of Europe's rivers. In January, Storm Éowyn impacted Ireland, the United Kingdom and Norway and was described by the Met Office as the United Kingdom's most powerful windstorm in more than a decade. During summer and autumn, convective storms caused localised flooding in several locations, including Italy, Sweden and Bulgaria. In October, two low-pressure systems brought widespread flooding, including flash floods, to southeastern Spain. In November, Storm Claudia caused significant flooding in Portugal, Spain, Ireland and the United Kingdom, and tornadoes were reported in Portugal and France. More information on precipitation, and on river flow and flooding, can be found in the respective sections.

Storms and flooding affected parts of Europe, but overall extreme precipitation and flooding were less widespread than in recent years.

Supplementary figures



Heatwaves in Europe since 1950

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

3.

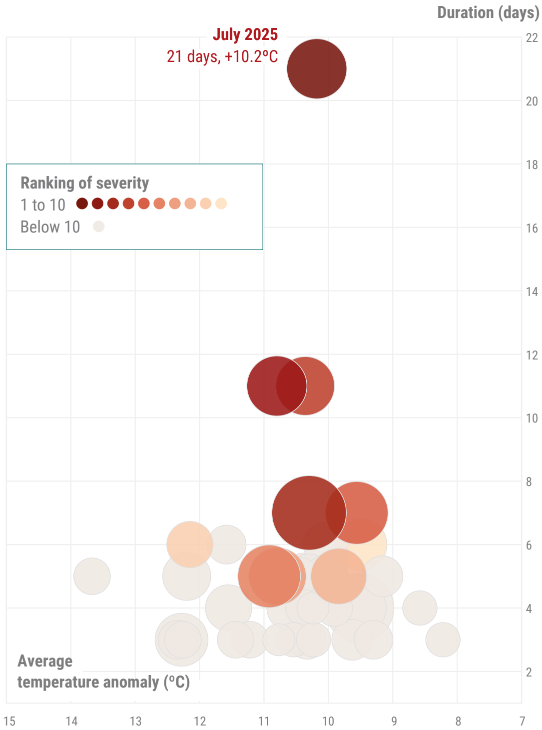
Long heatwave in sub-Arctic Fennoscandia

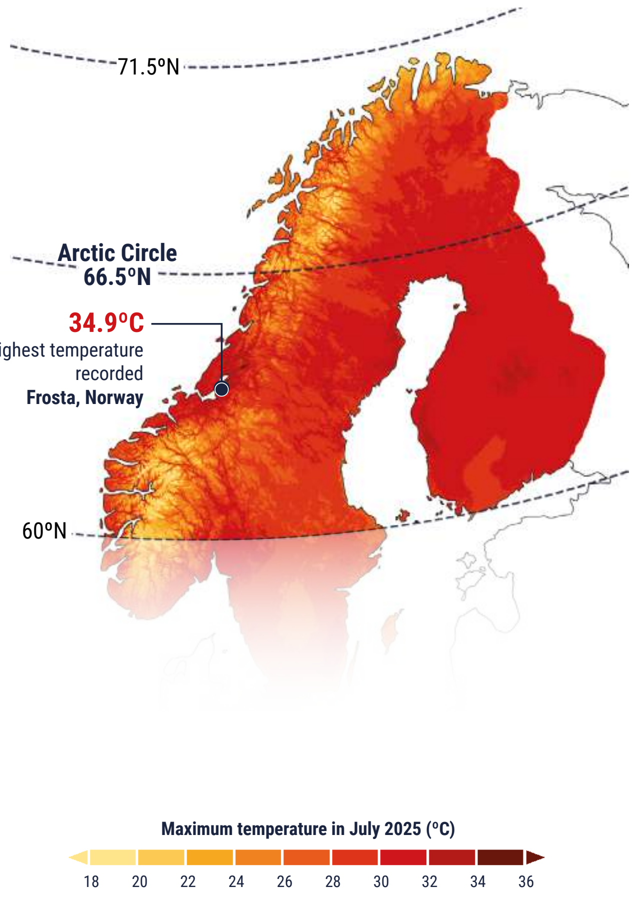
In July 2025, sub-Arctic Fennoscandia experienced its most severe heatwave on record, with temperatures close to and within the Arctic Circle reaching 30°C.

The region typically experiences up to two **'strong' heat stress** days per year, but in 2025, some areas saw almost **two weeks** at this level.

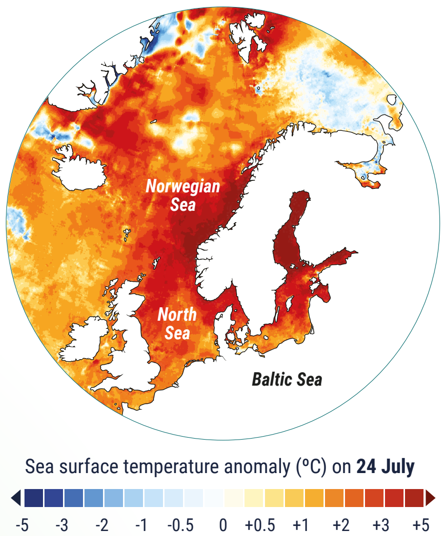
Dry conditions and high temperatures led to **'moderate' to 'severe' drought conditions** during the heatwave, and up to two weeks of high levels of **fire danger.**

The heatwave lasted a record **21 days**, from 12 July to 1 August. It was the **longest and most severe** on record.





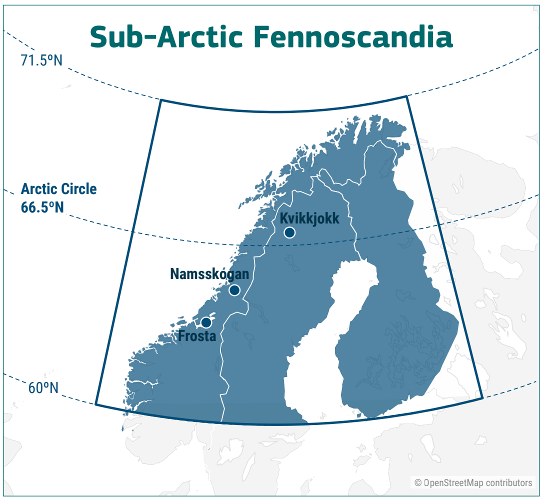
The heatwave coincided with a **marine heatwave** in the Norwegian Sea, parts of the North Sea and the Baltic Sea.



Data: E-OBS, SYNOP, ERA5, NGCD • Credit: DWD/C3S/ECMWF/Met Norway

For 2025 as a whole, much of Fennoscandia – the region encompassing Norway, Sweden and Finland – experienced record warmth. Norway had its warmest year on record, and Sweden and Finland their second warmest.[6]

In July 2025, sub-Arctic Fennoscandia experienced its most severe heatwave on record, with a record-long duration of 21 days and temperatures close to and within the Arctic Circle reaching or exceeding 30°C. The maximum temperature recorded was 34.9°C in Frosta, Norway.



In July, sub-Arctic Fennoscandia[7] was impacted by its most severe heatwave on record – where severity is a combination of the duration, intensity and area affected. While maximum temperatures in Fennoscandia did not reach the extreme levels seen in southern Europe during the summer, this heatwave saw temperatures reaching or exceeding 30°C close to and within the Arctic Circle, with several records broken for maximum temperatures and heatwave duration. Some locations in southern coastal areas of Norway, Sweden and Finland also experienced some tropical nights, where the temperature remains at least 20°C overnight. A new record of 10 consecutive tropical nights was set in Vestfold, Norway.

6 More information on temperatures across Europe can be found in the 'Temperature' section and national annual temperature rankings can be found in the Graphics Gallery.

7 Defined here as mainland Norway, Sweden and Finland north of 60°N. This region is used for the analysis in this section and reflects both the area affected by the heatwave and the distinct sub-Arctic climatic conditions north of 60°N compared with more temperate regions farther south.

Records indicate that previous heatwaves reached higher intensity, based on average temperature anomalies, but affected smaller areas and for much shorter durations. The July 2025 heatwave is the longest duration heatwave on record for the region, at 21 days. This is significantly longer than the previous most severe heatwave, which lasted 11 days in June and July 1972, while in 2018, two heatwaves affected the region in quick succession, one lasting one week, followed by an 11-day heatwave just three days after the first. These are ranked third and fourth most severe, respectively.

The heatwave was caused by an 'omega blocking pattern' over northern Europe – a large-scale weather pattern where a persistent high-pressure system becomes 'stuck' between two low-pressure systems. The region of high pressure became anchored over the Norwegian Sea and Fennoscandia, bringing prolonged sunshine which, at a time of nearly continuous daylight at these latitudes, sustained unusually high temperatures. Before impacting Fennoscandia, the same weather system also brought high temperatures to Iceland for two days in mid-July, with several locations seeing new temperature records, reaching a maximum of 29.5°C. The event also coincided with a marine heatwave in the Norwegian Sea, parts of the North Sea and the Baltic Sea. More information on marine heatwaves can be found in the 'Ocean' section.

Sub-Arctic Fennoscandia saw its most severe heatwave on record in 2025

Heatwaves in sub-Arctic Fennoscandia since 1950. The size of a circle is proportional to the area affected by the corresponding heatwave.

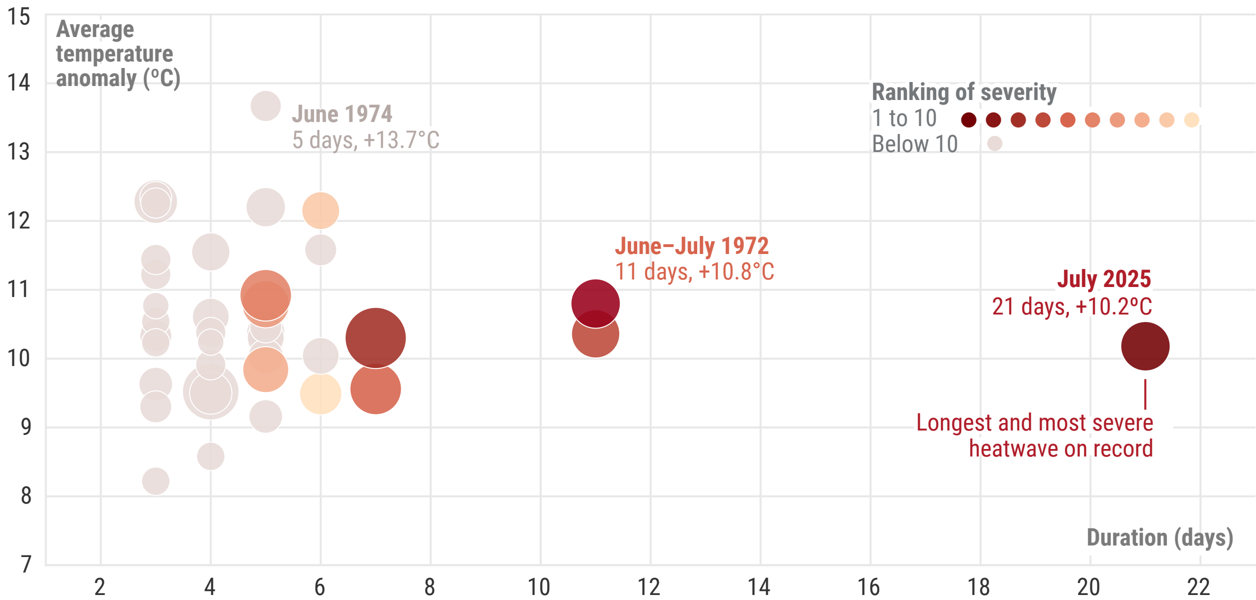


Figure 3.1. Heatwaves in sub-Arctic Fennoscandia since 1950. The circle size is proportional to the area affected by the corresponding event. The 10 most severe heatwaves are indicated by darker colours and grey indicates those with a severity ranking below 10. Sub-Arctic Fennoscandia is defined here as mainland Norway, Sweden and Finland north of 60°N (60°–72°N, 4°–32°E). Severity is based on a combination of the average temperature anomaly relative to the 1961–1990 reference period, the duration and the area affected. Data: E-OBS, SYNOP. Credit: DWD/C3S/ECMWF.

Record-breaking temperatures

The July 2025 heatwave brought record-breaking temperatures and unusually long periods of extreme heat across sub-Arctic Fennoscandia. The highest temperature reached was 34.9°C in Frosta, Norway on 17 July.

One way to quantify heatwaves is to look at the number of days where the maximum temperature exceeded certain thresholds, such as 30°C or 25°C. Stations at Namsskogan and Gartland, in Norway, saw a new national record with 13 consecutive days of maximum temperatures at or above 30°C. In Finland, temperatures exceeded 30°C at one or more locations for 22 consecutive days (12 July–2 August), marking one of the longest such streaks on record. At Ylitornio, Meltosjärvi, close to the Arctic Circle in Finnish Lapland, there were 26 days with temperatures reaching at least 25°C. Sweden also experienced exceptional heat in the north – Jokkmokk recorded 15 consecutive days and Haparanda 14 consecutive days with temperatures of at least 25°C, and several stations in Norrland registered 11 days at or above 30°C. At Kvikkjokk-Årrenjarka, which lies just north of the Arctic Circle, there were 10 days with temperatures exceeding 30°C, up to a maximum of 32.4°C. Notably, these prolonged high temperatures extended to areas near and north of the Arctic Circle, with local reports indicating the event stands apart from previous heatwaves in the region due to the long duration so far north. For July as a whole, a cooler-than-average start to the month meant that the average maximum temperature over sub-Arctic Fennoscandia was 28.7°C, making it the joint third warmest July on record, together with 2014, after 2018 (29.7°C) and 2019 (28.9°C).

July 2025 was the joint third-warmest on record for sub-Arctic Fennoscandia

Average maximum temperature in July for sub-Arctic Fennoscandia, 1961–2025

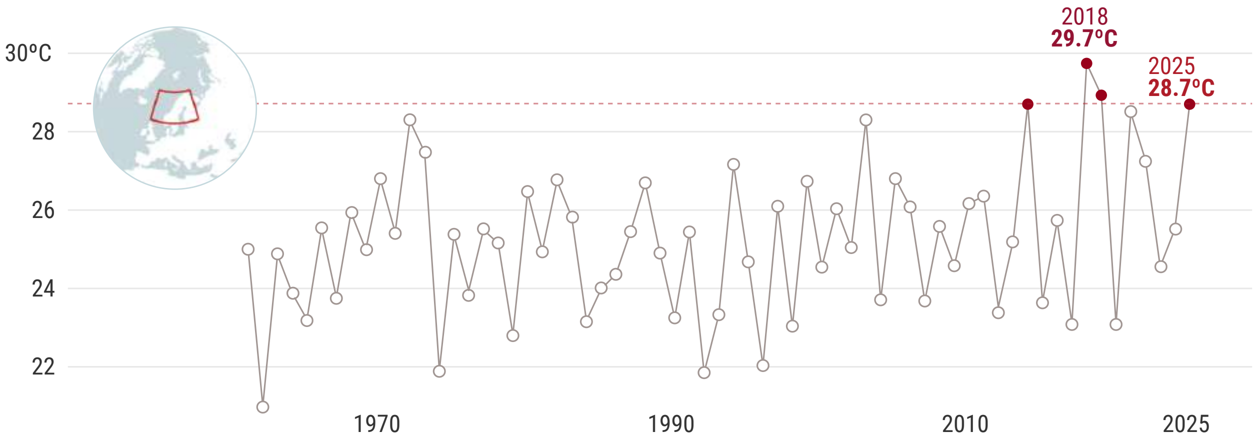


Figure 3.2. Average maximum temperature (°C) for sub-Arctic Fennoscandia, for each July from 1961 to 2025. Sub-Arctic Fennoscandia is defined here as mainland Norway, Sweden and Finland north of 60°N. Data: NGCD. Credit: Met Norway/C3S/ECMWF.

Heat stress

The heatwave also brought record levels of heat stress to the region. Typically, most of sub-Arctic Fennoscandia sees up to two days of strong heat stress, where the feels-like temperature reaches 32°C or more, per year. But in July 2025, a large area, mostly around the Gulf of Bothnia, saw feels-like temperatures of 33–34°C, reaching up to 36°C[8] in some locations, and up to 12 days of strong heat stress. Averaged over sub-Arctic Fennoscandia, this is the highest number of strong heat stress days on record by a large margin – almost double that of the previous record set in 2018. While parts of southern Europe saw up to 100–150 days of this level of heat stress in 2025, around 10 to 30 days above average depending on the area, 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.

Parts of sub-Arctic Fennoscandia, a region that typically experiences up to two 'strong' heat stress days per year, saw almost two weeks at this level.

Record-breaking heat stress in Fennoscandia in July 2025

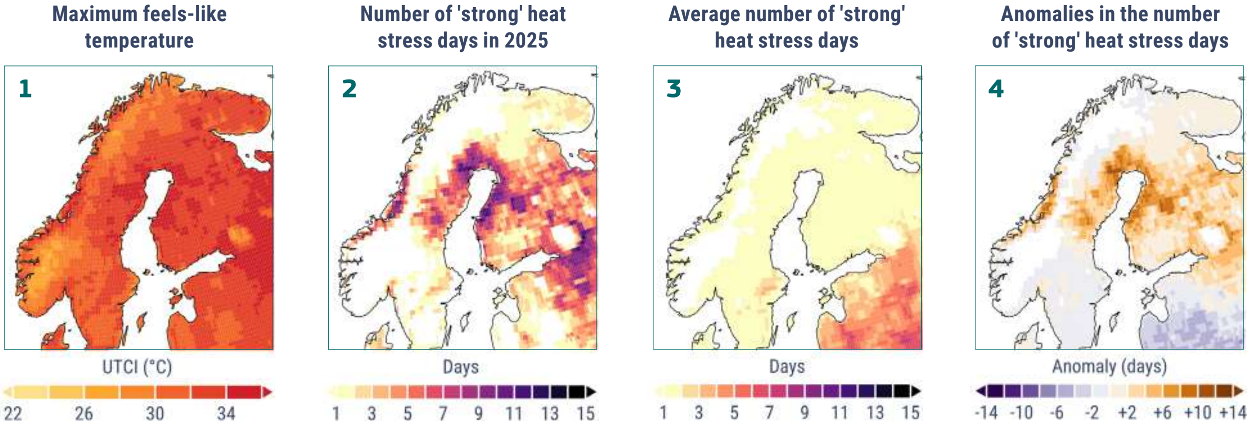


Figure 3.3. (1) Maximum feels-like temperature in July 2025, (2) number of days with 'strong' heat stress in 2025, (3) the average number of days per year with 'strong' heat stress for 1991–2020 and (4) associated anomalies, relative to the average for the 1991–2020 reference period. A day with at least 'strong' heat stress has a maximum feels-like temperature, based on the Universal Thermal Climate Index (UTCI), of 32°C or higher. Data: ERA5-HEAT. Credit: C3S/ECMWF.

8 Feels-like temperatures and heat stress indices account for other environmental factors beyond temperature. In this case humidity, wind speed, radiation and the response of the human body to the environment are all considered. As a result, feels-like temperatures can differ substantially from recorded air temperatures.

Drought and wildfire risk

Beyond high temperatures and the potential health impacts of heat stress, heatwaves can also influence drought and wildfire risk. In July 2025, 'moderate' drought conditions were reached across much of sub-Arctic Fennoscandia, with locally 'severe' or 'extremely dry' conditions. The onset of drought conditions was rapid and associated with the heatwave, as June had been generally near average, and moderately wet in some areas. Following the heatwave, recovery was also rapid, with conditions returning to average or moderately wet in August. More information on drought conditions across Europe can be found in the 'Soil moisture' section.

Dry conditions and high temperatures led to 'moderate' to 'severe' drought conditions during the heatwave, and up to two weeks of high levels of fire danger.

Weather also plays an important role in wildfire risk. Although it does not account for ignition, fire danger can be estimated using the Fire Weather Index. Due to the combination of high temperatures and dry conditions, much of sub-Arctic Fennoscandia saw up to two weeks, and locally up to 20 days, where the Fire Weather Index was higher than 95% of historical values for the region. Data on burnt areas indicate a number of smaller fires (less than 100 hectares) across the region in 2025. While no large wildfires were recorded, monthly estimated totals indicate above-average[9] wildfire emissions in Finland during July. More information on wildfires across Europe in 2025 can be found in the 'Wildfires' section.

9 Relative to the 2003–2019 reference period.

Drought conditions and fire danger during the July heatwave in sub-Arctic Fennoscandia

Standardised Precipitation-Evapotranspiration Index (SPEI-1) and Fire Weather Index (FWI) in July 2025

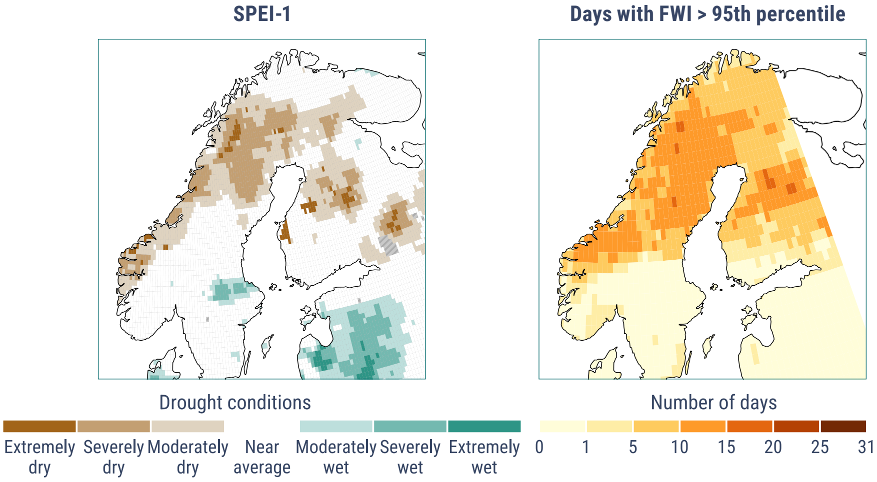


Figure 3.4. Drought conditions based on (left) the Standardised Precipitation-Evapotranspiration Index (SPEI-1) in July 2025 and (right) number of days during which the Fire Weather Index (FWI) was above the 95th percentile in July 2025. Data: ERA5-Drought, FWI based on ERA5. Credit: CEMS/C3S/ECMWF.

Impacts of heatwaves on biodiversity

Much of sub-Arctic Fennoscandia is classified as boreal (forest) or alpine (tundra). In these biogeographical regions, extreme events such as heatwaves, and associated droughts and fires, can have significant impacts on biodiversity. For example, through habitat loss, facilitating the spread of invasive species and promoting pest outbreaks. Prolonged heatwaves may also accelerate glacier melt and alter hydrological regimes. Cold-adapted species shift their distributions northward or to higher elevations in response to warming, and extreme events can have detrimental effects on growth, reproduction and survival [R3.1].

2025 was characterised by above-average growing degree days, a measure of accumulated heat above a base temperature of 5°C, consistent with prolonged warm conditions that can increase ecosystem sensitivity to extreme events in boreal and alpine environments. The summer also saw above-average lake surface water temperatures in the region, in particular in Finland, with reports indicating a number of harmful algal blooms related to the heatwave. More information on lake temperatures across Europe can be found in the 'Lakes' section.

Research has also shown that in recent decades extreme weather events have become more frequent across the Arctic, and within Fennoscandia there is an increase in growing degree days and other bioclimatic indicators, such the heatwave magnitude index [R3.1]. More information on biodiversity, and related climate policy and action topics, can be found in the 'Climate policy and action: biodiversity' section.

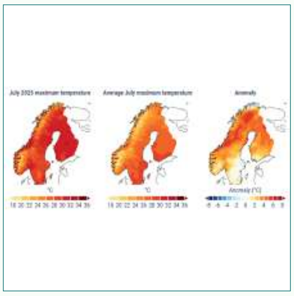
Long-term trends

Europe is warming twice as fast as the global average, making it the fastest-warming continent, while the Arctic is the fastest-warming region on Earth, at a rate of 0.75°C per decade over the last thirty years. Within Europe, the rate varies and, over the last thirty years, Fennoscandia has seen a trend of 0.2–0.7°C per decade. More information on long-term trends in temperature can be found in the 'Why is Europe warming so quickly?' section.

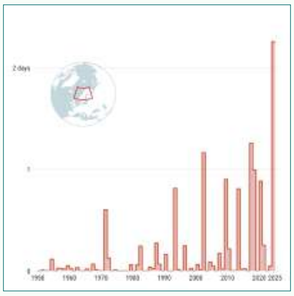
The IPCC AR6 reports that, in Europe, there has been a significant increase in the frequency and intensity of hot extremes, and these are projected to continue increasing with climate change. Increases in heatwaves are projected to be greatest across the southern Mediterranean and Scandinavia. In a 1.3°C cooler climate, the temperatures seen during the July heatwave would have been extremely rare. In addition, a recent report from Met Norway concluded that the annual average temperatures seen in 2025 would have been virtually impossible in most of Norway in the climate of 1900. The area of Europe that sees temperatures below freezing is also shrinking over time. More information on these changes can be found in the 'Temperature' section.

Averaged across Europe, there is an increasing trend in the number of all categories of heat stress days. While heat stress varies year-to-year in sub-Arctic Fennoscandia, here there is an increasing trend in the number of strong heat stress days. Thermal Trace, an interactive app for exploring heat and cold stress worldwide, indicates that sub-Arctic Fennoscandia has not yet experienced any days with very strong or extreme heat stress. While heat stress days here are increasing, there is no clear trend in the number of July days with a Fire Weather Index exceeding 95% of the historical values. However, 2025 was amongst the years with the highest number in a record starting in 1970. More information can be found in the 'Thermal stress' and 'Wildfires' sections of the report.

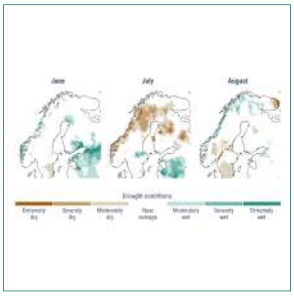
Supplementary figures



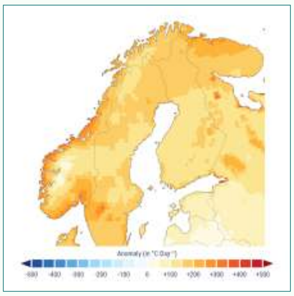
July 2025 maximum temperature and anomalies



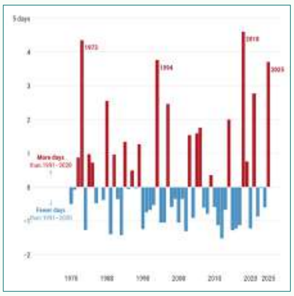
Number of heat stress days since 1950



SPEI for summer 2025



Growing degree day anomalies for 2025



July extreme fire weather days since 1970

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

4.

Temperature

Surface air temperature, measured at around 2 m above the surface and referred to in this section as ‘temperature’, has impacts on both human and natural systems. It affects health, agriculture and energy demand, for example, as well as biodiversity and natural environments.

Almost the entire European continent (at least 95%) saw above-average annual temperatures in 2025.

This section gives an overview of temperature anomalies and extremes in 2025 across the continent, explores variations throughout the year, and provides historical context for the findings alongside key information on long-term trends in temperature.

Almost all of Europe saw above-average temperatures for 2025

Anomalies and extremes in annual surface air temperature in 2025

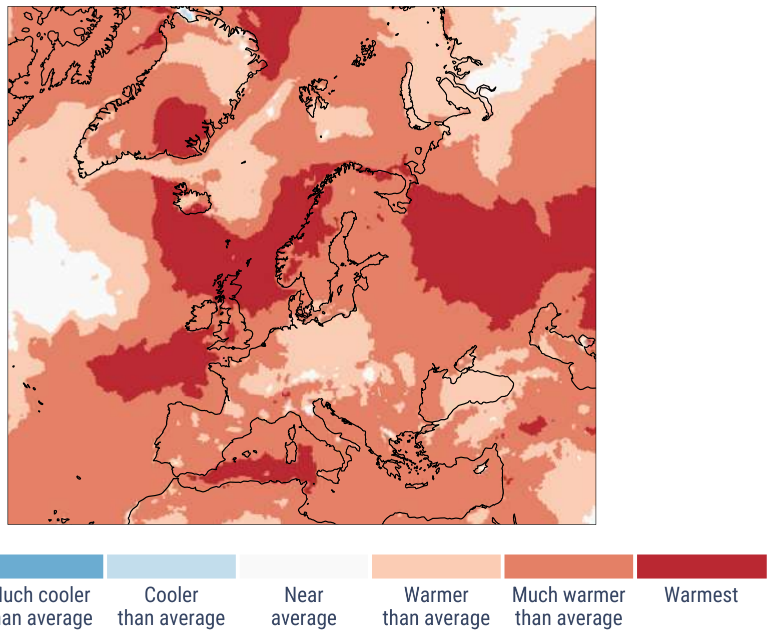


Figure 4.1a. Anomalies and extremes in annual surface air temperature in 2025. The extreme categories (‘coolest’ and ‘warmest’) are based on rankings for 1979–2025. The other categories describe how the temperatures compare to their distribution during the 1991–2020 reference period. ‘Much cooler/warmer than average’ – cooler/warmer than 90% of temperatures; ‘cooler/warmer than average’ – than 66% of temperatures; ‘near average’ – within the middle 33%. Data: ERA5. Credit: C3S/ECMWF.

Annual overview

In 2025, annual temperatures were above average across almost the entire continent (at least 95%[10]). Some very small areas in Italy, Croatia and Poland saw close-to-average or slightly below-average temperatures (up to 0.2°C below average).

Record annual temperatures were seen in several regions, including parts of northern Europe such as western Scandinavia, parts of Greenland, Iceland, the United Kingdom and western Russia. Several countries[11] in northern Europe reported their warmest (United Kingdom, Norway and Iceland) or second warmest (Ireland, Sweden and Finland) year on record.

Much of the rest of Europe saw much warmer-than-average annual temperatures. The largest anomalies were in western Russia, where temperatures reached up to 2.5°C and locally 3°C above average, and in Greenland, where they were up to 5°C above average. Central Europe also saw warmer-than-average temperatures, but with smaller anomalies, of up to +1°C.

European temperature ranking for 2025

C3S supports the adaptation and mitigation policies of the European Union, while the WMO Regional Office for Europe serves its 50 Member States across a broader region. The ***WMO European domain****, known as Regional Association VI (RA VI), includes Greenland, the South Caucasus and part of the Middle East, which are not covered by the* ***C3S European domain****. Maps of the two domains are shown on page 167. As the two domains differ in size and climate, variations in statistics are expected.*

2025 was the warmest year on record for WMO RA VI (Europe).

For the C3S European domain, 2025 ranked as the third-warmest year in the ERA5 dataset and the second-warmest year in the E-OBS dataset, which has a slightly more limited spatial coverage.

10 95% in the E-OBS dataset for the C3S domain and 99.99% in the ERA5 dataset for the larger WMO RA VI domain.

11 A table with national temperature statistics reported by the national meteorological and hydrological services within WMO RA VI (Europe) is available in the Graphics Gallery.

Variations throughout the year

The year was generally characterised by above-average temperatures. Over European land[12] as a whole (excluding Greenland), 27 days saw record-high daily temperatures, mainly in late January and spring. There were some periods, between 1 and 11 days long, and one in May reaching 20 days, of cooler-than-average daily temperatures during the year, between long periods of warmer- or much warmer-than-average temperatures.

The year started with a contrast between northwestern Europe, which was cooler than average in January, and the rest of Europe, which was warmer than average. This pattern then shifted, with northwestern Europe generally seeing warmer-than-average temperatures from February to August and again from October to December. Parts of eastern Europe, however, saw average to cooler-than-average temperatures during February and from May to August.

Several northern European countries saw the warmest or second warmest year on record.

During winter, northeastern Europe saw particularly large temperature anomalies, with the seasonal average anomaly reaching a record high of 7°C for northwestern Russia. This contrasts with southern Greenland, which saw below-average temperatures for winter as a whole.

In spring and summer, parts of western Europe saw their warmest seasonal temperatures on record, while eastern Europe saw near-average summer temperatures. This pattern aligns with heatwave conditions seen during the summer, affecting western and southern Europe. More can be read about these heatwaves in the 'Key events' section.

Despite these variations, above-average temperatures persisted across most of Europe throughout the year, and all seasons were among the four warmest on record. When the region is extended to include Greenland, the Caucasus and parts of the Middle East, summer ranked sixth warmest, while autumn was the warmest on record.

12 Daily statistics based on E-OBS.

Temperature variations through 2025

Anomalies and extremes in monthly surface air temperature in 2025

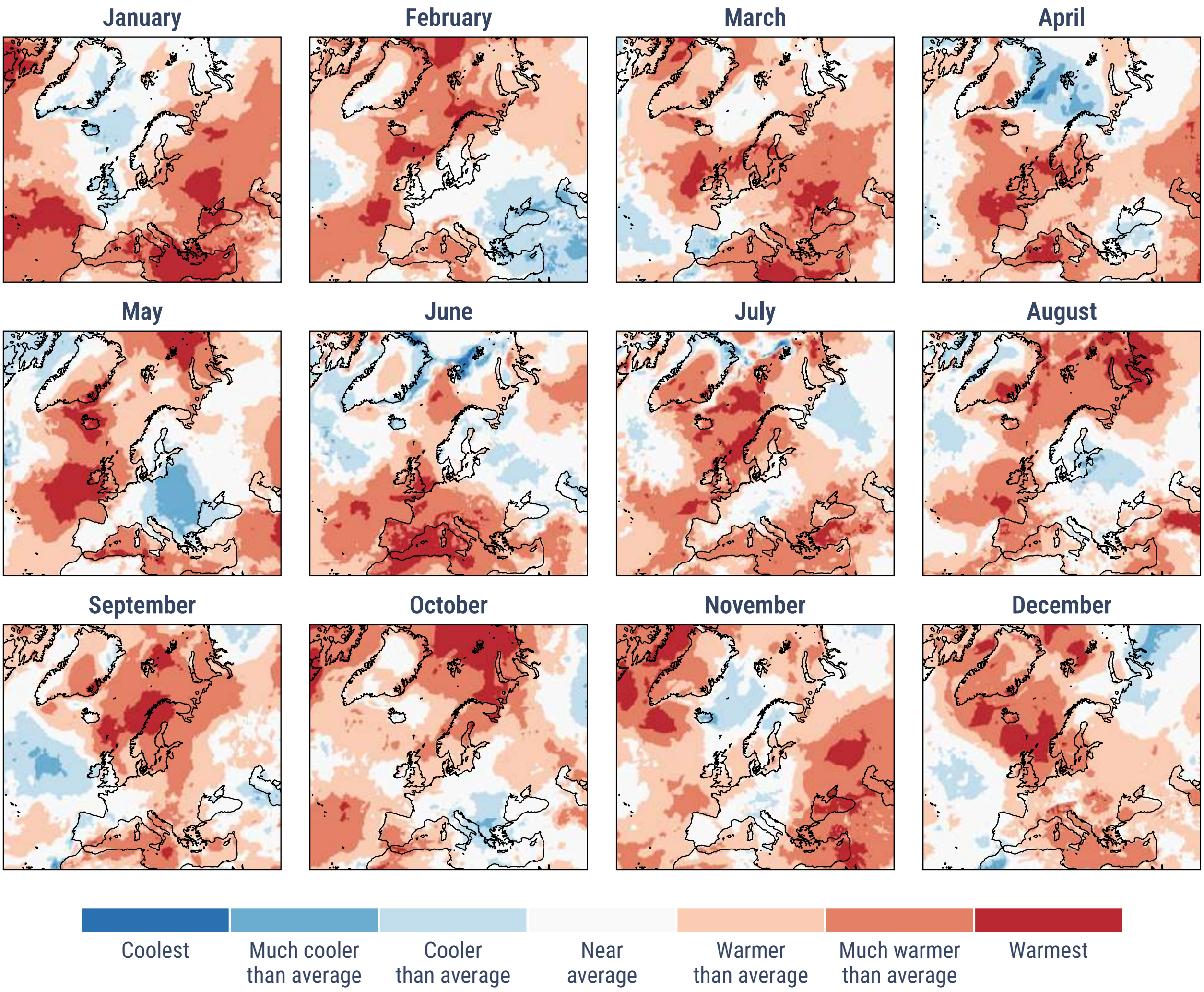


Figure 4.2a Anomalies and extremes in monthly surface air temperature in 2025. The extreme categories ('coolest' and 'warmest') are based on rankings for 1979–2025. The other categories describe how the temperatures compare to their distribution during the 1991–2020 reference period. 'Much cooler/warmer than average' – cooler/warmer than 90% of temperatures; 'cooler/warmer than average' – than 66% of temperatures; 'near average' – within the middle 33%. Data: ERA5. Credit: C3S/ECMWF.

Extremes

Both minimum and maximum temperatures were generally higher than average in 2025. Maximum temperatures were most above average in winter and spring in northern and eastern Europe, and in summer in western and central Europe. January and March saw maximum temperatures up to 6–8°C above average in eastern Europe, while in June maximum temperatures in southwestern Europe were 5–6°C above average. In July, maximum temperatures in Fennoscandia reached 6°C above average, linked to a heatwave in the second half of the month that led to record levels of heat stress in the region. This event is discussed in more detail in the

'Long heatwave in sub-Arctic Fennoscandia' spotlight section.

Minimum temperatures were above average through most of the year, with some periods of below-average minimum temperatures in February, May and August in eastern parts of Europe. No land areas saw record-low seasonal- or monthly-average temperatures in 2025.

Another way to look at cold extremes is by counting the number of days when the minimum temperature is 0°C or lower ('frost days') and the days when the maximum temperature is 0°C or lower ('ice days'), or by looking at the areas that see an average winter temperature of 0°C or lower. Climate change means that the area of Europe experiencing these types of days is decreasing. During winter, the area that saw two consecutive weeks of frost or ice days was smaller than average. Such periods of ice days are generally limited to northeastern Europe, Iceland and the Alps. In 2025, only small, localised parts of the Alps experienced two weeks of ice days and a smaller area than average in Fennoscandia saw these conditions. Over time, the area that usually experiences such conditions has also decreased, with the 1991–2020 average showing a substantially smaller extent than 1961–1990. The area of Europe with an average winter temperature of 0°C or below is also shrinking and becoming restricted to higher altitudes in mountainous areas.

The area of Europe experiencing days below freezing is shrinking

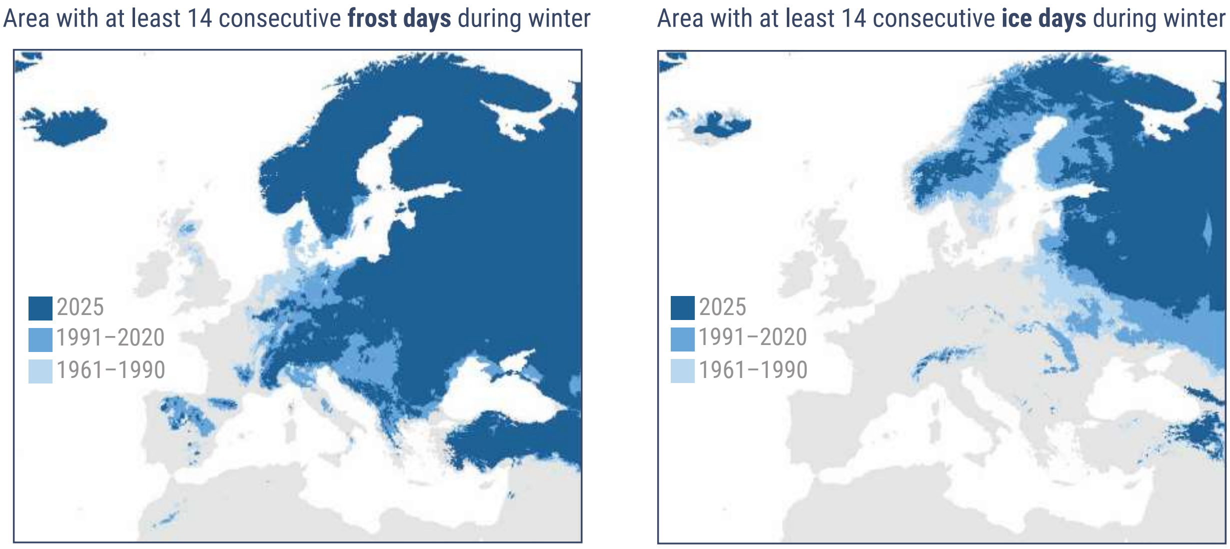


Figure 4.3. The area of Europe that experienced at least 14 consecutive (left) 'frost days' and (right) 'ice days' in 2025 (dark blue) compared to the 1991–2020 average (medium blue) and the 1961–1990 average (light blue). A frost day is defined as a day with a minimum temperature of 0°C or lower, and an ice day is a day during which the maximum temperature remains at 0°C or lower. Data: E-OBS. Credit: KNMI/C3S/ECMWF.

Long-term trends

Global temperatures continue to rise and temperatures for Europe show long-term warming trends. The IPCC AR6 reports that temperatures will rise across Europe at a faster rate than the global average, and the frequency and intensity of hot extremes will increase, with potential impacts on a range of sectors including agriculture, health, water resources, ecosystems and biodiversity.

The area of Europe experiencing winter days with freezing temperatures is shrinking and was substantially below average in 2025.

2025 was the warmest year on record for WMO RA VI (Europe)

Anomalies in annual surface air temperature according to several international sources

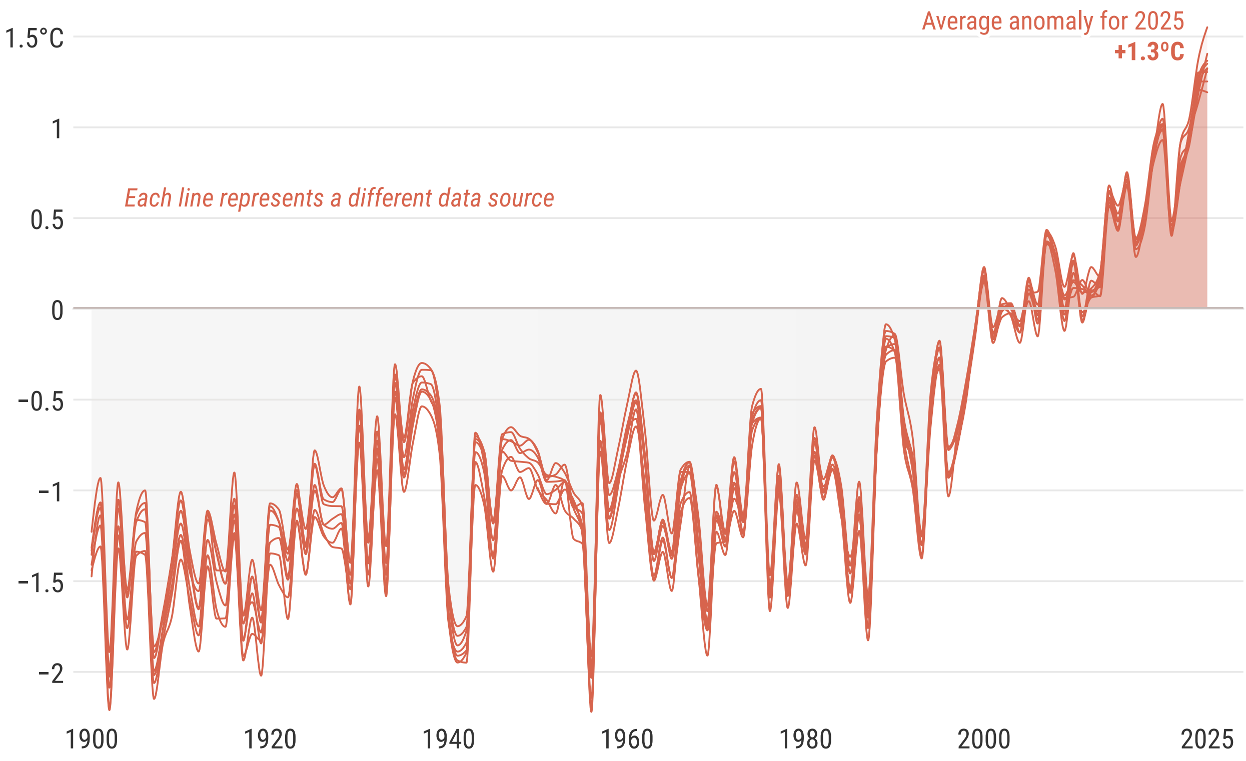


Figure 4.4a. Annual surface air temperature anomalies over European (as defined by the WMO Regional Association VI) land, from a range of datasets, for 1900–2025 (start year varies by dataset), relative to the average for the 1991–2020 reference period. Data: HadCRUT5, NOAAGlobalTemp, GISTEMP, Berkeley Earth, JRA-3Q, ERA5, CMST, CMA-GMST, DCENT-I. Credit: C3S/ECMWF/WMO. Data can be downloaded and information on the methodology can be found on the WMO Regional Dashboard for Europe.

Monitoring of long-term climate indicators confirms that Europe is the fastest-warming of all the WMO regions, at around twice the global average. The trends are not uniform over time – they show little change, or weak cooling, from the 1950s to the 1980s, with the 1980s being slightly cooler than the 1930s. Most of the warming has happened since the 1980s. Five of Europe's warmest years on record have all occurred since 2019, and the ten warmest since 2014. Temperatures over the Arctic have risen more rapidly than those over most of the rest of the globe, with an estimated warming of around 3°C since the 1970s.

Five of Europe's warmest years on record have occurred since 2019, and ten since 2014.

More information on why Europe is warming faster than the global average and differences in the rate of warming across Europe can be found in the 'Why is Europe warming so quickly?' section. Information on changes in heat stress can be found in the 'Thermal stress' section, and the recent Global Climate Highlights 2025 report offers additional context.

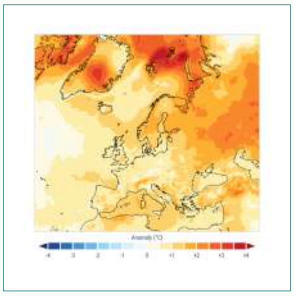
Compared to the pre-industrial level (1850–1900), there has been an increase in the five-year average surface air temperature of around:

Globe: +1.4°C
WMO RA VI: +2.6°C
Europe: +2.4°C
Arctic: +3.2°C

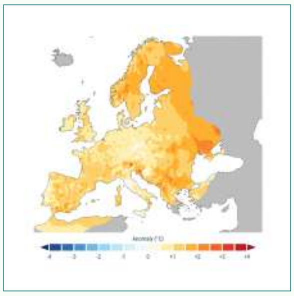
Latest five-year averages.
Values for Europe, WMO RA VI and the Arctic are over land only.
Data: ERA5.

Supplementary figures

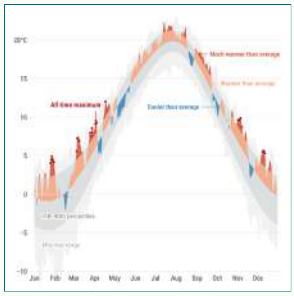
Temperature statistics and rankings for 2025



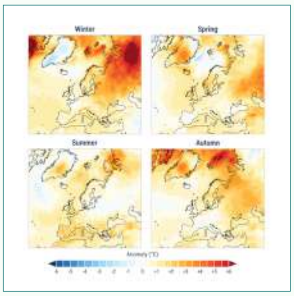
Annual temperature anomalies - ERA5



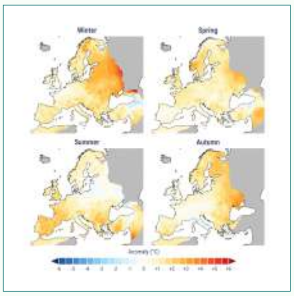
Annual temperature anomalies - E-OBS



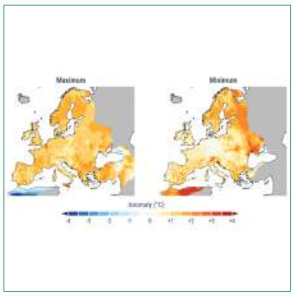
Daily temperature for Europe in 2025



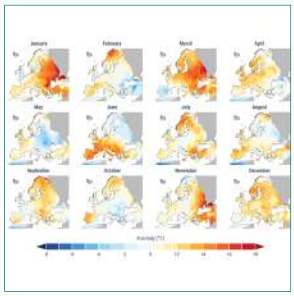
Seasonal temperature anomalies - ERA5



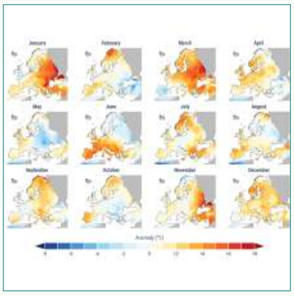
Seasonal temperature anomalies - E-OBS



Maximum and minimum temperature anomalies

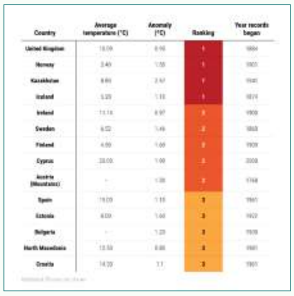


Monthly maximum temperature anomalies



Monthly minimum temperature anomalies

Area with winter-average temperature below zero

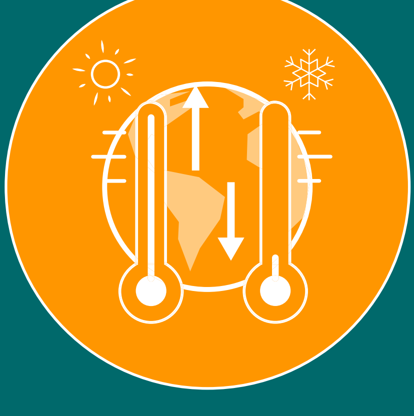


National temperature statistics and rankings

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

5.

Thermal stress



Temperatures above or below the optimal range, alongside other environmental factors, can impact human health. There were estimated to be around 62,800 heat-related deaths in Europe in 2024, 47,700 in 2023 and 61,700 in 2022. An estimate for 2025 is not yet available.

Thermal comfort indices can be used to represent the effect of the environment on people. The Universal Thermal Climate Index (UTCI), used here, takes into account temperature, humidity, wind speed, sunshine and heat emitted by the surroundings, and how the body responds to different thermal environments. The UTCI has units of °C, representing a 'feels like' temperature, divided into ten heat and cold stress categories.

In 2025, there was a record low number of cold stress days in Europe.

High nighttime temperatures can also affect health, offering little respite from daytime heat stress. Tropical nights – those during which the temperature does not fall below 20°C – are an indicator of this.

This section provides an overview of heat stress, tropical nights and cold stress across Europe in 2025. More information about regional heatwaves can be found in the 'Key events' and 'Long heatwave in sub-Arctic Fennoscandia' sections. Heat and cold stress data can also be explored interactively with the 'Thermal Trace' app.

Heat stress

In 2025, 41% of Europe saw more days than average with at least 'strong' heat stress, where the feels-like temperature is 32°C or higher. In contrast, just 19% of Europe, mostly in southern Scandinavia and northeastern Europe, saw fewer days than average with this level of heat stress. In southern and eastern Spain, there were up to 50 more days than average with at least strong heat stress. Parts of southern Europe, in particular the Iberian Peninsula, southern Spain, and parts of southeastern Europe, also saw more days than average with at least 'very strong' heat stress, where the feels-like temperature is 38°C or higher.

In central Fennoscandia, prolonged heatwave conditions in July led to the region, which typically sees up to two days of strong heat stress per year,[13] experiencing as many as 12 days at that level – a record number. This is discussed in more detail in the ‘Long heatwave in sub-Arctic Fennoscandia’ spotlight section.

Southern Europe saw more days than average with at least ‘strong’ heat stress.

While much of Europe does not typically see ‘extreme’ heat stress, where feels-like temperatures reach 46°C or higher, there was a mixed picture in those regions that do. Parts of southern Spain and Portugal, for example, saw up to six more extreme heat stress days than average, while other areas in Spain, Portugal, Italy, and elsewhere in southern Europe, saw average levels of extreme heat stress.

41% of Europe saw more days than average with at least ‘strong’ heat stress in 2025

Number of days with at least ‘strong’ heat stress in 2025

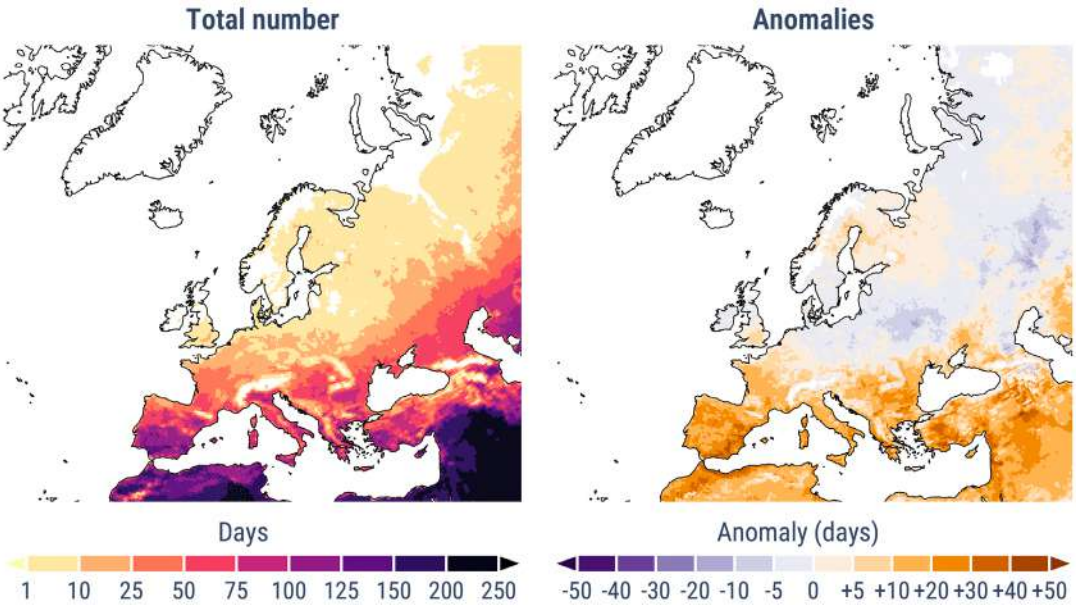


Figure 5.1. (Left) Number of days with at least ‘strong’ heat stress in 2025, and (right) associated anomalies, relative to the average for the 1991–2020 reference period. A day with at least strong heat stress has a maximum feels-like temperature, based on the Universal Thermal Climate Index (UTCI), of at least 32°C. Data: ERA5-HEAT. Credit: C3S/ECMWF.

13 Based on the 1991–2020 reference period.

Tropical nights

In 2025, most of Europe saw a near-average number of tropical nights. Parts of southern Europe, however, in particular the Iberian Peninsula and coastal areas around the Mediterranean Sea, saw up to 30 more tropical nights than average, with up to 40 more in some localised areas.

Southern Europe saw more tropical nights than average in 2025

Number of tropical nights in 2025

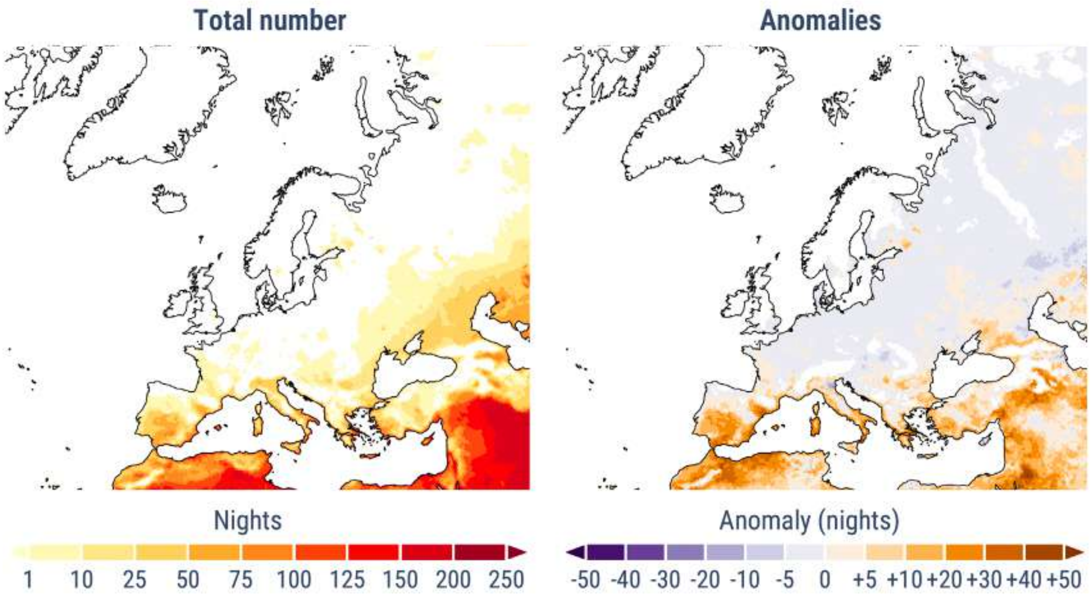


Figure 5.2. (Left) Number of tropical nights in 2025 and (right) associated anomalies relative to the average for the 1991–2020 reference period. Tropical nights are those during which the temperature does not fall below 20°C. Data: ERA5-HEAT. Credit: C3S/ECMWF.

Cold stress

For Europe as a whole, 2025 saw a record low number of cold stress days[14] across all categories at or above ‘strong’ cold stress. 90% of Europe saw fewer days than average with at least strong cold stress. The only regions to see average or slightly above-average numbers of days with at least strong cold stress were Greenland and

14 Statistics are based on the daily (24-hour) minimum UTCI values, so a cold stress ‘day’ may see its coldest feels-like temperatures during the nighttime.

parts of northeastern Europe. Positive anomalies here, however, generally did not exceed seven days, and these regions saw fewer days than average with feels-like temperatures reaching 'very strong' or 'extreme' cold stress. Notably, a large region north of the Caspian Sea saw as many as 58 fewer days than average with at least strong cold stress, southern Scandinavia as many as 50 fewer, and Iceland as many as 30–40 fewer.

Almost all of Europe (90%) saw fewer days than average with at least 'strong' cold stress.

90% of Europe saw fewer cold stress days than average in 2025

Number of days with at least 'strong' cold stress in 2025

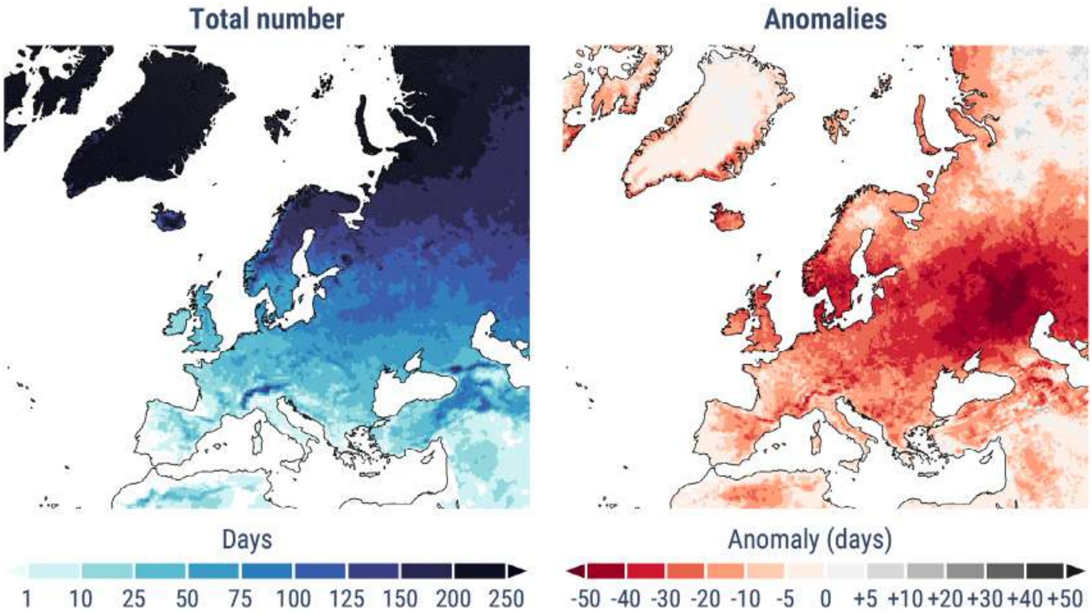


Figure 5.3. (Left) Number of days with at least 'strong' cold stress in 2025 and (right) associated anomalies relative to the average for the 1991–2020 reference period. A day with at least strong cold stress has a minimum feels-like temperature, based on the Universal Thermal Climate Index (UTCI) of -13°C or lower. Data: ERA5-HEAT. Credit: C3S/ECMWF.

Long-term trends

For Europe as a whole, the numbers of days with strong, very strong or extreme heat stress, and the number of tropical nights, have all been increasing since the 1980s, while the number of cold stress days is decreasing. In recent decades, heat has been the leading cause of reported deaths due to extreme weather in Europe. In the World Health Organization European Region, heat-related mortality has increased by around 20% in the past 20 years.

Heat stress days are increasing while cold stress days decline

Average number of heat stress days, tropical nights and cold stress days in Europe (WMO RA VI) since 1980

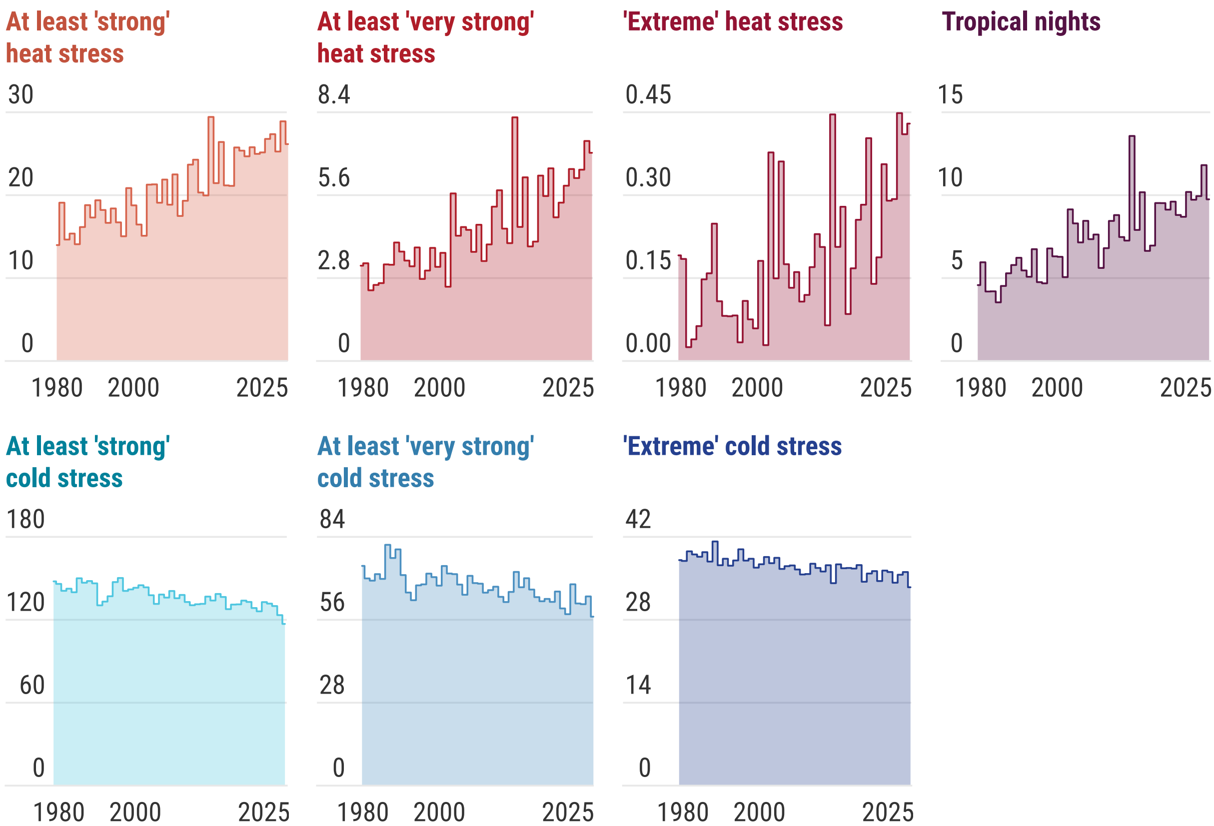
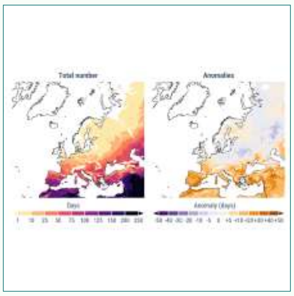


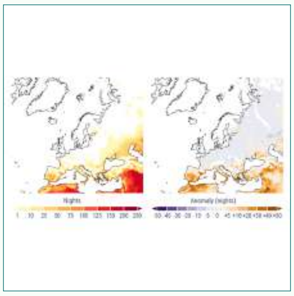
Figure 5.4. Annual average number of days with at least 'strong', 'very strong' or 'extreme' heat stress, annual average number of tropical nights, and annual average number of days with at least 'strong', 'very strong' or 'extreme' cold stress for WMO RA VI (Europe), from 1980–2025. The thresholds for 'strong', 'very strong' and 'extreme' heat stress are 32°C, 38°C and 46°C, respectively, and for 'strong', 'very strong' and 'extreme' cold stress are -13°C, -27°C and -40°C, based on the Universal Thermal Climate Index (UTCI). Tropical nights are those during which the temperature does not fall below 20°C. Data: ERA5-HEAT. Credit: C3S/ECMWF.

The IPCC AR6 states that although 'evidence of higher heat tolerance is also emerging', for Europe as a whole, a 'global warming level of 1.5°C could result in 30,000 annual deaths due to extreme heat', with up to three times this at 3°C of global warming [R5.1]. The number of heat-related deaths is projected to be highest and to increase most rapidly in southeastern Europe, but other regions will also experience accelerating consequences beyond 1.5°C of global warming. The discomfort and mortality risks of heat stress also depend on the level of socioeconomic development. While cold spells are projected to decrease across Europe, particularly in southern Europe, this decrease does not compensate for the additional heat-related deaths [R5.1].

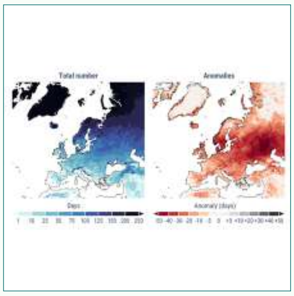
Supplementary figures



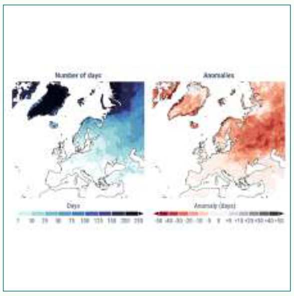
Days with at least 'very strong' heat stress



Days with 'extreme' heat stress



Days with at least 'very strong' cold stress



Days with 'extreme' cold stress

Area with above or below average thermal stress

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

6.

Wildfires

Wildfires, or wildland fires, are fuelled by combustible vegetation and triggered by ignition sources such as lightning or human activity. They are influenced by a range of factors, both natural and anthropogenic, including vegetation type and structure, moisture, topography and wind. The increased frequency and intensity of extreme wildfires may result in habitat destruction and air quality deterioration.

Emissions from fires in Europe reached a record high in 2025, with Spain contributing around half the total. Spain, Cyprus, the United Kingdom, the Netherlands and Germany all saw record high annual emissions.

This section focuses on wildfires across Europe[15] in 2025. Here, the fire season, defined as the period when at least 80% of the total annual burnt area occurs, generally runs from June to September. Wildfire potential is analysed based on the prevailing climate conditions and is expressed here as fire danger. The section also covers the burnt areas from wildfires, estimated from satellite observations, and emissions of carbon and pyrogenic pollutants, estimated using fire radiative power.

Fire danger

Where fuel is available, weather plays a pivotal role in determining the risk of fires. Fire danger is estimated using the Fire Weather Index (FWI) to understand how weather conditions influence flammability and to evaluate potential spread and intensity. While the FWI does not account for ignition, it generally correlates well with actual fire activity in terms of burnt area [R6.1].

In 2025, fire danger levels were above average for Europe as a whole from March to April and from June to September, and were slightly above average in November. The largest anomalies were seen from mid-June to mid-August and were predominantly driven by warm and dry conditions in southern Europe. Southeastern areas saw above-average fire danger from June to September, and generally higher values and anomalies than in the rest of Europe, while the highest positive anomalies in southwestern areas were seen towards the end of September.

15 The definition may differ depending on the variable being discussed, but when not specified, follows the C3S definition.

These variations in conditions are reflected in the above-average number of days during the year with 'extreme' fire danger (FWI of 50 or above, when 'critical' fires, those above 10,000 ha, can develop). While most of Türkiye saw 25 to 30 such days, much of the Iberian Peninsula saw 5 to 15 days, with only a small region of southern Spain reaching up to around 30 days.

Fire danger was above average across most of Europe during the summer, with the highest anomalies observed in July and August, mainly influenced by conditions in southern Europe.

More days than average with 'extreme' fire danger in southern Europe in 2025

Anomalies in the number of days with Fire Weather Index ≥ 50 in 2025

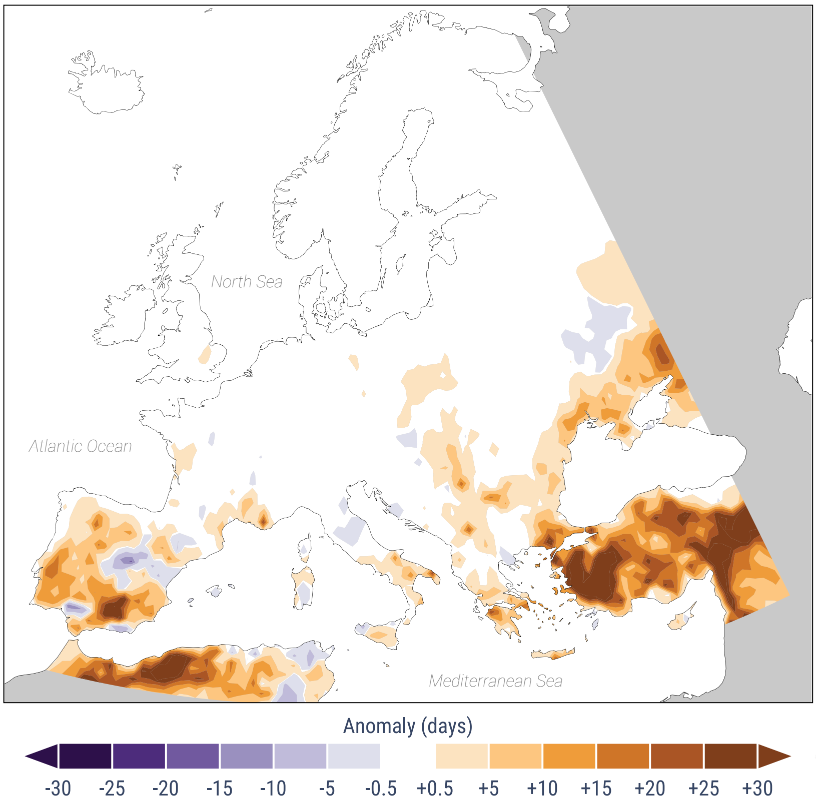


Figure 6.1. Anomalies in the number of days with a Fire Weather Index of 50 or above (indicating 'extreme' fire danger) in Europe in 2025, relative to the average for the 1991–2020 reference period. These conditions are when 'critical' fires, those above 10,000 ha, can develop. Data: FWI based on ERA5. Credit: CEMS/C3S/ECMWF.

Burnt areas

Burnt areas across Europe and the Mediterranean in 2025

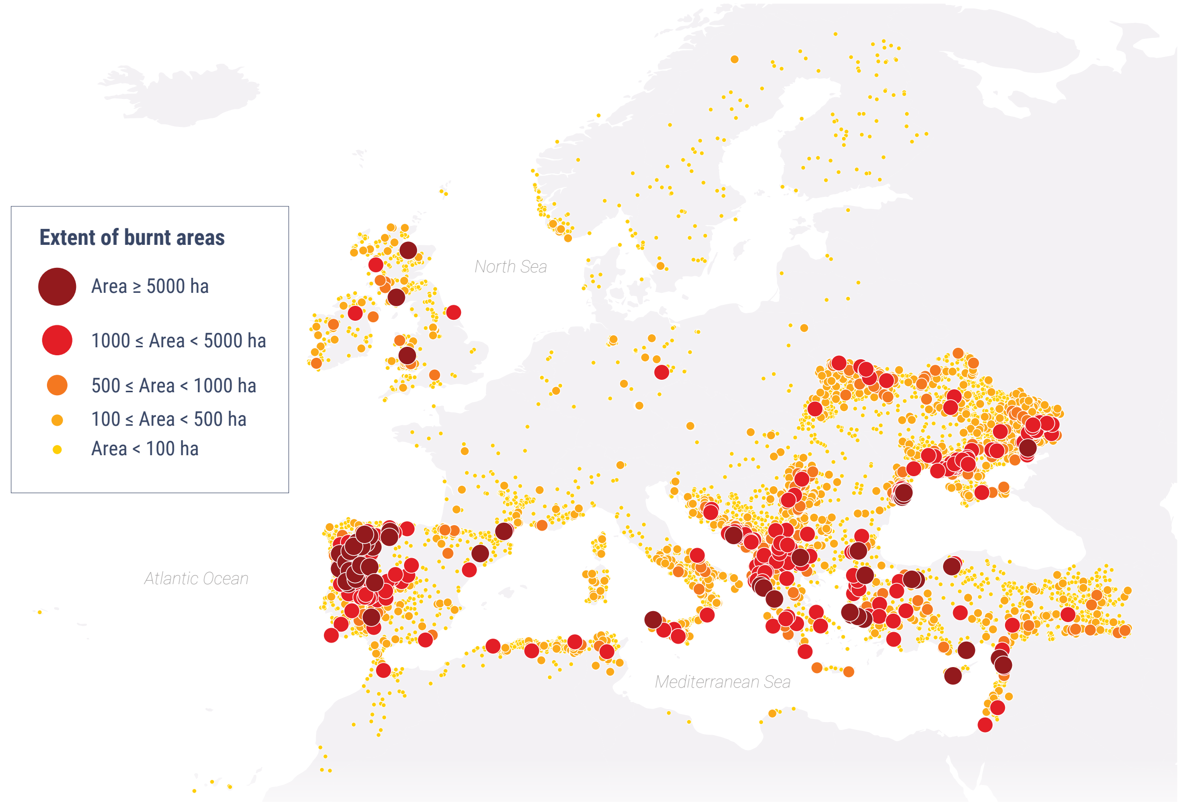


Figure 6.2. Distribution and extent of burnt areas across Europe and the Mediterranean[16] in 2025. Data: European Forest Fire Information System (EFFIS). Credit: EFFIS/CEMS/C3S/ECMWF.

Europe[17] as a whole saw a new record for burnt areas in 2025,[18] at 1,034,552 hectares,[19] surpassing the previous record of around 988,524 hectares set in 2017 [R6.2].

The fire season began exceptionally early. Parts of western Europe, including the United Kingdom and Ireland, saw significant wildfire activity and associated burnt areas in February, and parts of western, central and eastern Europe in March and April. Warm and dry conditions may have contributed to the spread and intensification of

16 This domain encompasses the EU27 countries and Albania, Bosnia and Herzegovina, Kosovo under UNSCR 1244, Montenegro, North Macedonia, Norway, Serbia, Switzerland, Türkiye, the United Kingdom and Ukraine; and Algeria, Israel, Lebanon, Libya, Morocco, Palestinian Territory, Syria and Tunisia.

17 The European Union (EU27): Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Sweden, Slovakia, Slovenia and Spain.

18 All estimates in this subsection unless otherwise specified, have been provided by EFFIS, the *European Forest Fire Information System.*

19 Based on fires larger than 30 hectares.

these early fires. In summer, several severe heatwaves, including two in June and early July, affected large parts of western and southern Europe, creating ideal conditions for large wildfires. In early August, a third heatwave impacted the Iberian Peninsula. There, a shift from wet to dry conditions had provided abundant dried-out vegetation to fuel several large wildfires in Spain and Portugal, which contributed to a larger-than-average burnt area for Europe. In Zamora, Spain, around 40,081 hectares were burnt – the largest fire in the country since records began in 1968.

Burnt area in Europe also reached a record level in 2025, at around 1,034,552 hectares. The largest contributions came from fires across the Iberian Peninsula in August. By the end of the month, Spain and Portugal had seen record cumulative burnt areas.

By the end of August, Spain and Portugal had seen record cumulative burnt areas of around 380,877 hectares and 265,139 hectares respectively. These were 4.6 times the average for Spain and 3.7 times the average for Portugal for the same period between 2006 and 2024.

While Portugal and Spain were the most affected countries, accounting for 65% of Europe's total burnt area, other countries also experienced significantly larger than average burnt areas. This included France, where a fire in Ribaute (Aude department) burnt around 11,391 hectares,[20] and Germany, Italy, Romania and Slovakia.

Several European countries outside of the geographic domain used to calculate these annual totals, such as the United Kingdom, Montenegro, North Macedonia, Türkiye and Bosnia and Herzegovina, also recorded larger-than-average burnt areas.

Wildfire emissions

Wildfires release a complex mixture of gases and aerosols, including large amounts of carbon dioxide and 'black carbon'. Monitoring these emissions is one way to assess the scale of fire activity in a region. In Europe, the resulting CO_2 emissions are usually limited compared with total anthropogenic CO_2 emissions, but the impact on air quality can be significant.

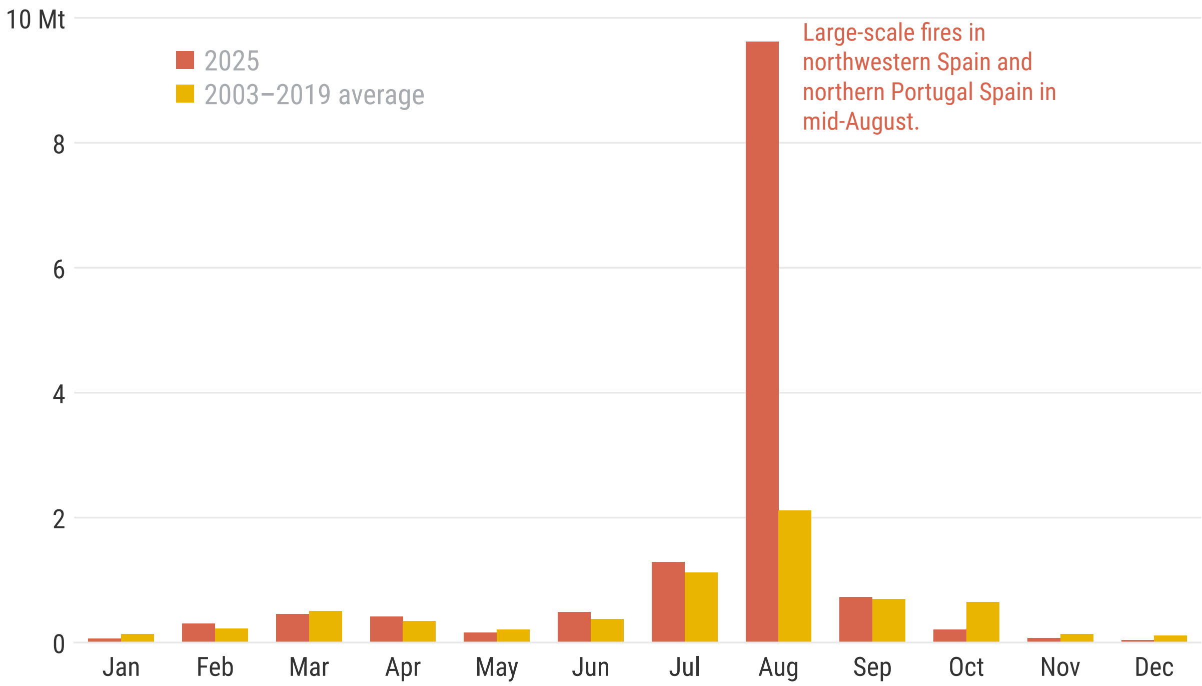
20 While similar estimates are consistent with those published in reports by Météo France and the Office National des Forêts, different burnt area extents may have been reported elsewhere

Total annual emissions for 2025 were the highest in the Copernicus Atmosphere Monitoring Service (CAMS) record, which started in 2003, with higher-than-average contributions from both northern and southern Europe. Fire emissions for Europe[21] as a whole were near average for every month except August. In southeastern Europe, Cyprus, Türkiye and some Balkan countries – notably Albania, Bulgaria, Kosovo, Montenegro, North Macedonia and Serbia – experienced above-average emissions for July and August, with Cyprus recording a record annual high. In southwestern Europe, the large-scale fires in northwestern Spain and northern Portugal in mid-August generated much above-average emissions, contributing approximately half of the European total estimated fire emissions for the year. Spain saw a new annual record.

In northern Europe, the annual fire emissions for the United Kingdom, Netherlands and Germany were all the highest on record.

August saw the highest wildfire emissions of 2025

Monthly wildfire carbon emissions for Europe



Mt = megatonnes = 1 million tonnes. The domain comprises: Austria, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Figure 6.3. Estimated total monthly wildfire carbon emissions for Europe in 2025 (red) compared to the monthly average emission for the 2003–2019 reference period (yellow). Data: CAMS GFASv1.2 wildfire data record. Credit: CAMS/C3S/ECMWF.

21 Austria, Czechia, Denmark, Estonia, Finland, Germany, Hungary, Ireland, Latvia, Lithuania, the Netherlands, Poland, Sweden, Slovakia and the United Kingdom (northern Europe) as well as Bulgaria, Croatia, Cyprus, France, Greece, Italy, Portugal, Romania, Slovenia and Spain (southern Europe). Southwestern Europe comprises France, Italy, Portugal and Spain; southeastern Europe comprises Bulgaria, Croatia, Cyprus, Greece, Romania and Slovenia.

Long-term trends

In recent years, European summers have seen increased wildfire potential [R6.3; R6.4], with a growing number of larger fires and an extended fire season.

The IPCC AR6 reports that wildfire risk could increase across all regions of Europe, particularly in southern Europe and the Mediterranean. Projections suggest that new wildfire-prone regions in western, central and northern Europe may emerge.

Extreme fire-weather days are increasing in the northwestern Iberian Peninsula

Number of extreme fire-weather days in August

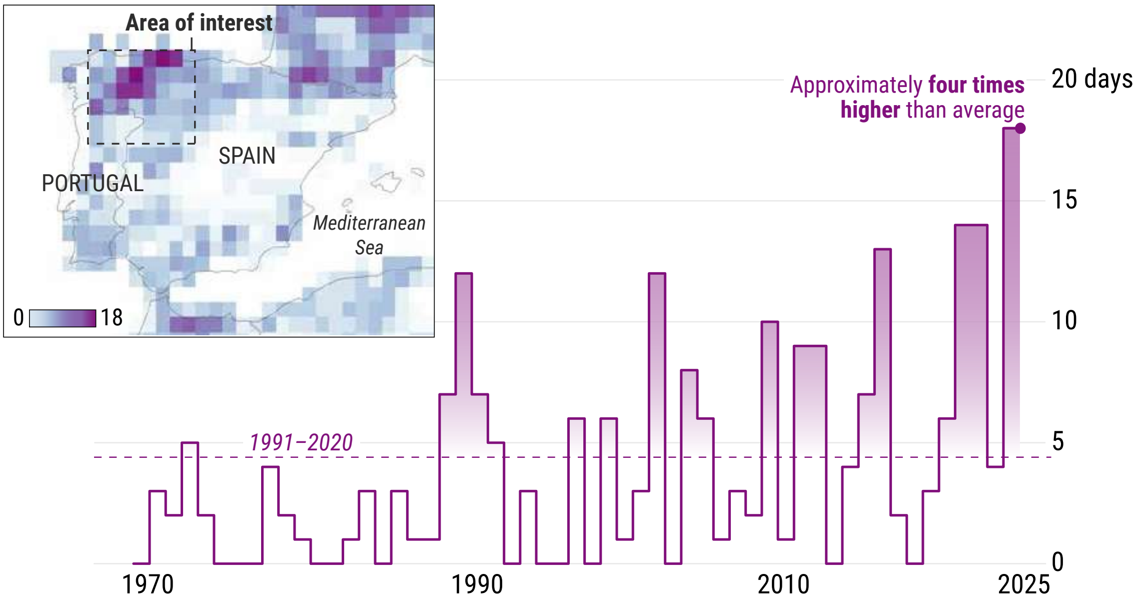


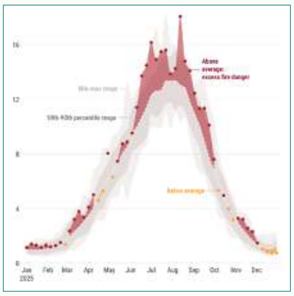
Figure 6.4. Number of days with Fire Weather Index above the 95th percentile – or 'extreme' fire weather days – in August 2025 in an area in the northwestern Iberian Peninsula (map inset) and spatial averages for the same area for August from 1970 to 2025. The dashed horizontal line shows the August average for the 1991–2020 reference period. Data: FWI based on ERA5. Credit: CEMS/C3S/ECMWF.

Analysing the trend of the FWI for a region of the northwestern Iberian Peninsula that experienced exceptionally severe fires in August shows that the number of days with 'extreme' FWI,[22] or 'extreme' fire weather days, in 2025 was 18, around four times higher than the average for the month. There is a clear increasing trend in extreme fire weather conditions for this region, associated with an approximately 15% increase in the area affected by extreme summer drought [R6.5].

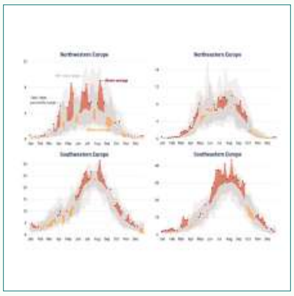
22 Above the 95th percentile i.e. FWI higher than the highest 5% of values for the period and region in question during the reference period.

Where increasing fire weather extremes are observed, fire activity may also increase due to the presence of larger amounts of dried-out vegetation. This can happen when wetter-than-average conditions, favouring vegetation growth, are followed by hot and dry periods.

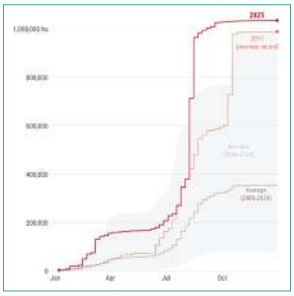
Supplementary figures



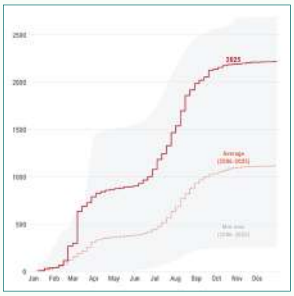
Weekly Fire Weather Index for Europe



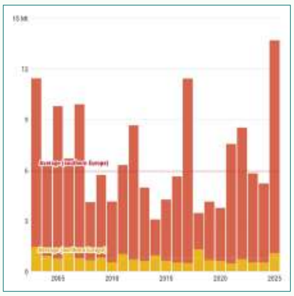
Weekly Fire Weather Index for four regions



Cumulative wildfire burnt areas through 2025



Cumulative number of fires through 2025



Annual wildfire emissions since 2003

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

7.

Clouds and sunshine

Cloud cover and sunshine duration are relevant to many sectors of society, including renewable energy and tourism. Both variables have been observed since the late 19th century, initially by eye and by simple instruments on the ground. Since the early 1980s, satellite observations have been used to obtain estimates of cloud cover, surface solar radiation[23] and sunshine duration.[24]

In 2025, sunshine duration and surface solar radiation were much above average in northwestern, central and eastern Europe, as well as in parts of the Mediterranean, and below average across the Iberian Peninsula and northeastern Europe.

This section provides an overview of anomalies in sunshine duration, solar radiation and cloud cover across Europe in 2025.

Sunshine and solar radiation

For Europe as a whole, sunshine duration in 2025 was around 5% higher than average.

Above-average values were seen over much of the continent, with the largest positive anomalies observed in parts of northwestern, central and eastern Europe. Parts of northern France, Germany, Denmark, Ireland and the United Kingdom as well as Türkiye, experienced much above-average to record-high sunshine duration. In parts of the United Kingdom, the annual anomaly reached up to 300 hours, which is around 30% above average. For the United Kingdom as a whole, the Met Office reported a record high sunshine duration. The largest anomalies were seen in spring in central and northwestern Europe and in early summer in Türkiye and adjacent regions.

In contrast, three main regions experienced below-average sunshine duration in 2025: a large area of northeastern Europe encompassing part of western Russia, northern Belarus and much of the Baltic states; parts of the western Mediterranean, including the Iberian Peninsula; and the North Atlantic Ocean west of Ireland.

23 A measure of how much solar energy within the 2.0-4.0 μm wavelength (or shortwave) region reaches Earth's surface per unit area.

24 A measure of the total amount of time, usually in hours per day, month or year, in which direct normal (perpendicular to the surface) solar radiation exceeds a threshold intensity of 120 W/m^2.

In all these areas, annual negative anomalies spanning 60 to 180 hours (-5% to -15%) were observed. The largest negative anomalies were seen in May to July for northeastern Europe, in March for the Iberian Peninsula and throughout summer as well as in October for the North Atlantic Ocean.

The positive sunshine duration and surface solar radiation anomalies are in line with the trends observed during the last 40 years.

In general, the spatial distribution of sunshine duration anomalies largely mirrors those of surface solar radiation anomalies.

Much of Europe saw above-average sunshine duration in 2025

Anomalies in annual sunshine duration in 2025

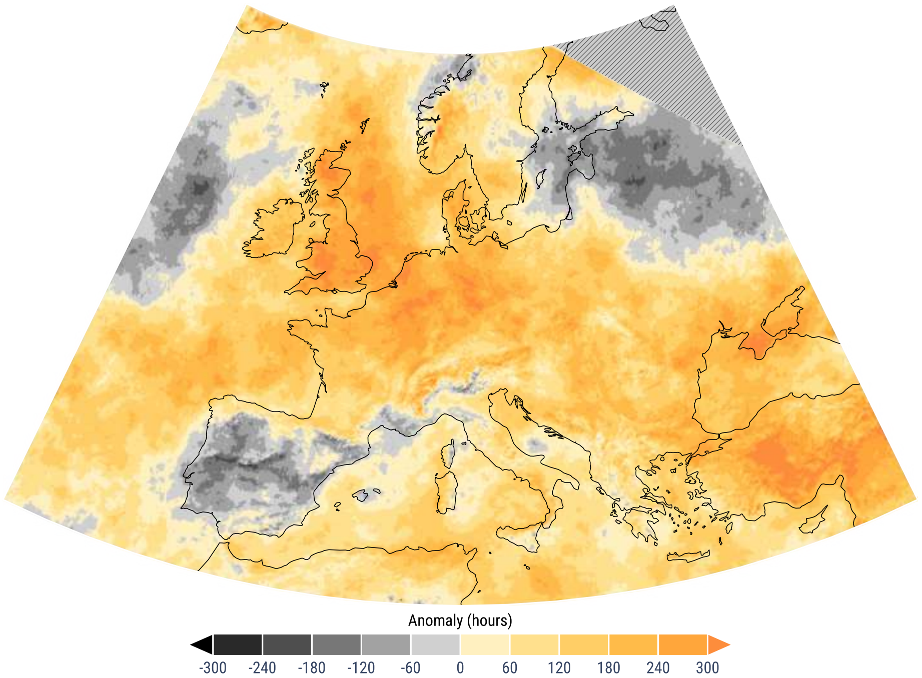


Figure 7.1. Sunshine duration anomalies (hours) over Europe for 2025, relative to the average for the 1991–2020 reference period. Grey hatching in the top right corner of the map indicates missing data. Data: CM SAF SARAH-3 CDR/ICDR. Credit: C3S/ECMWF/DWD/EUMETSAT.

Cloud cover

As cloud cover is the main moderator for solar radiation reaching the surface, positive anomalies in sunshine duration and surface solar radiation generally correspond to negative anomalies in cloud cover and vice versa.

Cloud cover was below average over much of Europe. Above-average cover was seen over the Iberian Peninsula, northeastern Europe and the Aegean Sea.

Much of Europe saw below-average cloud cover during 2025, with a negative anomaly of around 3% for the continent's land areas as a whole. Following a similar pattern to that of sunshine duration, the largest negative anomalies, of -6 to -8%, were observed in parts of northwestern, central and eastern Europe as well as over the central and eastern Mediterranean. Conversely, the Iberian Peninsula and the Baltic states, as well as the Aegean Sea, saw large scale positive anomalies of around 5–8%. The largest anomalies were observed in February and March for the Iberian Peninsula, and in May to July for northeastern Europe. The most-above-average cloud cover anomalies for the Aegean Sea were in late summer.

In general, the annual patterns observed for sunshine duration, cloud cover and solar radiation reflect the wet and dry patterns seen during 2025. Southwestern Europe was predominantly wet, while northwestern, central and eastern Europe were widely dry, as shown in multiple variables including precipitation, soil moisture and river flow.

Much of Europe saw below-average cloud cover in 2025

Anomalies in annual cloud cover in 2025

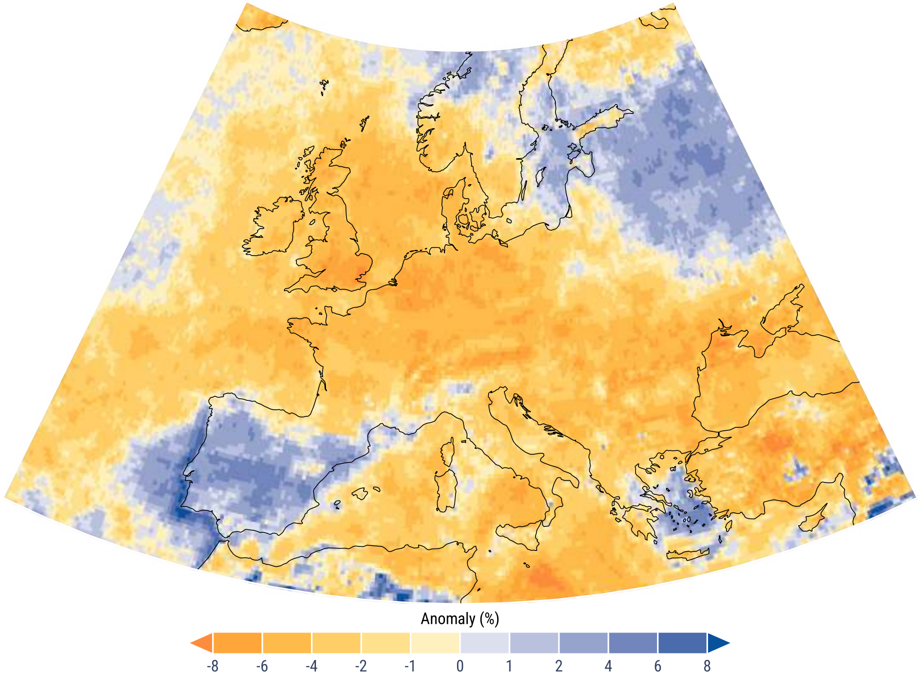


Figure 7.2. Average annual cloud cover fraction anomalies (%) over Europe for 2025, relative to the average for the 1991–2020 reference period. Data: CLARA-A3 CDR/ICDR. Credit: C3S/ECMWF/DWD/EUMETSAT.

Long-term trends

Sunshine duration in Europe is increasing

Anomalies in annual sunshine duration for European land

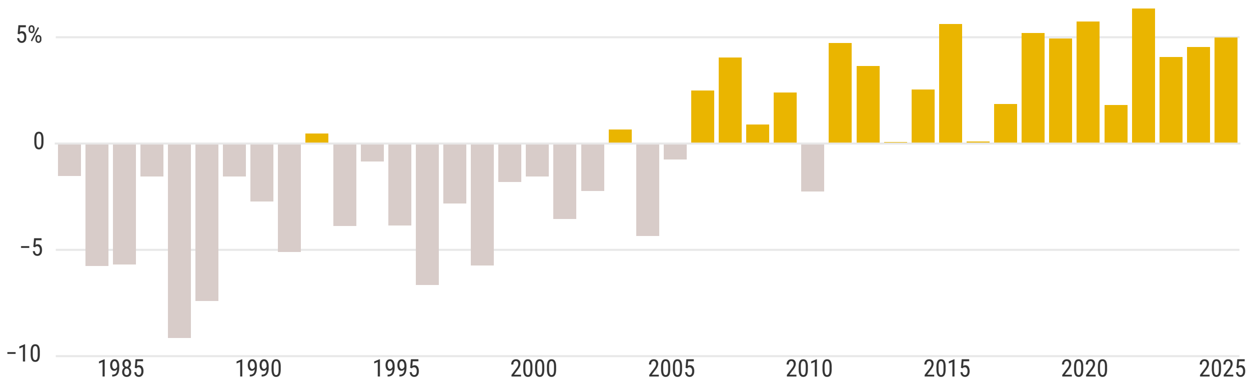


Figure 7.3. Annual sunshine duration anomalies (%) for Europe for 1983–2025, relative to the average for the 1991–2020 reference period. The anomalies are for land areas only and expressed as a percentage above or below average. Data: CM SAF SARAH-3 CDR/ICDR Credit: C3S/ECMWF/DWD/EUMETSAT.

Cloud cover in Europe is decreasing

Anomalies in cloud cover over European land

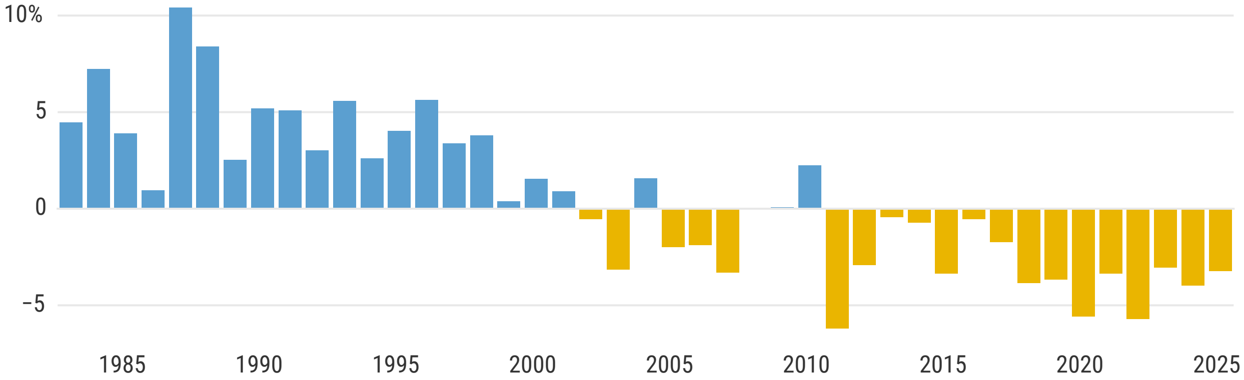


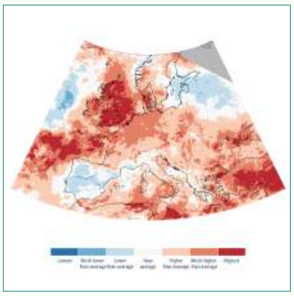
Figure 7.4. Annual cloud cover fraction anomalies (%) for Europe for 1983–2025, relative to the average for the 1991–2020 reference period. The anomalies are for land areas only and expressed as a percentage above or below average. Data: CLARA-A3 CDR/ICDR Credit:C3S/ECMWF/DWD/EUMETSAT.

The past four decades have seen a trend towards higher values of sunshine duration and surface solar radiation. The above-average sunshine duration observed during 2025 continues a series of positive anomalies seen since 2006, with the exception of 2010.

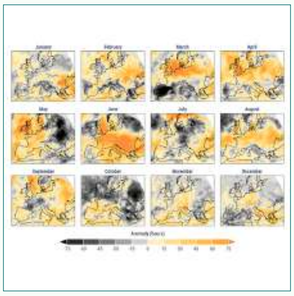
For cloud cover, a decrease over time has been observed.

According to the IPCC AR6, surface solar radiation in Europe has generally been rising over the past 40 years. There is also increasing sunshine duration and decreasing cloud cover. Higher greenhouse gas concentrations and lower aerosol levels are contributing to these changes. With fewer aerosols there are fewer cloud condensation nuclei, resulting in larger, less reflective water droplets and reduced cloud cover. Projections suggest surface solar radiation will rise further over southern Europe. By contrast, northern regions may see a decrease. These changes may be related to shifts in cloud properties, with fewer but larger ice crystals and more but smaller water droplets that may increase the reflection of solar radiation into space.

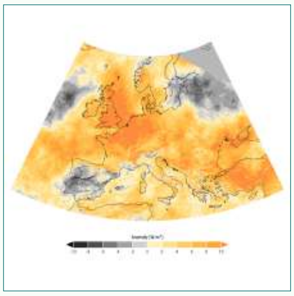
Supplementary figures



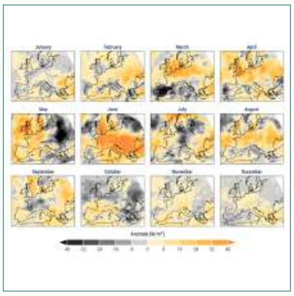
Anomalies and extremes
in sunshine duration



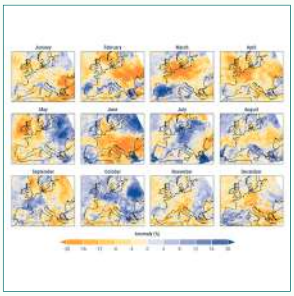
Monthly sunshine
duration anomalies



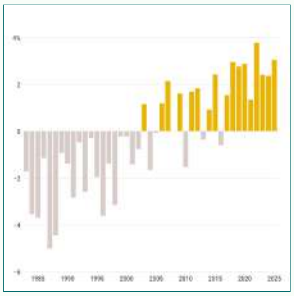
Annual solar
radiation anomalies



Monthly solar
radiation anomalies



Monthly cloud cover anomalies



Annual solar radiation
anomalies since 1983

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

8.

Renewable energy resources

Renewable power generation is core to Europe's transition to a decarbonised energy system. Ember reports that in 2025, 14 out of 27 EU countries generated more electricity from wind and solar than from fossil fuels.

Renewables supplied nearly half (46.4%) of Europe's electricity in 2025, almost matching the record level reached in 2024, with solar power setting a new contribution record, at 12.5%.

Renewable power generation and electricity demand are highly sensitive to environmental conditions, which are shaped by phenomena occurring across different timescales, from short-term weather events to long-term climate trends. As Europe increasingly relies on renewables, understanding their temporal and spatial variability in an evolving climate is vital. This includes assessing how these variations affect electricity demand and the potential for renewable power generation.

This section reviews Europe's actual electricity generation in 2025 and the influence of climate conditions on potential power generation from onshore wind and solar photovoltaic (PV). Non-climatic factors, such as technological efficiency improvements, are not considered.

Europe's electricity generation

In 2025, almost half (46.4%) of the actual electricity generation in Europe came from renewables. This is nearly unchanged from 2024 (46.5%), which was a new record for the share of electricity generated from renewables and marked the first time that electricity generation from wind and solar exceeded that from fossil fuels. In 2025, wind and solar together supplied 30.5% of Europe's electricity, compared with 27.5% from fossil fuels. Including hydropower, renewables have generated more electricity than fossil fuels every year since 2023, following a period from 2020 to 2022 when electricity generation from renewables and fossil fuels was similar.

Solar power reached a record-high contribution of 12.5% in 2025, up from 10.3% in 2024, while wind contributed 18% and hydro 15.9%. From 2016 to 2021, the contribution from solar grew from 3.4% to 5.3% and has since increased rapidly. According to Ember, the record contribution in 2025 is predominantly due to increasing solar capacity across Europe, with an additional 65 GW added to the EU fleet in 2025. Onshore and offshore wind capacity also increased, with 19 GW added, according to WindEurope.

New record for solar power generation in Europe

Percentage of the total annual actual electricity generation for Europe from different sources

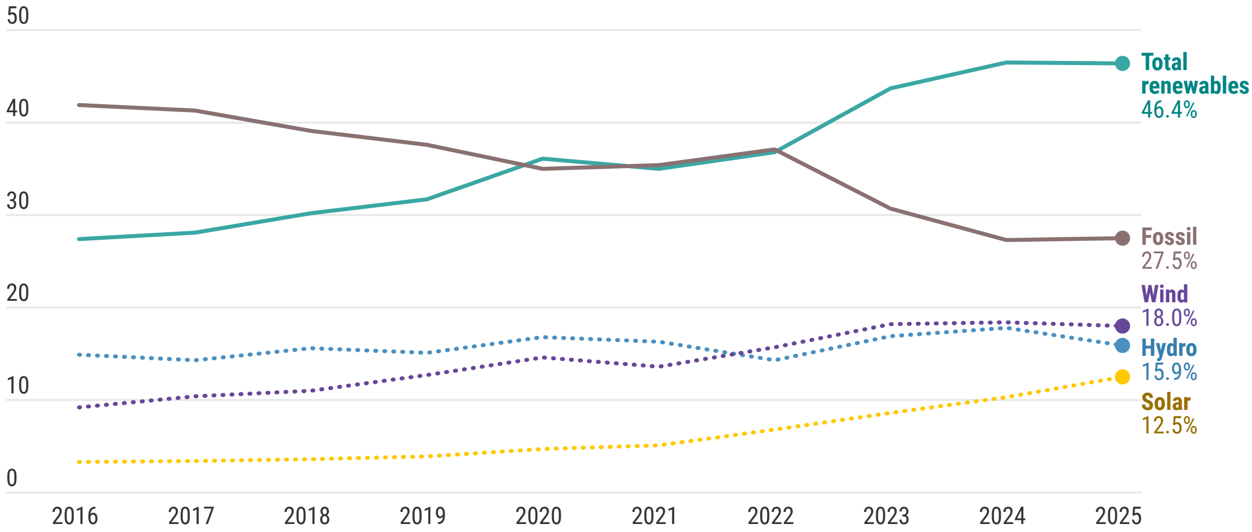


Figure 8.1. Percentage of the total actual annual electricity generation for Europe, from solar (yellow), wind (purple) and hydro (blue) power, alongside the total contribution from renewables (green) and from fossil fuels (brown), for 2016–2025. The remaining proportion in 2025 came from nuclear (22%) and bioenergy (4%) (not shown). The definition of Europe used here is the EU27 and Bosnia and Herzegovina, Kosovo, Moldova, Montenegro, North Macedonia, Norway, Serbia, Switzerland and the United Kingdom. Data: Ember. Credit: Rabobank/C3S/ECMWF.

Solar and wind potential

In 2025, there was a mixed picture for potential power generation from solar PV, with above-average potential in a swathe from northwestern to central and eastern Europe, and below-average potential in much of southern Europe and parts of northern Europe. This generally reflects the sunshine and solar radiation conditions,[25] with much

25 The calculation of solar PV power potential (capacity factor) depends on surface solar radiation, near-surface air temperature and solar panel characteristics. As panel efficiency decreases with temperature, and higher solar radiation is often associated with warmer conditions, anomalies in solar PV potential can differ from those in surface solar radiation.

above-average solar radiation across northwestern, central and eastern Europe, and below-average solar radiation across the Iberian Peninsula and northeastern Europe. Across the United Kingdom, which saw its sunniest year on record in 2025, and part of the Netherlands, the potential for power generation from solar PV was up to 10% higher than average. Across much of the rest of northwestern Europe, potential was up to 6–8% above average. More information on sunshine duration and solar radiation can be found in the 'Clouds and sunshine' section.

Solar photovoltaic power potential reflected contrasting sunshine conditions, with above-average potential in northwestern and central Europe and below-average potential in the Iberian Peninsula and northeastern Europe.

Strong regional contrasts in solar radiation and solar photovoltaic potential in 2025

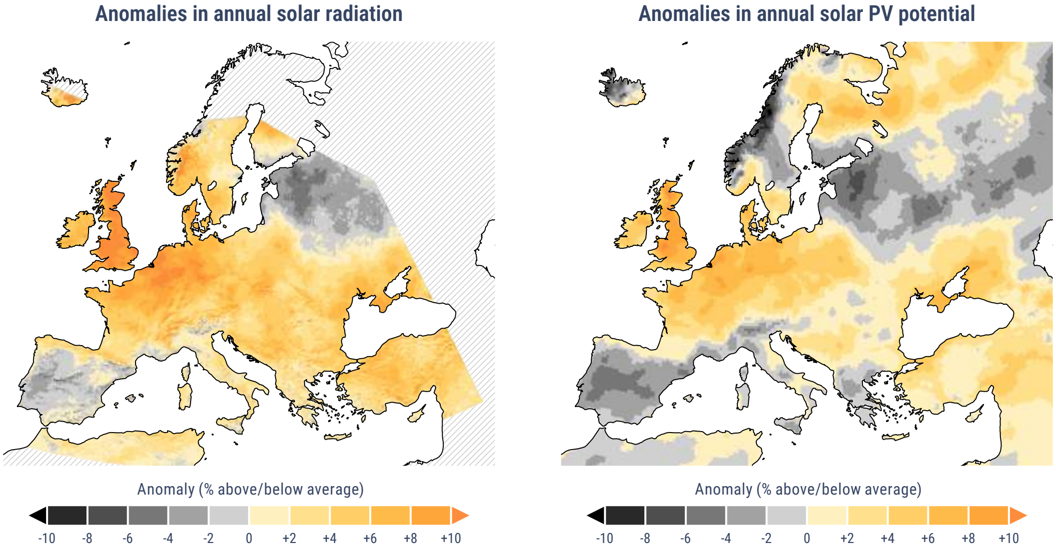


Figure 8.2. (Left) Annual anomalies (%) in solar radiation and (right) potential power generation from solar photovoltaic (PV) in 2025, relative to the average for the 1991–2020 reference period. Anomalies are expressed as a percentage above or below average. Potential for power generation is based on the capacity factor. Grey hatching indicates areas outside of the dataset domain. Data: Solar radiation from CM-SAF SARAH-3, Solar PV potential from C3S Global climate and energy indicators derived from ERA5. Credit: DWD/EUMETSAT/C3S/ECMWF.

In contrast, potential power generation from onshore wind in Europe was generally below average, reflecting below-average wind conditions across the continent. This was particularly the case in much of central and southeastern Europe, such as around the Alps, southern Germany, western Czechia, Italy and Greece, where the potential power generation from wind was up to 25% lower than average. However, there were some exceptions, notably in Fennoscandia, Türkiye and parts of western Europe, including northwestern areas of the Iberian Peninsula and parts of western France.

Despite below-average wind conditions, wind power contributed 18% of Europe's total actual electricity generation, only slightly below the shares in 2024 (18.4%) and 2023 (18.2%). This reflects the fact that weaker winds were at least partially offset by increased installed onshore wind capacity in Europe, with a total of 17 GW added in 2025. Wind conditions can vary from year to year, within a year and with height. The existing fleet of wind turbines is diverse, with different turbines exhibiting different characteristics that help to smooth the effects of wind variability.[26] While low-wind conditions can limit wind power generation, this effect may be partly mitigated by newer, taller turbine models designed to generate power more efficiently during low-wind periods, or by a higher share of offshore wind energy.

Below-average wind speeds and wind power potential across much of Europe in 2025

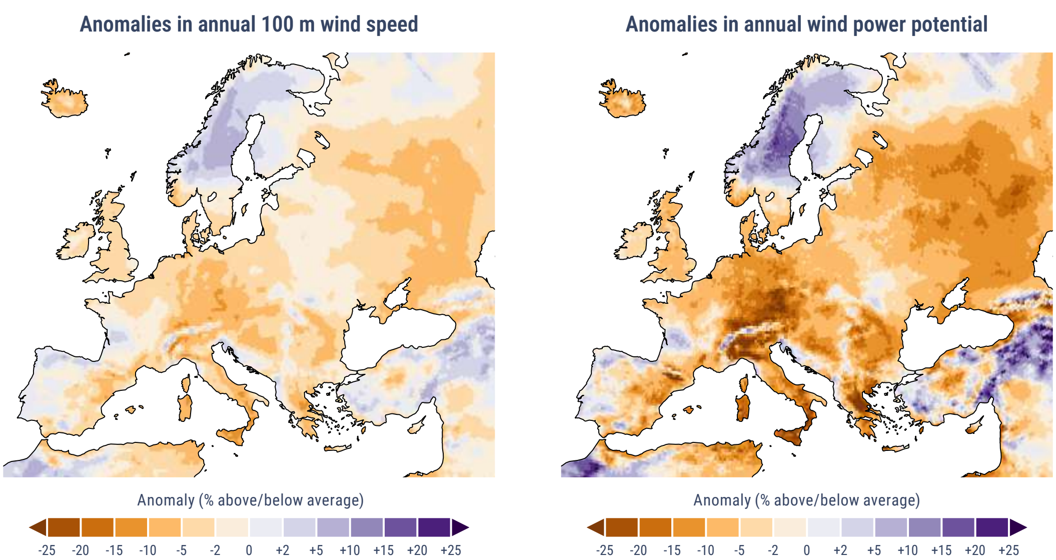


Figure 8.3. Annual anomalies (%) in (left) 100 m wind speed and (right) potential power generation (capacity factor) from onshore wind in 2025, relative to the average for the 1991–2020 reference period. Anomalies are expressed as a percentage above or below average. Data: C3S Global climate and energy indicators derived from ERA5. Credit: C3S/ECMWF.

26 Here, potential wind power generation is modelled using a single turbine from the existing fleet (a GE Energy 2.5–103 with a hub height of 100 m). The results could vary if a different turbine were used, as each turbine has specific cut-in and cut-off wind speeds and therefore reacts differently to wind speed.

Seasonal and regional variation

Comparing regional anomalies in potential power generation can highlight energy resources at a larger scale. Here, two regions are chosen with contrasting climatic conditions during 2025, although countries within each region saw relatively similar conditions for the year as a whole. The two regions are northwestern and central Europe (NWC region), defined as Ireland, the United Kingdom, France, Belgium, the Netherlands, Luxembourg, Denmark and Germany, and the Iberian Peninsula (Spain and Portugal).

Contrasting conditions for potential power generation from renewables

Monthly anomalies in the potential for renewable power generation for two regions in Europe

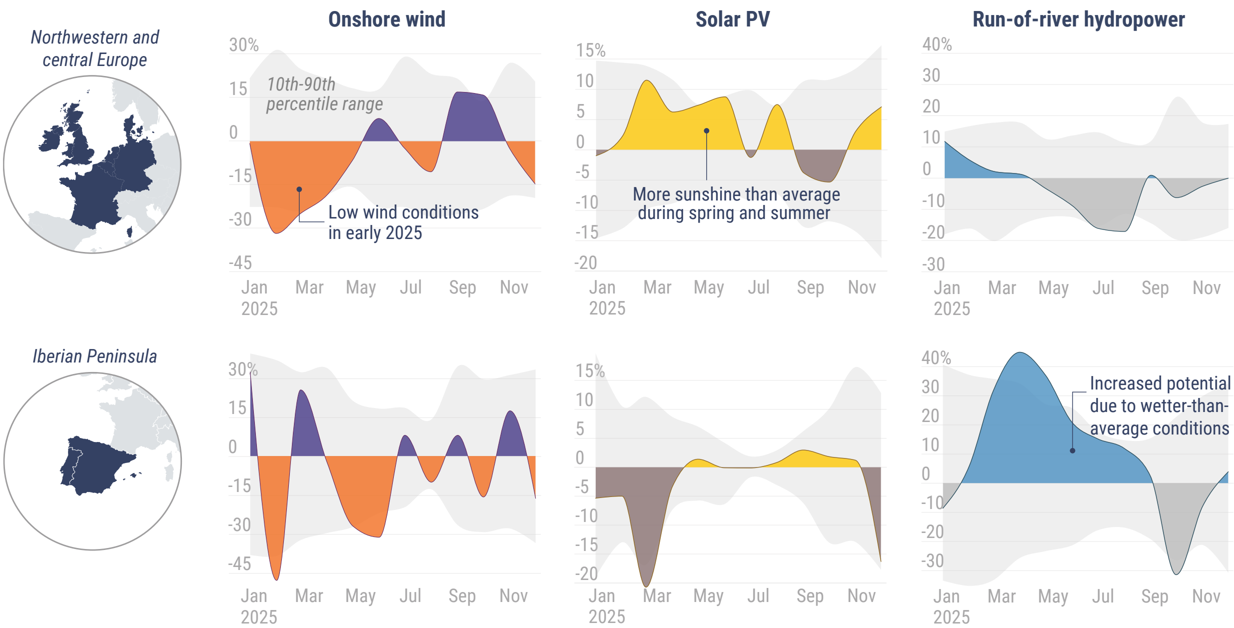


Figure 8.4. Monthly anomalies in the potential for power generation (capacity factor) from onshore wind, solar photovoltaic (PV) and run-of-river hydropower, averaged over (top) northwestern and central Europe (Ireland, the United Kingdom, France, Belgium, the Netherlands, Luxembourg, Germany and Denmark) and (bottom) the Iberian Peninsula (Spain and Portugal). The anomalies are expressed as percentages relative to the 1991–2020 reference period. Grey shading indicates the 10–90th percentile range of the 1991–2020 reference period, which represents the majority of historical values excluding the highest and lowest 10%. Data: C3S Global Energy Indicators. Credit: C3S/ECMWF.

In the NWC region, January to May saw below-average potential for wind power generation, reaching 32% below average in February. During the summer, anomalies varied and then remained above average from September to November. For the Iberian Peninsula, potential for wind power generation was more variable. Anomalies switched from above- to below-average potential every one or two months, with the largest anomalies in the first half of the year, reaching 48% below average in February and 26% above average in March. These statistics are based on the wind power generation obtained with a specific 100 m high wind turbine. Other turbines, such as those with newer designs or different characteristics, can smooth the impact of low and variable wind conditions, resulting in smaller anomalies for potential wind power generation.

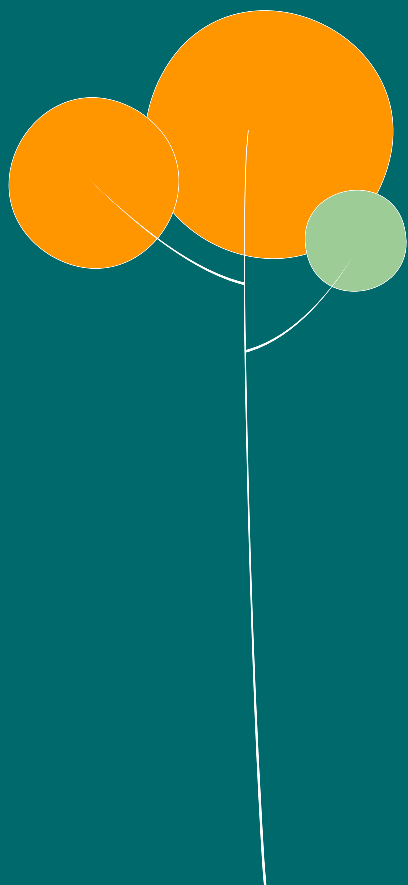
Onshore wind power potential was generally below average across much of Europe due to lower wind speeds. Despite this, the share of Europe's actual electricity generation from wind was 18% and only slightly lower than in 2024 (by 0.4%), in part due to increased installed capacity.

The potential for solar PV shows substantial contrast between the two regions for much of the year. For the NWC region, solar PV potential was generally above average from February to September, consistent with the sunshine conditions. In contrast, for the Iberian Peninsula, potential for solar PV power generation was much below average (up to -21%) in March, before becoming close to average for much of the rest of the year, despite the below-average solar radiation and sunshine duration for the year as a whole.

The potential for run-of-river hydropower also reflected contrasting climatic conditions between the two regions. In the NWC region, potential for run-of-river hydropower was above average at the start of the year before shifting to mostly below-average conditions from May to December, particularly in June and July. This largely reflected precipitation and river flow patterns across Europe. By contrast, the Iberian Peninsula saw much above-average potential from February to September, reaching a peak of 45% above average in April. Increased potential from one renewable energy resource may offset lower potential from others. In this case, increased hydropower potential could help offset lower potential from wind and solar power. Spring, in particular, saw a strong contrast in precipitation between the two regions, while the year as a whole saw generally below-average river flow in the NWC region and above-average river flow across the Iberian Peninsula. More on precipitation and river flow can be found in their respective sections of the report.

9.

Precipitation



Precipitation is a key component of the global water cycle. It is essential for freshwater resources, food production, ecosystem health and inland waterway transport. It reflects how moisture is redistributed from the atmosphere to the land and oceans, and naturally varies with changing weather patterns over daily, seasonal and annual timescales. Prolonged periods of above- or below-average precipitation can be precursors to floods or droughts. Short-lived intense rainfall can also trigger flooding and cause severe damage. In addition to natural fluctuations, climate change is altering precipitation patterns and increasing the likelihood of extremes in many regions.

Drier-than-average conditions prevailed across a large area from northwestern to eastern Europe.

This section provides an overview of anomalies and extremes in annual and seasonal precipitation across Europe in 2025 based on three datasets[27] (ERA5, E-OBS and GPCC). The section concludes with a summary of current knowledge on long-term precipitation changes in Europe.

Annual overview

In 2025, annual precipitation was below average across much of Europe, particularly across a large swathe stretching from the United Kingdom, northern France and the Benelux countries in the west to Ukraine, Türkiye and the Caucasus in the east. Across much of this region, annual precipitation totals were 10 to 40% below average.

Much drier-than-average conditions, with precipitation deficits reaching 20 to 40%, were observed along the eastern coasts of Scotland and England, as well as in Belgium, the Netherlands, Germany, Hungary, Romania, Ukraine and Türkiye, and parts of southern Sweden. Some locations in Belgium, the Netherlands, Germany and around the Black Sea experienced their lowest annual precipitation totals since at least 1979. For Germany as a whole, 2025 ranked as the 15th driest year since measurements began in 1881. For Türkiye, 2025 was the driest year since at least 1964.

27 Some differences exist between the three datasets in the depiction of spatial anomalies, as well as in regional averages and rankings. The assessment presented here mainly focuses on areas of agreement between datasets.

By contrast, wetter-than-average conditions prevailed in much of southwestern and northeastern Europe, with much wetter-than-average conditions in Portugal and southwestern Spain, northern Norway, the Kola Peninsula in Russia and across the Baltic countries.

For northwestern and central Europe, 2025 was one of the 10 driest years since 1979, contrasting with exceptionally wet conditions in 2023 and 2024.

The widespread dry conditions were associated with below-average river flow, above-average sunshine hours and solar radiation, and reduced cloud cover. The contrast between the drier conditions in northwestern Europe and the wetter conditions in the Iberian Peninsula is further discussed in the 'Renewable energy resources' section.

West-east swathe of below-average precipitation across Europe in 2025

Anomalies and extremes in annual precipitation in 2025

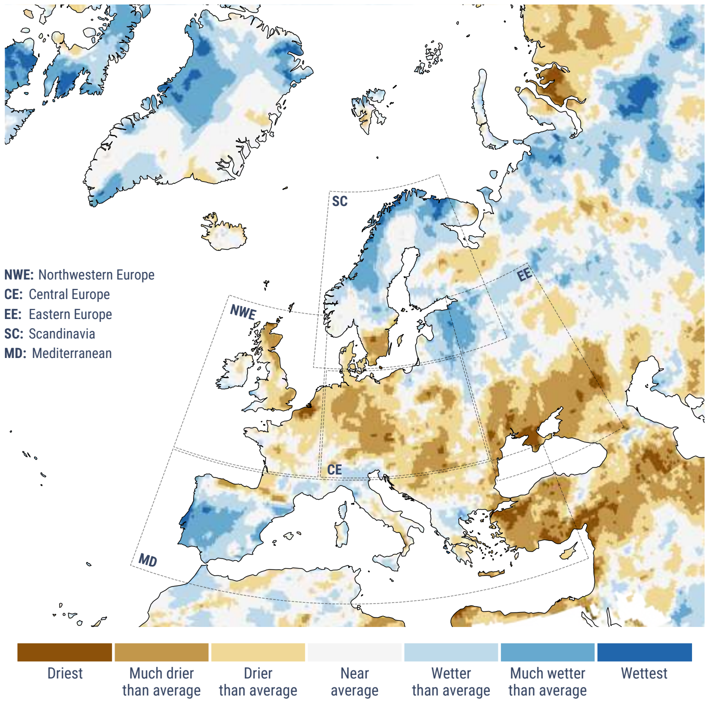


Figure 9.1a. Anomalies and extremes in annual precipitation in 2025. The extreme categories ('wettest' and 'driest') are based on rankings for 1979–2025. The other categories describe how precipitation compares to the distribution during the 1991–2020 reference period. 'Much wetter/drier than average' – wetter/drier than 90% of precipitation values; 'wetter/drier than average' – than 66% of precipitation values; 'near average' – within the middle 33%. The dashed boxes outline the five European subregions discussed in the text. Data: ERA5. Credit: C3S/ECMWF.

Regional averages

Precipitation conditions in 2025 were also assessed using averages across five European subregions[28] (Supplementary Figure S9.1.). In northwestern Europe, annual precipitation was 8% below average, placing 2025 among the 10 driest years since 1979. Central Europe saw a deficit of 11%, making it one of the eight driest years since 1979.

In northwestern Europe and parts of central Europe, these dry conditions followed two exceptionally wet years, 2023 and 2024, when widespread flooding was linked to successive months with much wetter-than-average conditions and to extreme events, including Storm Boris in September 2024. In 2025, precipitation in eastern Europe was 3% below average, a smaller deficit than in 2024 (–11%).

In contrast, precipitation was 4% above average for Scandinavia, consistent with the long-term trend towards wetter conditions. The Mediterranean region as a whole saw near-average precipitation (+1%), but with a pronounced contrast between wet conditions in the west and dry conditions in the east.

28 The statistics reported are based on the average of the three datasets for the annual anomalies and on their range for annual rankings (i.e. minimum and maximum rankings).

Variations throughout the year

Marked precipitation contrasts across western Europe in spring

Anomalies and extremes in seasonal precipitation in 2025

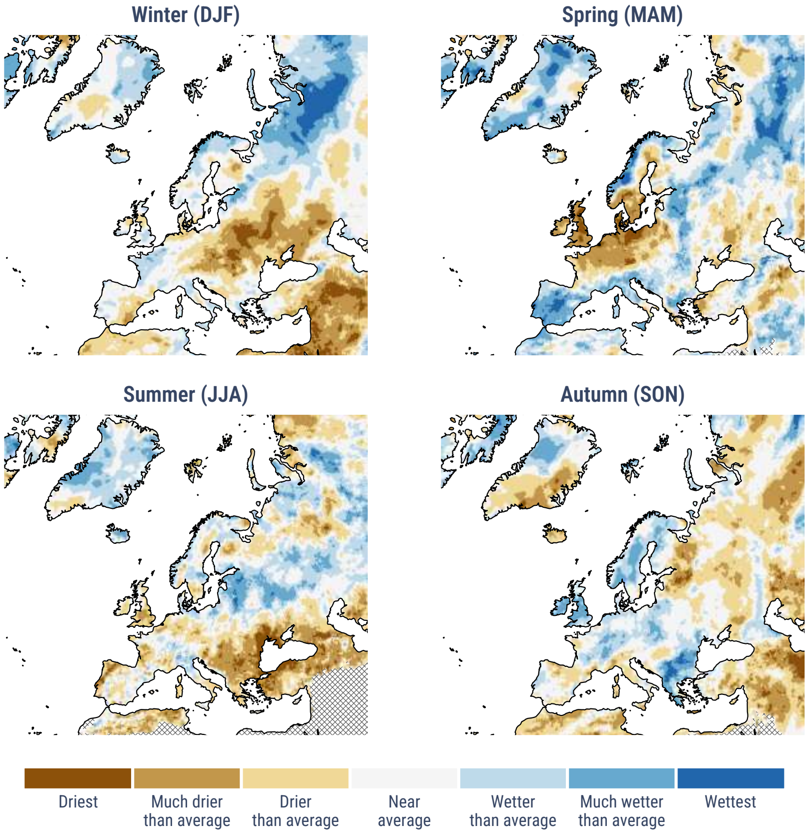


Figure 9.2a. Anomalies and extremes in seasonal precipitation in 2025. The extreme categories ('wettest' and 'driest') are based on rankings for 1979–2025. The other categories describe how precipitation compares to the distribution during the 1991–2020 reference period. 'Much wetter/drier than average' – wetter/drier than 90% of precipitation values; 'wetter/drier than average' – than 66% of precipitation values; 'near average' – within the middle 33%.
Data: ERA5. Credit: C3S/ECMWF.

Winter

Much drier-than-average conditions were seen across much of eastern Europe, as well as in eastern Spain, and were most pronounced and widespread in February. Wetter-than-average conditions were observed in parts of northwestern and northeastern Europe. Three winter storms (Éowyn, Herminia and Ivo) brought heavy rainfall to northwestern France, causing severe flooding.

Spring

A sharp contrast in precipitation conditions across Europe was seen in spring, which is largely reflected in the conditions for the year as a whole.

Much drier-than-average conditions prevailed across most of northwestern Europe. Some areas in the United Kingdom, Belgium, Germany, southern Sweden and Denmark registered their lowest spring precipitation totals since at least 1979. Both England and Belgium experienced their driest spring since 1893, while Germany recorded one of its three driest springs since 1881. The lack of precipitation was linked to a persistent high-pressure area centred over the North Sea.

In contrast, much wetter-than-average conditions prevailed to the south, east and north of this dry region, particularly in the Iberian Peninsula, northern Italy, the Baltic countries and along the western coast of Norway. Spain registered its fifth wettest spring since records began in 1961, alleviating drought conditions that had persisted since 2022 but also promoting vegetation growth that increased wildfire risk during the summer. Further north, the Greenland Ice Sheet experienced its wettest spring since at least 1979, according to ERA5. The unusually high precipitation amounts, mainly falling as snow, limited the ice sheet's mass loss for the year as a whole.

Spring saw contrasts in precipitation across the continent, with much drier-than-average conditions across northwestern and central Europe and much wetter-than-average conditions in surrounding regions.

Summer

Much drier-than-average conditions prevailed across southeastern Europe, Türkiye and the Caucasus during summer. Some areas around the Black Sea registered their lowest precipitation amounts for the season since at least 1979. The conditions were most pronounced in June, contributing to droughts. It was also much drier-than-average in parts of Portugal, northwestern Spain and southwestern France, contributing to an exceptional wildfire season. In contrast, much wetter-than-average conditions were observed in the Baltic countries and parts of western Russia.

Autumn

Precipitation patterns during autumn partly contrasted those seen in summer. Much wetter-than-average conditions occurred in the Balkans, with new seasonal precipitation records across much of the region. In October, Mediterranean cyclone Barbara brought heavy rainfall, causing severe flooding in Romania and Bulgaria. Wetter-than-average conditions were also observed in Ireland, the United Kingdom and parts of Fennoscandia. Drier-than-average conditions were mainly seen in southwestern and northeastern Europe.

Extremes

Precipitation extremes can be characterised by different aspects, such as their intensity, duration or rarity. Here, extremes at each location are assessed by comparing daily precipitation totals with a historical benchmark, defined as the average of the highest daily total recorded each year during the 1991–2020 reference period. A day is classified as 'extreme' if its precipitation total exceeds this value.[29]

Below-average extreme precipitation in Europe in 2025

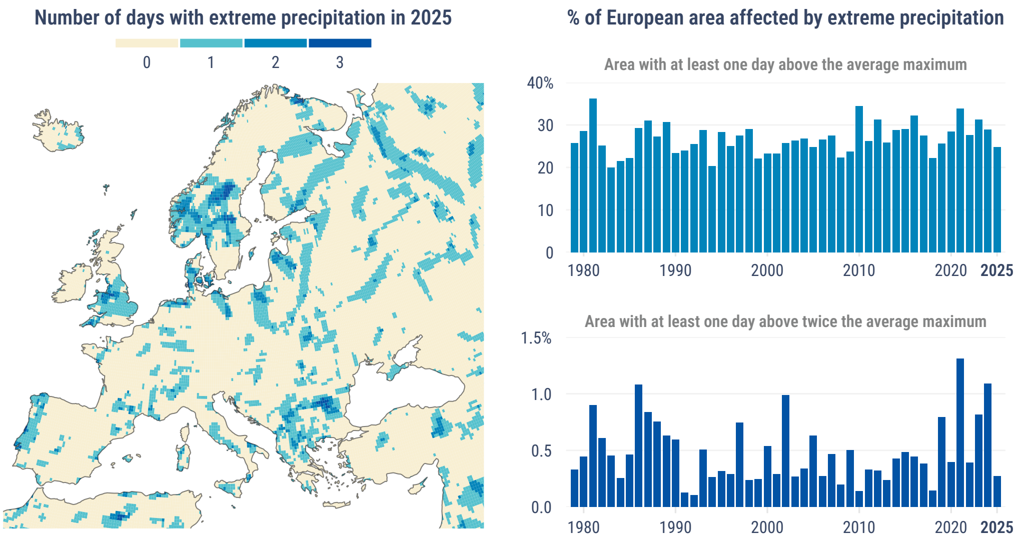


Figure 9.3. (Left) Map showing the total number of days with extreme precipitation across Europe in 2025. 'Extreme precipitation' refers to a day with total precipitation exceeding the average annual maximum daily precipitation during the 1991–2020 reference period. (Right) Annual time series showing the percentage of Europe's land area (shown in the map) that experienced at least one day of extreme precipitation each year from 1979 to 2025. The time series show the area affected by daily precipitation exceeding one (top) and two (bottom) times the average annual maximum. Data: ERA5. Credit: C3S/ECMWF.

The share of Europe's land area affected by extreme precipitation was below average and notably smaller than in some recent years, particularly for the most extreme events.

29 The analysis of extreme precipitation presented here is based on the Extreme Rain Multiplier (ERM) [R9.1]. More details can be found in 'About the data'.

In 2025, many areas across Europe experienced at least one day of extreme precipitation. Such events are often highly localised. Broader areas can be impacted, however, reflecting the influence of larger weather systems. Three regions stand out due to the size of the area affected and because they experienced up to three extreme precipitation days: the Balkans, particularly Romania, linked to Mediterranean cyclone Barbara in October; the United Kingdom, with events in January, September and November; and Sweden, with events mainly in July and September.

On average, about 26% of Europe's land area experiences at least one day of extreme precipitation a year. In 2025, this proportion was slightly lower, at 25%. The affected area was also smaller than in each of the previous four years, particularly 2021 (34%), 2023 (31%) and 2024 (29%). For the most extreme events, defined as days when precipitation exceeded twice the average annual maximum, the affected area is much smaller, averaging only 0.4%. Such events, however, are often associated with the most severe impacts. In 2025, the affected area was 0.3%, again lower than in 2021 (1.3%), 2023 (0.8%) and 2024 (1.1%).

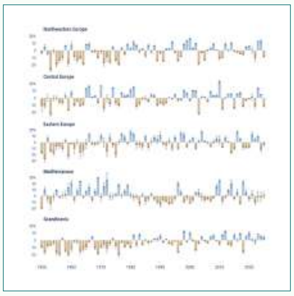
Long-term trends

According to the IPCC AR6, precipitation trends in recent decades indicate wetter conditions in northern Europe and drier conditions in southern Europe, particularly in winter. These patterns are consistent with changes in atmospheric circulation and increased moisture availability in a warmer climate.

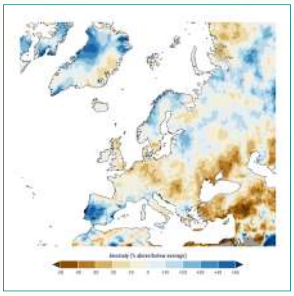
Heavy precipitation has increased across most of Europe, including in regions where average precipitation has declined. Short-duration, extreme rainfall events have become more frequent and more intense, reflecting higher atmospheric water vapour content (a warmer atmosphere can hold more moisture), contributing to increased flood risk in many regions.

Projections indicate these trends will continue and intensify, with average precipitation continuing to increase in northern Europe and decrease in southern Europe, particularly in summer. At the same time, heavy precipitation is projected to intensify across all European regions, including the Mediterranean, increasing the risks of flooding alongside growing pressures on water resources.

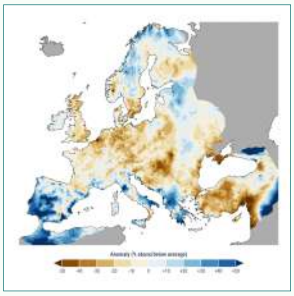
Supplementary figures



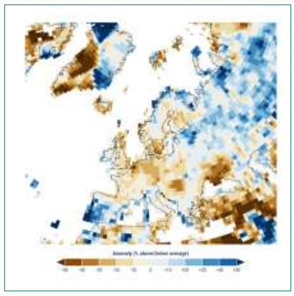
Precipitation anomalies for five regions since 1950



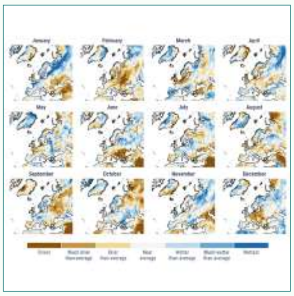
Annual precipitation anomalies - ERA5



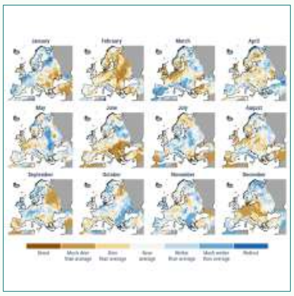
Annual precipitation anomalies - E-OBS



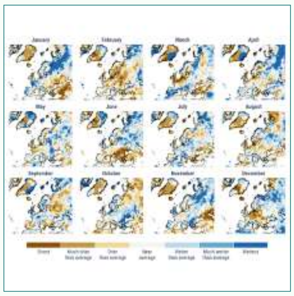
Annual precipitation anomalies - GPCC



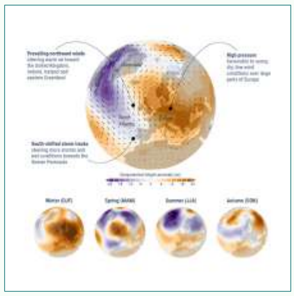
Monthly precipitation anomalies and extremes - ERA5



Monthly precipitation anomalies and extremes - E-OBS



Monthly precipitation anomalies and extremes - GPCC

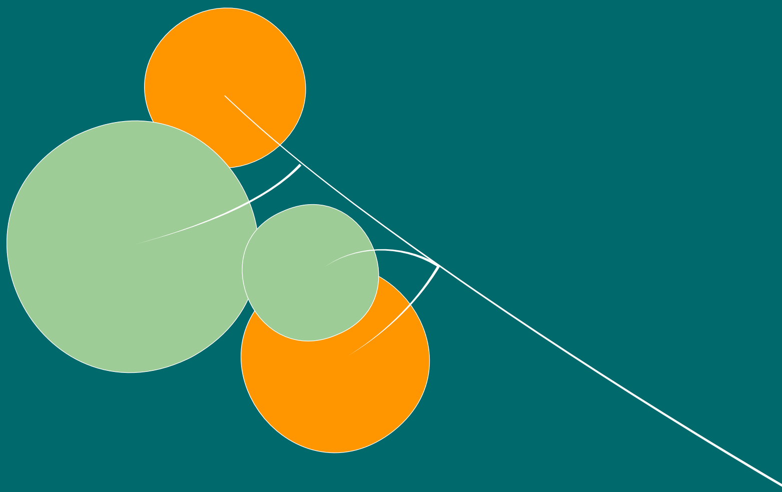


Annual atmospheric circulation anomalies

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

10.

Soil moisture



Soil moisture is a key component of Earth's climate and hydrological systems. It plays a crucial role in the exchange of water and energy between the land surface and the atmosphere, influencing weather patterns, temperature regulation and the water cycle. Soil moisture affects atmospheric processes and climate predictability. Saturated soils have limited capacity to absorb additional rainfall, increasing surface runoff and the risk of flooding. When soil moisture is low, reduced infiltration and weakened soil structure make the land prone to runoff, erosion and degradation. Prolonged soil moisture deficits can lead to drought conditions, reducing crop yields and increasing the risk of wildfires. In this section, the data represent conditions in the first few centimetres of the soil,[30] with root zone soil moisture conditions down to 1 m.

For Europe as a whole, 2025 saw the driest soil moisture conditions in the 33-year satellite record.

2025 was one of the three driest years since 1992

Anomalies in soil moisture in 2025

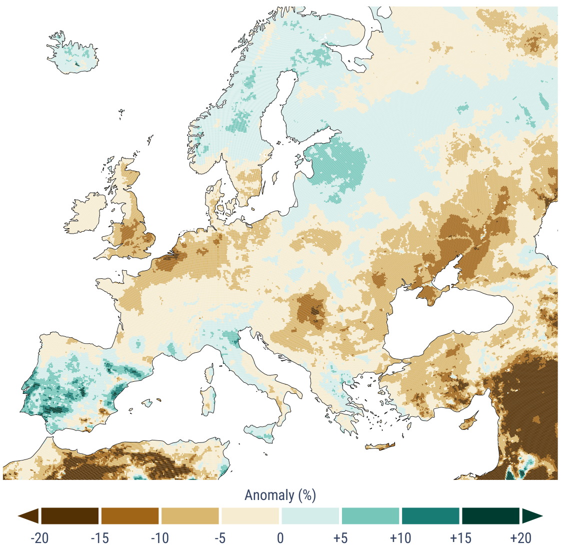


Figure 10.1a. Annual surface soil moisture anomalies (%) in 2025, showing positive (green) and negative (brown) anomalies, expressed as a percentage of the annual average for the 1991–2020 reference period. Surface soil moisture in ERA5-Land represents conditions in the upper 0–7cm of the soil. Data: ERA5-Land. Credit: C3S/ECMWF/TU Wien

30 ~0–5 cm for the satellite product and 0–7cm for ERA5-Land.

Annual overview

Across Europe, a trend towards increasingly drier-than-average surface soil moisture conditions has been observed over the past two decades. The annual soil moisture anomaly indicates that this trend continued in 2025, which was one of the three driest years since 1992.[31]

The drier-than-average conditions affected a large part of Europe, extending from western to eastern Europe, including the United Kingdom, the Netherlands, Ukraine and Türkiye, and persisted for much of the year.

Variations throughout the year

In February, drier-than-average root zone soil moisture anomalies became widespread, with nearly 50% of Europe classified as 'dry' to 'very dry' for that time of year, with northern France being an exception. The dry conditions intensified through the spring and summer and persisted until October.

Extended soil moisture deficits are of particular concern as they can trigger drought conditions. For agricultural droughts, when soil water availability is insufficient to meet crop needs, soil moisture in the root zone is especially important. The most extensive agricultural drought conditions of 2025 were in May, when 35% of Europe could be classed as experiencing 'extreme' drought,[32] and a further 19% 'moderate' drought. In July, sub-Arctic Fennoscandia could also be classed as experiencing regional agricultural drought following its most severe heatwave on record. The drought conditions across Europe persisted through summer, lessening in severity and extent in early autumn.

Drier-than-average soil moisture conditions persisted for much of the year and affected large parts of Europe.

31 2025 was the driest year in the satellite record and the third driest in ERA5-Land over the same period (since 1992).

32 Drought conditions are classified as: extreme drought (very dry; Z-score ≤ -2), moderate drought (dry; Z-score ≤ -1), average (Z-score between -1 and 1), wet (Z-score ≥ 1) or very wet (Z-score ≥ 2). Z-scores are how far a value is from the average, using standard deviation as units.

December was the month with the highest soil moisture conditions, when nearly 30% of Europe was classified as having 'wet' or 'very wet' soils, particularly in southern and eastern Europe. For the second year in a row, the Iberian Peninsula experienced wetter-than-average soil moisture conditions, following drier-than-average conditions in 2022 and 2023.

Extensive drought conditions throughout the year

Root zone soil moisture (0–100 cm) drought classifications for each month of 2025.

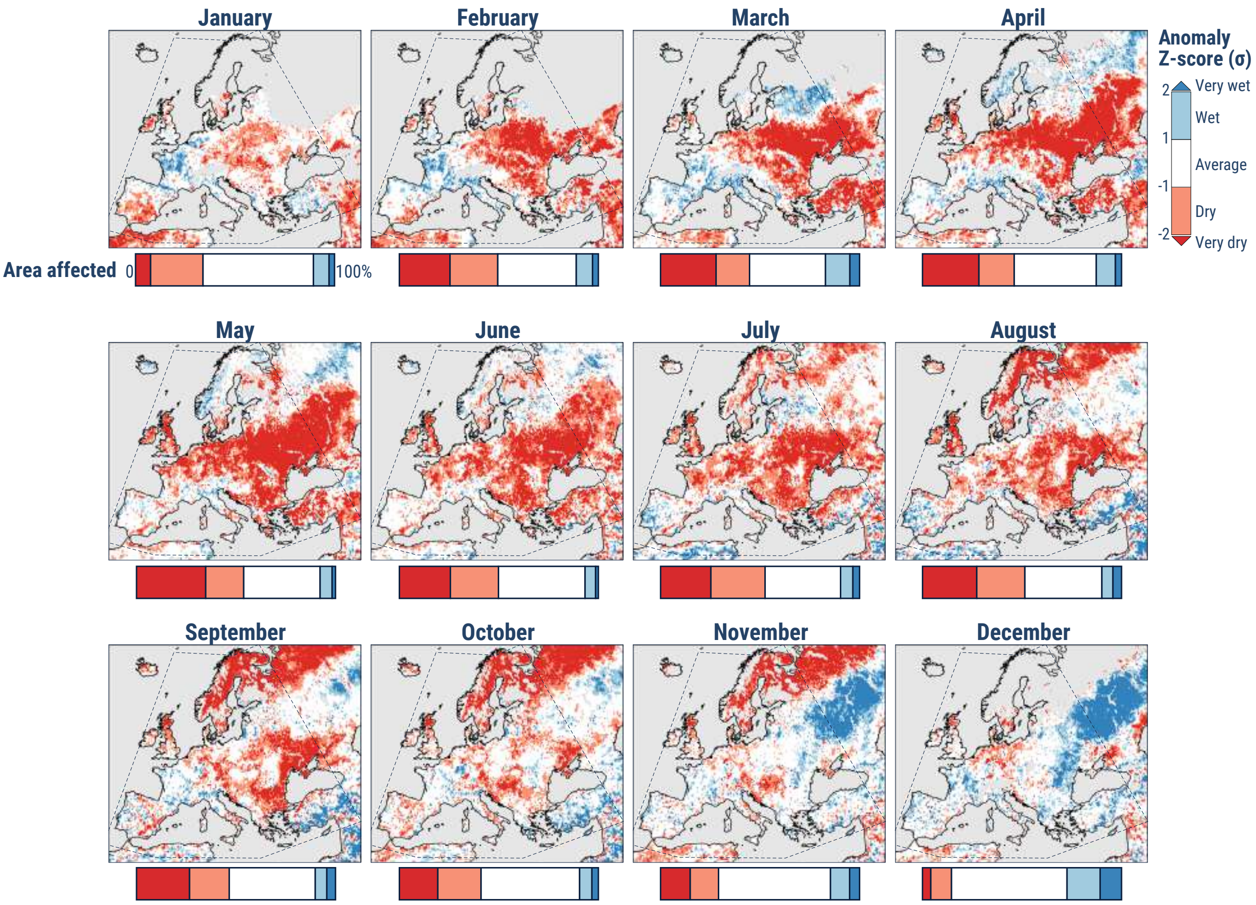


Figure 10.2. Root zone soil moisture (0–100 cm) drought classifications for each month of 2025. Anomalies are expressed as Z-scores, which indicate how far a value is from the average using standard deviation as units. The bars indicate the affected area for each drought category within the map area bounded by the dotted black line. Data: C3S SM v202505 RZSM. Credit: TU Wien/C3S/ECMWF.

Extremes

Large parts of Türkiye and Ukraine saw record-low soil moisture for March, and soil moisture remained below average throughout the rest of spring. This was followed by an exceptionally dry summer, during which Türkiye again experienced record-low soil moisture and faced one of its worst droughts in 50 years. The prolonged dry conditions in both Türkiye and Ukraine caused yield reductions in summer crops and contributed to an increase in the number of wildfires.

In parts of the United Kingdom, the Netherlands, Belgium and northern Germany, 10 months of the year saw drier-than-average conditions. These areas also experienced a record-dry May, with soil moisture 23% below average for the month. This coincided with below-average precipitation and, in the United Kingdom, much warmer-than-average temperatures.

Soil moisture in central Scandinavia was more variable through the year. The region saw multiple wet records during the early months, particularly in January and March, but conditions fluctuated more during spring and summer. Notably, during a heatwave in July, soil moisture dropped to its lowest levels of the year, reaching record lows in some areas. Small parts of the region experienced both record wet and record dry monthly conditions in 2025.

In May, 35% of Europe saw 'extreme' agricultural drought.

Parts of western Russia and the Baltics also had a wet start to the year, with record-wet soil moisture in January. The region then saw further record-wet soil moisture conditions from May to July, owing to the much above-average precipitation in the region. In some areas the number of wet days[33] in summer was up to 20 more than average.

The Iberian Peninsula also experienced extreme wet conditions, with soils 31% wetter than average in March, and Spain and Portugal receiving 251% and 229% of their average amount of rainfall, respectively. These wet conditions continued until June when they gave way to drier-than-average conditions. Such a shift from wet to dry creates abundant dried-out vegetation that can fuel extensive wildfires, as seen in August when Spain recorded its highest fire-related emissions in more than two decades.

More information on precipitation and wildfires can be found in their respective sections.

33 A day where the 24-hour accumulated precipitation is at least 1 mm.

Record wet and dry soil moisture conditions across Europe

Areas of Europe with record wet or dry monthly conditions in 2025, compared to the same month from 1950 to 2024.

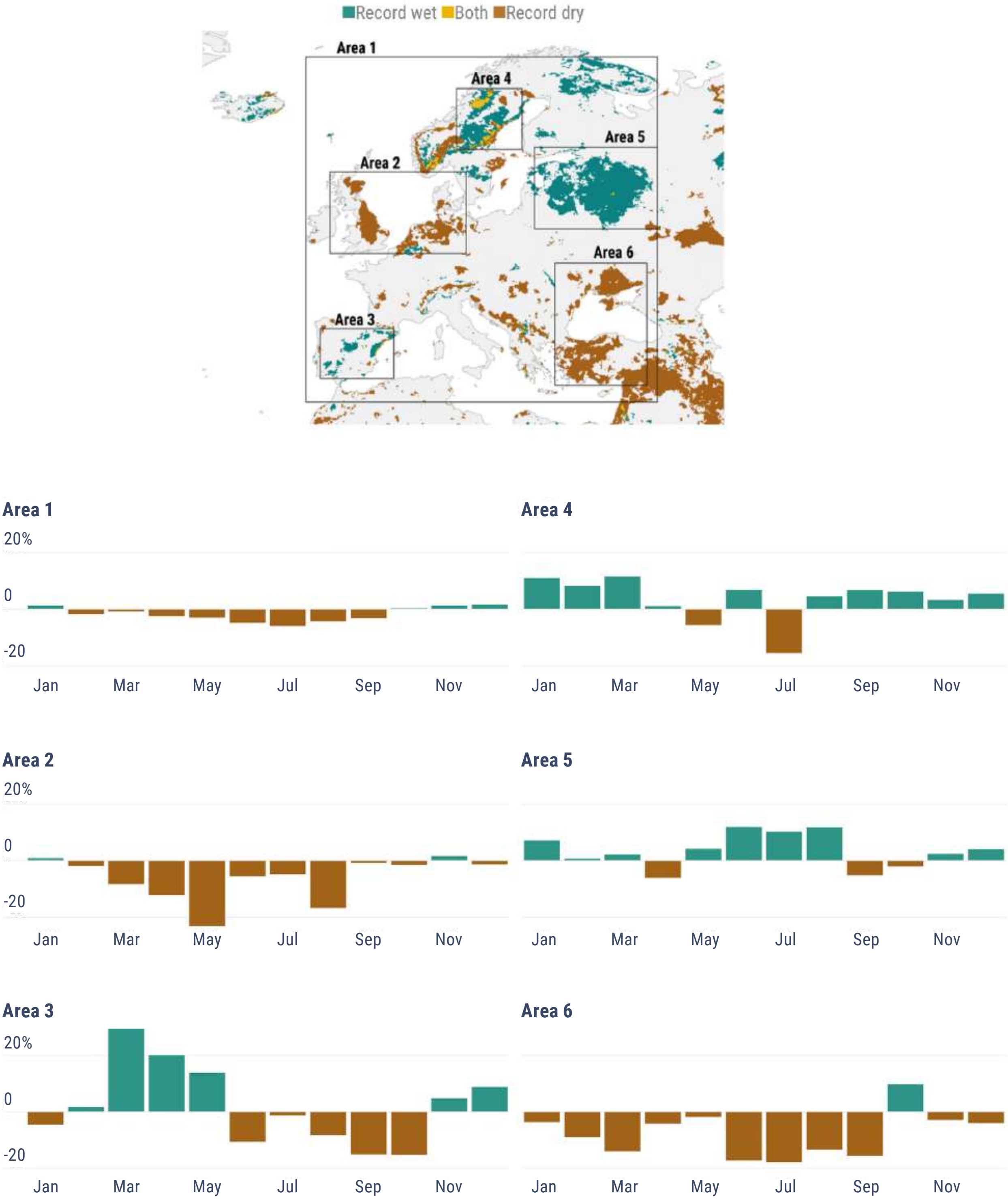
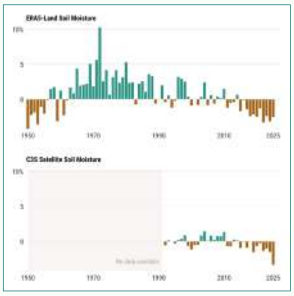
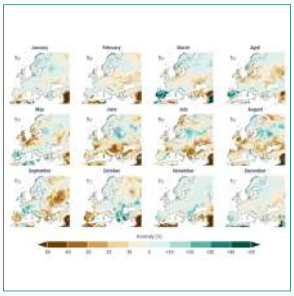


Figure 10.3. (Top) Areas of Europe with record wet (green) or dry (brown), or both (yellow) monthly conditions in 2025, compared to the same month from 1950 to 2024. (Bottom) Time series of 2025 monthly anomalies, showing positive (green) and negative (brown) anomalies, relative to the average for the 1991–2020 reference period. Data: ERA5-Land. Credit: C3S/ECMWF/TU Wien.

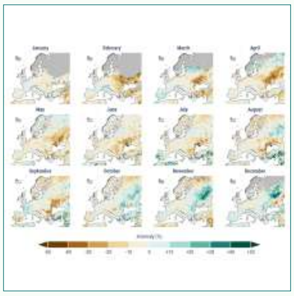
Supplementary figures



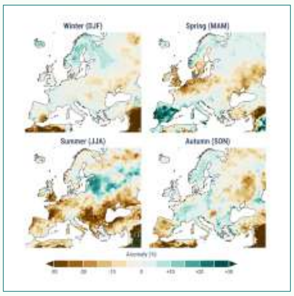
Annual soil moisture anomalies since 1950



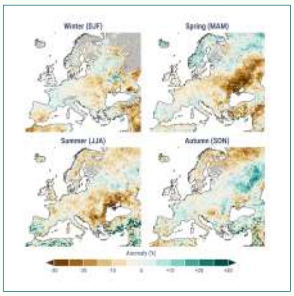
Monthly soil moisture anomalies - ERA5-Land



Monthly soil moisture anomalies - Satellite



Seasonal soil moisture anomalies - ERA5-Land



Seasonal soil moisture anomalies - Satellite

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

11.

River flow and flooding

River flow is the volume of water flowing through a river channel, as measured at a given point, in cubic metres per second. High river flow can lead to flooding, while low river flow can negatively impact species dependent on freshwater and riverside ecosystems. In extreme cases, low river flow can develop into a hydrological drought, affecting public water supply, hydroelectric power generation and commercial river transport, for example.

This section gives an overview of anomalies and extremes in annual river flow across the continent in 2025, variations throughout the year, the percentage of the European river network flooded and provides historical context for the findings.

Annual overview

River flow for the European river network as a whole was below average for 11 months of the year, with only January showing slightly above-average conditions. In May and June, river flow reached its lowest levels since records began in 1992.

River flow across Europe was below average for 11 months of the year and 70% of rivers saw below-average annual flow.

Annual river flow was below average in 70% of European rivers, with particularly pronounced deficits in several central, southern and eastern regions. In contrast, near-average or above-average annual flows were seen in western regions, especially the Iberian Peninsula, western France, Ireland, Italy, and parts of Norway and Sweden.

River flows were below average in Europe for most of 2025

Monthly average river flow for Europe

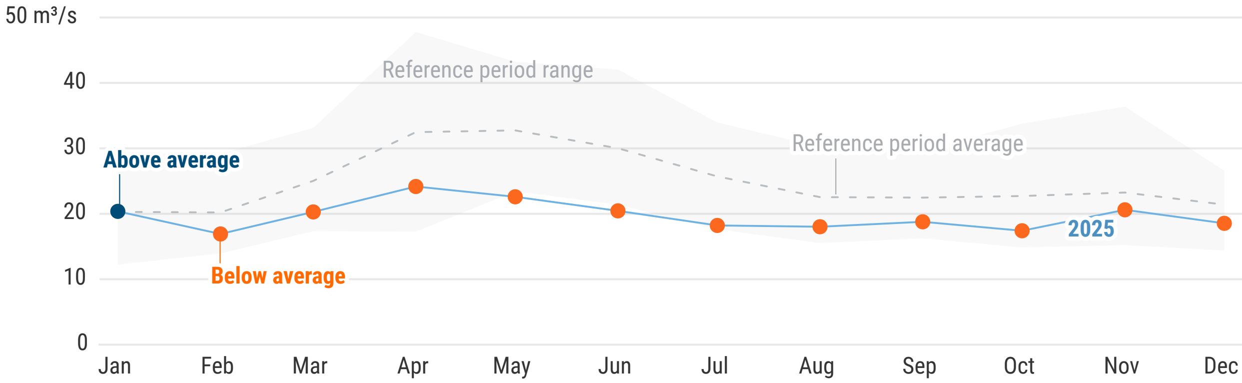


Figure 11.1. Monthly average river flow (m^3/s) for Europe, showing below-average (orange dots) and above-average (blue dots) river flow, compared to minimums and maximums for the 1992–2020 reference period (grey shading) and the average for the 1992–2020 reference period (dashed grey line). Data: EFAS. Credit: CEMS/C3S/ECMWF.

Annual river flow was below average in 70% of European rivers in 2025

Anomalies and extremes in annual average river flow in 2025

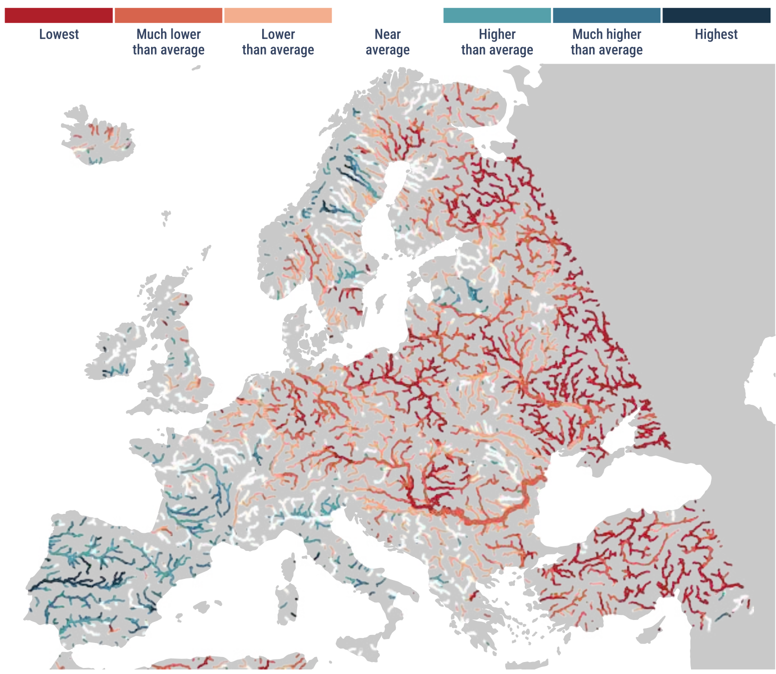


Figure 11.2. Anomalies and extremes in annual average river flow in 2025. The extreme categories ('highest' and 'lowest') are based on rankings for 1992–2025. The other categories describe how river flow compares to the distribution during the 1992–2020 reference period. 'Much higher/lower than average' – higher/lower than 90% of river flow values; 'higher/lower than average' – than 66% of river flow values; 'near average' – within the middle 33%. Only rivers with drainage areas greater than 1000 km^2 are shown. Data: EFAS. Credit: CEMS/C3S/ECMWF.

Variations throughout the year

Monthly river flow patterns in 2025 reveal strong seasonal contrasts and regional variability. January was the only month with above-average river flow for Europe as a whole, with around 40% of rivers seeing higher-than-average flows, particularly across much of southwestern, central and northern Europe. From February onwards, below-average river flow dominated and this pattern persisted to the end of the year.

In February, river flow began to decrease across large parts of central and eastern Europe, with below-average conditions in several major river basins, including parts of the Danube, Dnieper, Oder and Vistula. By March, lower-than-average river flow anomalies had extended into western Europe, including Ireland and the United Kingdom, and become more widespread across southeastern Europe.

River flows across Europe were below average for 11 months of 2025

Anomalies and extremes in monthly average river flow in 2025

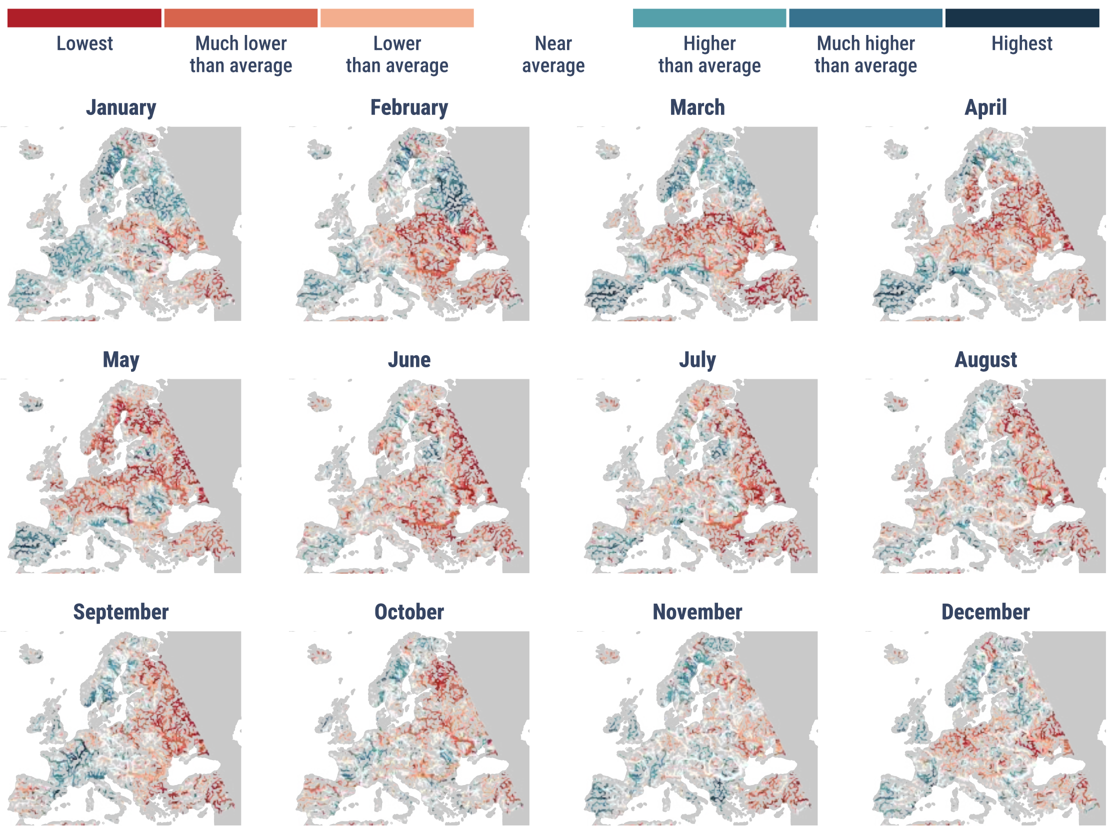


Figure 11.3. Anomalies and extremes in monthly average river flow in 2025. The extreme categories ('highest' and 'lowest') are based on rankings for 1992–2025. The other categories describe how river flow compares to the distribution during the 1992–2020 reference period. 'Much higher/lower than average' – higher/lower than 90% of river flow values; 'higher/lower than average' – than 66% of river flow values; 'near average' – within the middle 33%. Only rivers with drainage areas greater than 1000 km^2 are shown. Data: EFAS. Credit: CEMS/C3S/ECMWF.

Much higher-than-average river flows were observed across large parts of the Iberian Peninsula during spring, with the highest monthly flows on record in the Tagus and Guadiana river basins, contrasting with the broader European pattern. These high flows were linked to persistent and intense rainfall, driven by the passage of several named storms that brought widespread flooding across Spain and Portugal.

Lower-than-average river flow was most widespread in late spring and early summer. May and June had the highest proportion of rivers with below-average flows, at 69% and 66%, respectively. From September onwards, the area impacted by below-average river flow gradually reduced, reaching around 40% by the end of the year. This shift reflects a transition towards near-average or above-average river flow in some regions, particularly across parts of the Danube basin and northeastern Europe. The low flow conditions contributed to several drought warnings issued throughout the year by the Copernicus Emergency Management Service (CEMS) European Drought Observatory, particularly in eastern Europe.

Flooding

The extent of the European river network that experienced flooding during 2025 was the second lowest in the 33-year record. Around 12% of rivers exceeded the 'high' flood threshold at some point during the year, with around 5% reaching the 'severe' threshold. This contrasts with the past two years, when flooding was more widespread across Europe.

The flooded extent of Europe's rivers was the second lowest on record since 1992, and much smaller than the widespread flooding in 2023 and 2024.

Despite the low overall extent, notable flood events occurred at local and regional scales throughout the year. In January, Storm Éowyn brought exceptionally strong winds and heavy rainfall to parts of Ireland, the United Kingdom and Norway. While the storm was primarily characterised by its wind impacts, the associated rainfall and already saturated ground conditions led to localised flooding and increased river flow in some areas.

In March, persistent and intense rainfall associated with a series of named storms led to flooding across central and southern parts of the Iberian Peninsula, including Spain and Portugal. These events were linked to exceptionally wet conditions in

March, which contributed to damaging floods but increased reservoir storage in some drought-prone areas. In April, intense rainfall in northern and central Italy caused widespread flooding and landslides, prompting evacuations from floodplains.

In mid-November, Storm Claudia brought significant flooding to Portugal, Spain, Ireland and the United Kingdom. Elsewhere, short-lived floods were reported in parts of western and northern Europe, typically associated with periods of intense rainfall and saturated catchments. Towards the end of November, heavy rainfall caused rivers to overflow in parts of Albania, leading to flooding, evacuations and damage to infrastructure. Overall, the pattern of flooding in 2025 was localised rather than widespread, reflecting strong regional contrasts in hydrological conditions across Europe. More information on precipitation and soil moisture conditions can be found in the respective sections.

For more information on significant events across Europe in 2025, visit the interactive 'Key events map'.

Second-lowest flood extent on record across Europe's rivers in 2025

Annual percentage of the European river network experiencing flooding

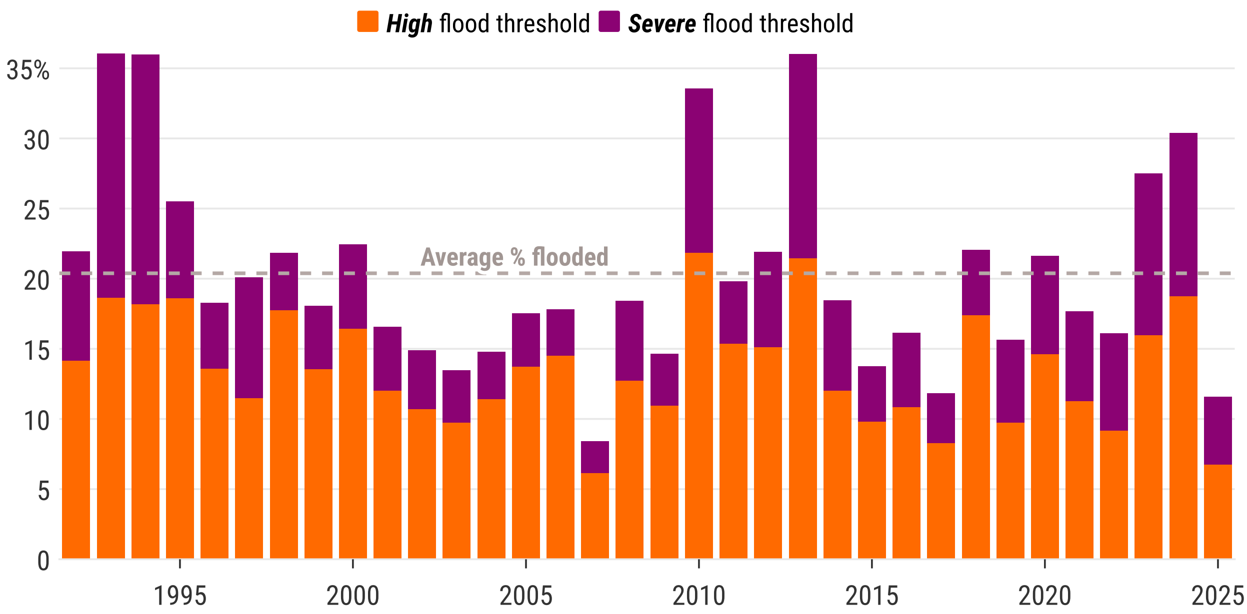


Figure 11.4. Percentage of the European river network that exceeded the 'high' (five-year return period) (orange) and 'severe' (20-year return period) (purple) flood thresholds during 1992–2025. The average annual percentage of the river network exceeding at least the 'high' threshold (grey line) is around 20%. Data: EFAS. Credit: CEMS/C3S/ECMWF.

12% of Europe's rivers saw flows exceeding the 'high' flood threshold in 2025

Rivers where the flow exceeded flood thresholds on any day in 2025

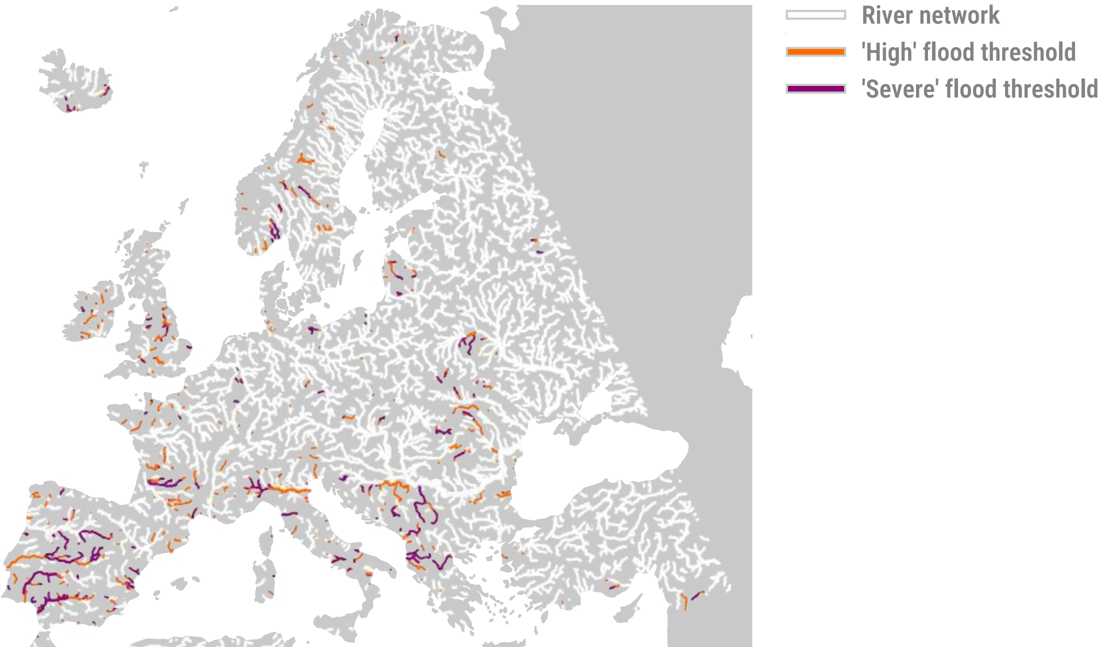


Figure 11.5. Rivers with upstream areas larger than 1000 km^2 (white), and those where the river flow exceeded the 'high' (five-year return period) (orange) and 'severe' (20-year return period) (purple) flood thresholds on any day across 2025. Data: EFAS. Credit: CEMS/C3S/ECMWF.

Long-term trends

The IPCC AR6 reports that, between 1960 and 2010, river flood hazard increased by 11% per decade in western and central Europe and the United Kingdom, and decreased by 23% per decade in eastern and southern Europe. Projections indicate that these trends will continue. Europe is one of the regions with the largest projected increase in flood risk, and the last three decades saw the highest number of floods of the past 500 years.

Despite the reduced overall flood extent, several significant flood events occurred, including in Ireland and the United Kingdom (January, October, November and December), Spain and Portugal (March and November), Italy (April) and Albania (November).

12.

Lakes

Lakes act as both indicators and regulators of climate variability and change and, as such, are vulnerable to their impacts. For example, shorter periods of ice cover create a changing environment for species populating the lake and, in some cases, temperature shifts may impact survival thresholds.[34] Nutrient and oxygen distributions may also change, which could have consequences for the ecosystem.

Lake levels directly respond to changes in climate variables such as precipitation, temperature and relative humidity. Anthropogenic activities, such as land use, can also influence them.

European lakes are warming faster than the global average, and in 2025 their temperatures were 0.32°C above average during the warm season.

As well as responding to climate change, lakes also influence the local weather and climate.

This section focuses on lake surface water temperature (LSWT) and lake water levels (LWL) during the warm season (July to September and June to September, respectively) in Europe in 2025. LSWT is the temperature of the lake water at the surface while LWL is the water level above Earth's surface. Both are estimated using satellite observations.

Lake surface water temperatures

The LSWT for the 2025 warm season of the 265 European lakes was 0.32°C above average, which is lower than the record value of 0.78°C seen in 2024. In total, 81% of lakes were warmer than average (overall 0.45°C), with the remaining lakes cooler than average (overall -0.25°C). The global anomaly, calculated across 1912 lakes, was also 0.32°C.

34 More information on the impact of warming waters on lake ecosystems can be found in the review paper by Woolway et al. (2020), for example.

Lake temperatures were most above average in northeastern Finland and adjacent areas of Russian Karelia, with positive anomalies throughout the warm season averaging 0.84°C.

For Fennoscandia as a whole, however, conditions were more variable. In July, when sub-Arctic Fennoscandia experienced its most severe heatwave on record, 80% of lakes in Norway and 88% in Sweden were warmer than average, and in Finland all lakes were warmer than average (0.80°C). In contrast, during August, 79% of lakes in Fennoscandia were cooler than average. Conditions reversed again in September, when all lakes across Norway, Sweden and Finland were warmer than average, with the exception of Stor-Rensjön in western Sweden.

In the United Kingdom and Ireland, lakes were warmer than average in July (up to 0.82°C) and August (up to 1.04°C), but cooler than average in September (down to -0.41°C). This change means that, for the warm season as a whole, LSWT in these countries was only slightly above average (0.26°C). Lakes across Spain and western France also exhibited a similar pattern of warming and cooling, while LSWT across the remainder of Europe was more variable.

81% of European lakes were warmer than average in 2025

Anomalies in lake surface water temperature for July to September 2025

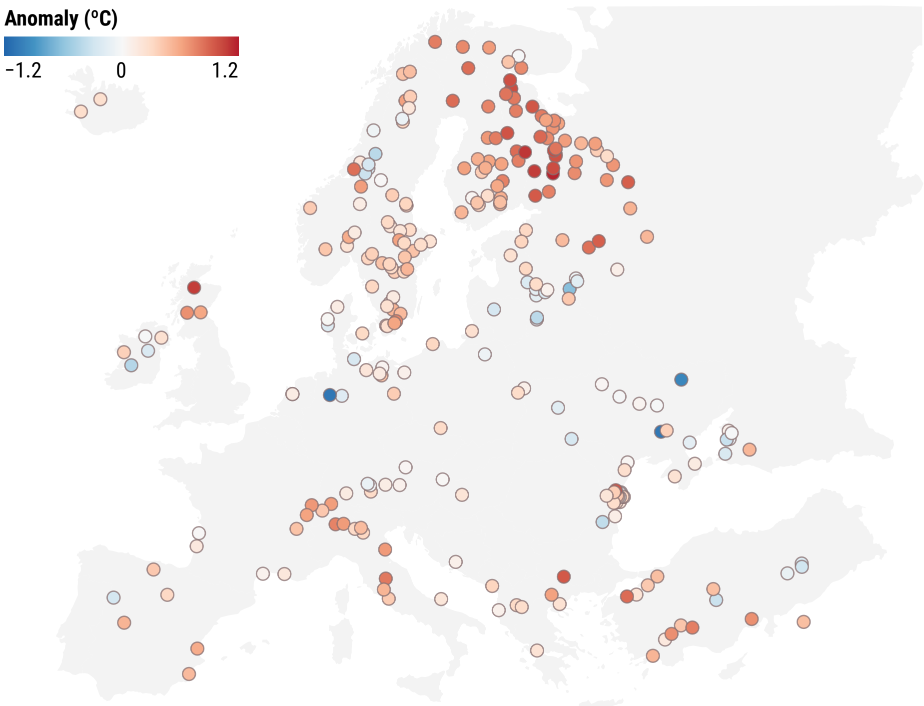


Figure 12.1. Warm season (July–September) LSWT anomalies, relative to the average for the 1995–2020 reference period, for 265 lakes in Europe. Data: ESA CCI LAKES, C3S, EOCIS lake surface water temperature data record. Credit: C3S/ECMWF/EOCIS/University of Reading.

Lake water levels

The warm season showed notable regional contrasts in LWL anomalies, largely reflecting the predominant precipitation and soil moisture conditions. Similarly to 2024, southeastern Europe saw below-average LWLs, reflecting the lower-than-average precipitation and drier-than-average soil moisture with persistent drought conditions. In contrast, after an exceptionally wet spring, many lakes across the Iberian Peninsula recorded positive LWL anomalies from June to September, with a greater number of lakes showing above-average levels than in 2024, despite Spain and Portugal both reporting the hottest summer on record with several heatwaves.

The Baltic states also had slightly higher-than-average LWLs during the warm season. This was due to the much above-average precipitation and associated wetter-than-average soils.

The natural Lake Prespa, located on the border of North Macedonia, Albania and Greece, continued its long-term declining trend that started in the 1960s, reflecting another dry year in southeastern Europe. Meanwhile, the artificial Guadalhorce reservoir in Spain – which has seen decreasing water levels since 2019 – showed recovery, reaching levels last seen in 2021, likely due to the exceptionally wet spring.

Contrasting lake levels across southern Europe in 2025

Anomalies in lake water levels for June to September 2025

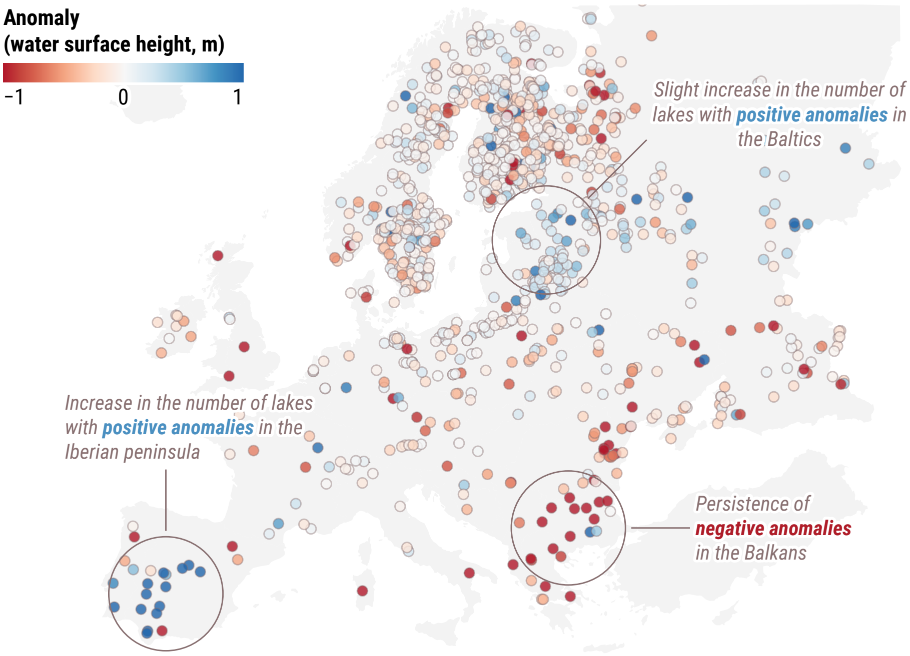


Figure 12.2. Lake water level (red and blue dots) anomalies (metres) in Europe for June–September, relative to the average for the 2015–2022 reference period. Data: Hydroweb, C3S lake water level. Credit: C3S/ECMWF/CLS/LEGOS/CNES.

Lakes

In addition to environmental conditions, human activities can also affect the water levels of both natural and artificial lakes. In some cases, water management, particularly associated with agricultural irrigation, plays a significant role in lowering LWLs, especially when conditions are drier than average.

During June to September, lake water level anomalies largely reflected those seen in precipitation and soil moisture. As in 2024, southern Europe showed a stark west-east contrast with above-average values in the west and below-average values in the east, alongside slightly positive anomalies in the Baltic countries.

Long-term trends

Over the last 30 years, the 1912 lakes globally have warmed by around 0.22°C per decade. In Europe, the rate of warming is faster, at around 0.33°C per decade. The IPCC AR6 reports that, globally, LSWTs warmed at 0.21°C–0.45°C per decade from 1970 to 2010.

European lakes are warming faster than the global average

Warm season (July to September) lake surface water temperature anomalies for 265 lakes in Europe and 1912 lakes globally

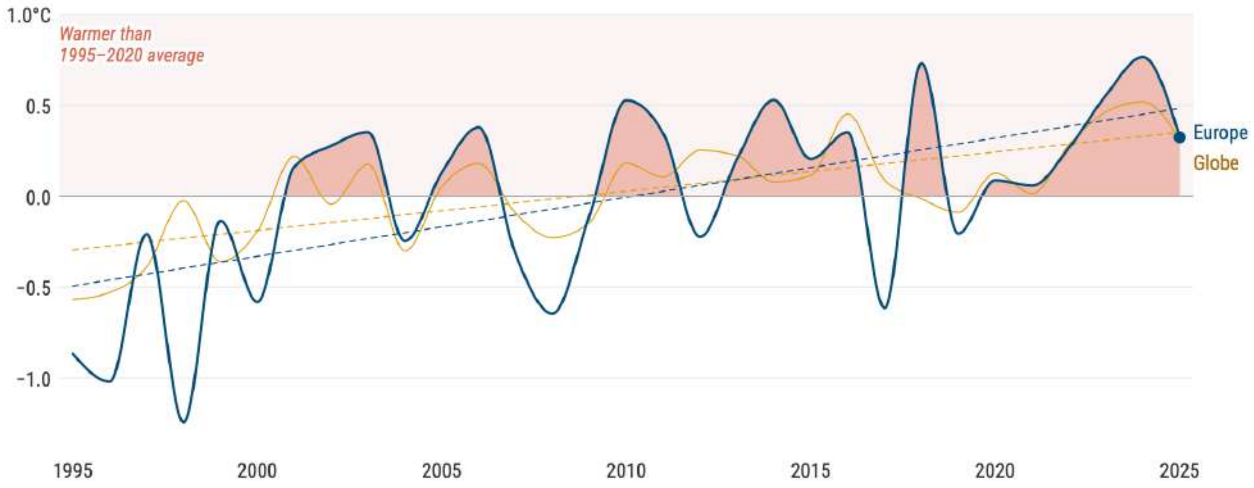


Figure 12.3. Lake surface water temperature anomalies (°C), relative to the average for the 1995–2020 reference period, for 265 European lakes and 1912 lakes globally. Values are averages for the warm season (July–September). The dashed line indicates the estimated linear trend. Data: LSWT ESA CCI Lakes, C3S, EOCIS. Credit: C3S/ECMWF/EOCIS/University of Reading.

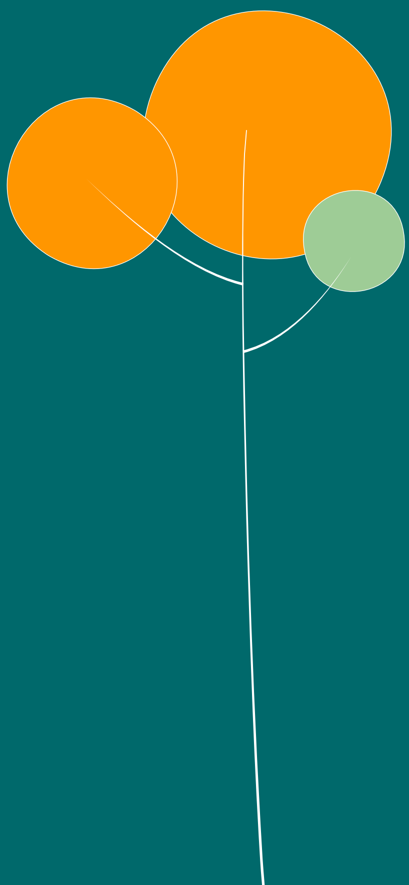
Supplementary figures

Monthly summer lake surface water temperature anomalies

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

13.

Snow



Snow plays a crucial role in weather and climate. Changes in snow cover influence temperatures, glacier mass balance, river flow, flooding and droughts.

Its impact on surface reflectivity ('albedo'), helps regulate surface temperature. The loss of snow cover thus further accelerates global warming. Snow also plays a vital role in storing fresh water, with changes in snow mass affecting soil moisture, river flow, flooding and glaciers.

The high sensitivity of snow to temperature and precipitation makes it a fundamental indicator of climate change. Rising temperatures and lower precipitation are leading to a decline in snow days (when the depth is at least 1 cm), a reduction in snow covered area and a decrease in the amount of water stored in the snowpack.

Snow days

Most of Europe saw a below-average number of snow days in winter 2025. The largest anomalies were seen in eastern and southern parts of central Europe, with stations in Romania reporting up to 45 fewer snow days than average. Much of Fennoscandia saw up to 10 more snow days than average in winter, except for the areas closer to the Atlantic and south Baltic coasts. Here, there were an average or below-average number of snow days. Southern parts of the Alpine region also saw up to 10 more snow days than average.

Much of Europe experienced fewer snow days than average, except for parts of northern Europe during winter.

For Europe as a whole, temperatures in winter were near average or slightly warmer than average. In Fennoscandia, however, precipitation ranged from average to wetter than average. The area with a below-average number of snow days coincides with the area where winter was warmer and considerably drier than average.

Fewer snow days than average across most of Europe in winter 2025

Anomalies in the number of snow days from December 2024–February 2025. The size of each dot is proportional to the absolute value of the anomaly

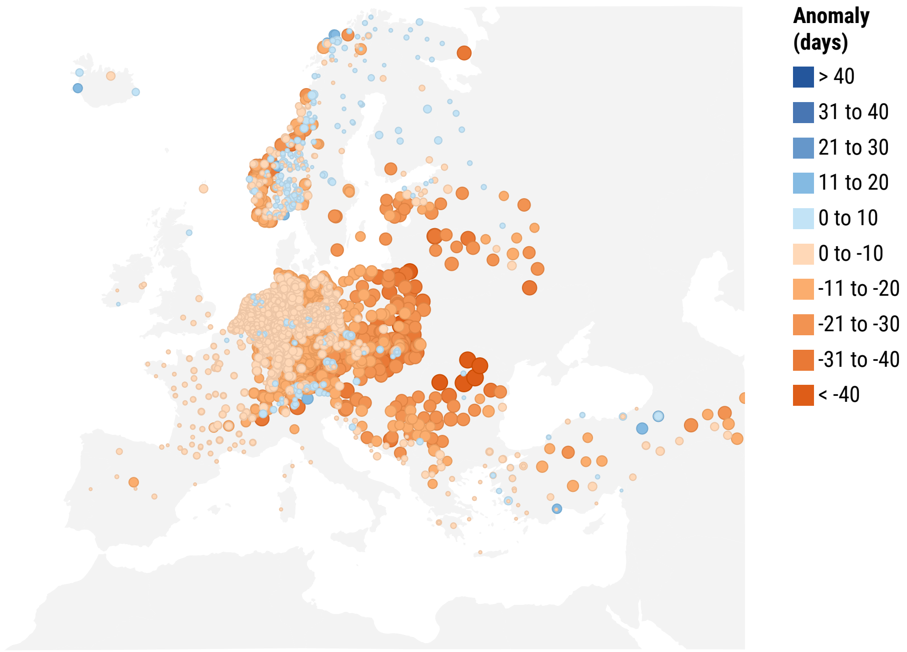


Figure 13.1. Anomalies in the number of snow days during winter 2025, relative to the average for the 1991–2020 reference period, showing more snow days than average (blue) and fewer snow days than average (orange). Winter covers the period from December 2024 to February 2025. Data: ECA&D. Credit: KNMI/C3S/ECMWF.

Snow cover

In Europe, the 2025 hydrological year[35] was characterised by a lower number of snow days, and below-average snow cover throughout the winter.

Although not a winter month, March is considered the most representative for evaluating snow cover changes, as it signifies the peak of accumulated snow mass in the Northern Hemisphere.

End-of-season snow cover extent and snow mass were 31% and 45% below average, respectively, making them both the third lowest in the 42-year record. The largest negative anomalies were observed in eastern Europe.

35 1 October 2024–30 September 2025.

In March 2025, the snow-covered area in Europe was about 1.32 million km^2 (31%) below average (4.24 million km^2). This negative anomaly is approximately the area of France, Italy, Germany, Switzerland and Austria combined and marks Europe's third lowest snow cover since 1983. The lowest value on record was 36% below average in 2020, and the second-lowest value was 32% below average in 1990. The largest negative anomalies in 2025 were observed in eastern Europe and linked to above-average temperatures in this area. Slightly positive anomalies were observed in northern parts of Fennoscandia, the southern Alps, Türkiye, Greenland's coastal areas and central Iceland.

Snow mass shows a similar pattern. Snow mass is more sensitive to the amount of snow in a given area and is expressed in millimetres of water equivalent, the depth of liquid water that would result if a snowpack melted completely. At 154 Gt,[36] the March snow mass anomaly was 45% below the average of 344 Gt and the third lowest in Europe since 1979. The lowest value on record was 51% below average in 2020, and the second lowest value was 46% below average in 1990. The largest negative anomalies were observed in Fennoscandia and European Russia, indicating that these regions experienced significantly less snow than average during winter.

36 Gt = gigatonnes = 1 billion tonnes.

Peak 2025 snow cover was the third lowest in the 42-year record

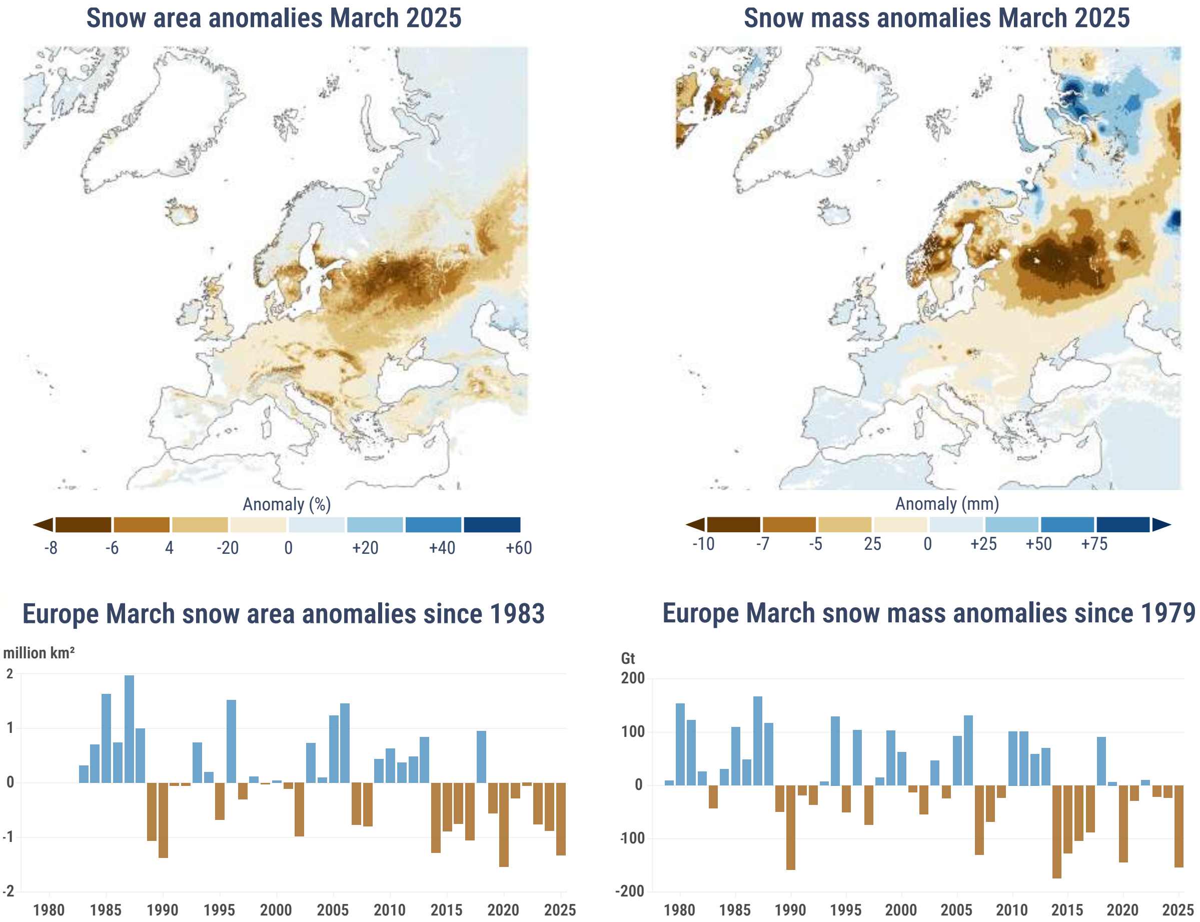


Figure 13.2. March anomalies in snow area (left) and snow mass (right), relative to the average for the 1991–2020 reference period. March 2025 average snow area (%) and snow mass (mm) anomalies (top), and time series of March snow area (million km²) and snow mass (Gt) anomalies for Europe (bottom). Water bodies, glaciers and ice sheets are masked and excluded from the calculations. The snow mass calculation excludes mountains. Data: C3S SCE and SWE v1.0. Credit: C3S/ECMWF/ENVEO/FMI.

Long-term trends

Long-term trends in snow area and mass indicate a reduction in snow cover across Europe over the past two decades, despite significant interannual variability. Positive anomalies in snow cover have become less frequent, while negative anomalies have become larger and more frequent, particularly over the past 12 years. From 1983, when records began, until 2005, winters with large positive anomalies in snow cover and mass were more frequent.

The long-term trend shows a reduction in Europe's snow cover over the last two decades. This has been particularly notable over the past 12 years.

This ongoing trend in snow cover becomes more notable at Northern Hemisphere and global scales. Climate models indicate that it will continue to decline in Europe and globally due to rising temperatures.

A reduction in snow in Europe over the last two decades

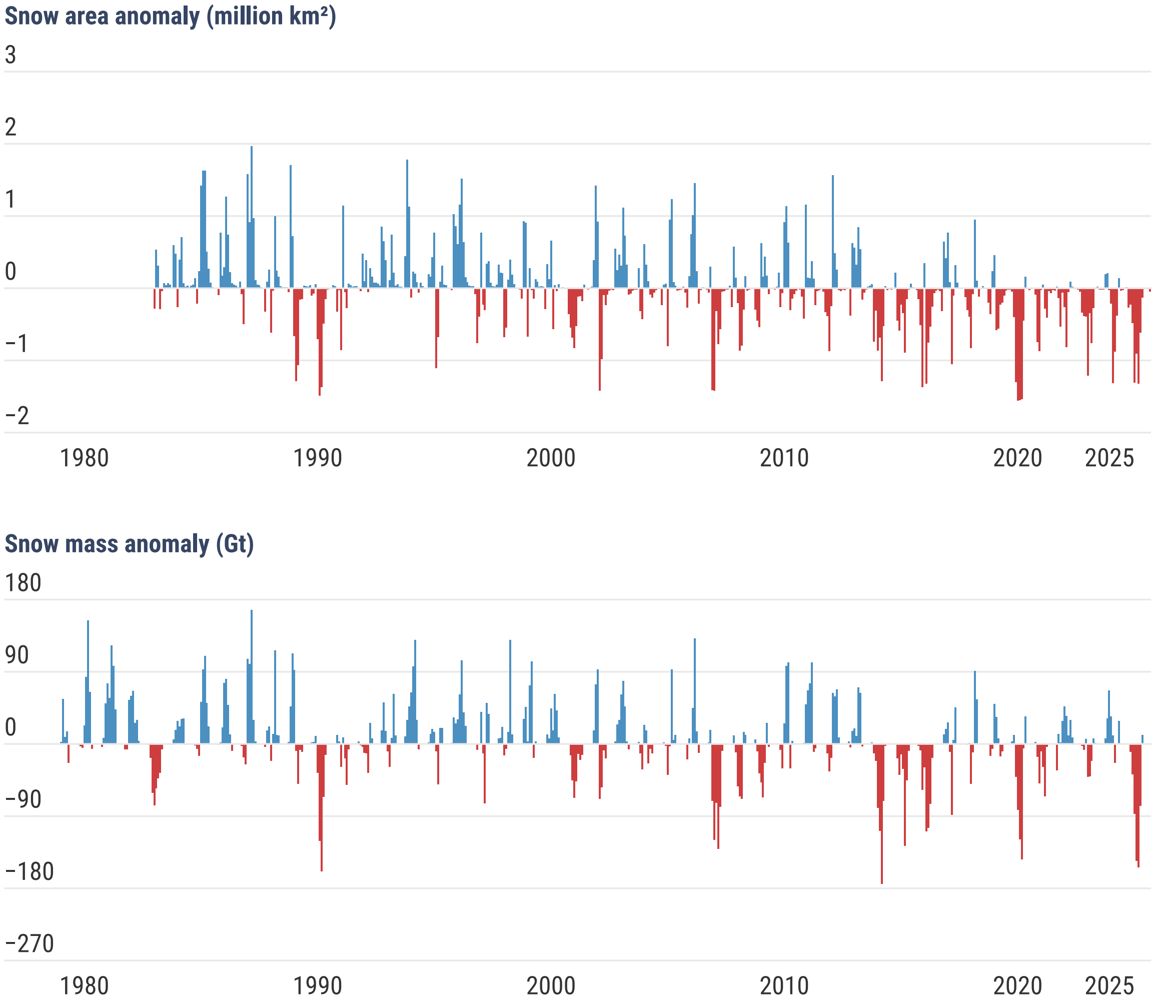
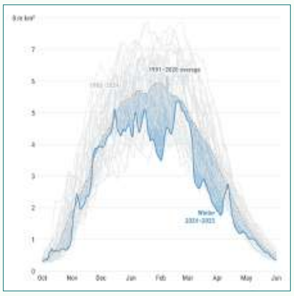
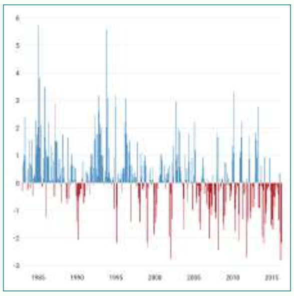


Figure 13.3. Monthly anomalies in (top) snow area (million km²) and (bottom) snow mass (Gt) for Europe, relative to the average for the 1991–2020 reference period. Positive anomalies (blue bars) indicate more snow, negative anomalies (red bars) indicate less snow than average. Data: C3S SCE and SWE v1.0. Credit: C3S/ECMWF/ENVEO/FMI.

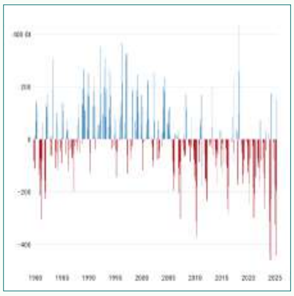
Supplementary figures



Daily snow area and mass



Global monthly snow area anomalies since 1983



Northern Hemisphere monthly snow mass anomalies since 1979

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

14.

Glaciers

Glaciers are bodies of perennial snow and ice that are shaped by local topography and flow slowly under their own weight. They differ from ice sheets, which are continental masses of snow and ice. Only two exist today – the Greenland Ice Sheet and the Antarctic Ice Sheet. In Europe, glaciers are found in mountainous areas such as the Alps, northern Scandinavia and Iceland, and around Greenland's periphery. These glaciers accumulate snow during winter and spring, and occasional summer snowfalls can temporarily slow or stop melt. Mass loss can be higher than mass gain through a thinner-than-average snowpack at the end of winter, higher-than-average temperatures and solar radiation during summer.

Long-term changes in glacier mass balance – the balance between accumulation of snow and melting of snow and ice – are directly linked to climate change and therefore important to monitor. Glacier changes also impact local geohazards, regional runoff and global sea-level rise. Over the last few decades, glaciers around the globe have been experiencing increasing mass loss, and the European Alps is one of the regions where glaciers are shrinking the most.

This section examines glacier mass changes across Europe in 2025 and provides long-term context, including comparisons with other glacier regions globally.[37] More information on the mass changes of the Greenland Ice Sheet can be found in the 'Greenland Ice Sheet' section.

Glaciers in 2025

European glaciers experienced a net mass loss in all regions during 2025, with exceptions in northern Scandinavia.

Glaciers in Europe saw a net mass loss in 2025, with Iceland recording its second-largest glacier mass loss (1.55 m w.e.) since 1976.

37 Glacier changes are measured in hydrological years. In Europe, the hydrological year begins on 1 October with the start of winter accumulation and finishes on 30 September of the following year with the end of the summer melt season.

The most negative mass balances were observed in Iceland, where glaciers lost an average of 1.55 metres of water equivalent (m w.e.). This is consistent with the region's record temperatures in late spring which reduced snow cover and left the glaciers more vulnerable to summer melt. Iceland's ice loss in 2025 was the second largest loss on record, just slightly more than in 2005 (1.52 m w.e.) and exceeded only by the loss in 2010 (2.56 m w.e.), which was exacerbated by reduced albedo — the amount of solar radiation reflected back into space — caused by ash from the eruption of Eyjafjallajökull.

Global glacier mass loss continued, with an annual net mass loss of about 410 Gt, equivalent to 1.1 mm of sea-level rise.

Similarly affected by above-average temperatures, but also by drier-than-average conditions, central Europe saw an average glacier mass loss of 1.38 m w.e. Svalbard, one of the fastest warming places on Earth in recent decades, recorded an average loss of 1.21 m w.e. Other areas of Europe, including the Caucasus, Greenland Ice Sheet periphery and Scandinavia experienced more moderate losses (0.39 to 0.53 m w.e.).

All European glacier regions saw ice loss in 2025

Glacier mass change in Europe during 2025

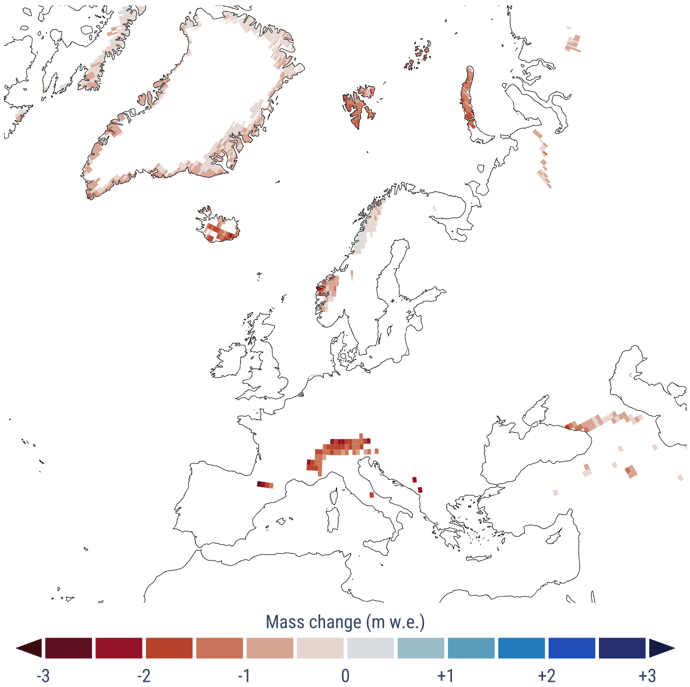


Figure 14.1. Glacier mass changes across Europe in the 2025 hydrological year. Positive (blue) and negative (red) mass change is shown in metre water equivalent (m w.e.; 1 m w.e. = 1000 kg per square metre) averaged over the glacier area within 0.5°x0.5° grid cells. For Greenland, the mass change estimates include the peripheral glaciers but not the Greenland Ice Sheet. In Europe, the hydrological year runs from 1 October to 30 September. Data: WGMS. Credit: WGMS/C3S/ECMWF.

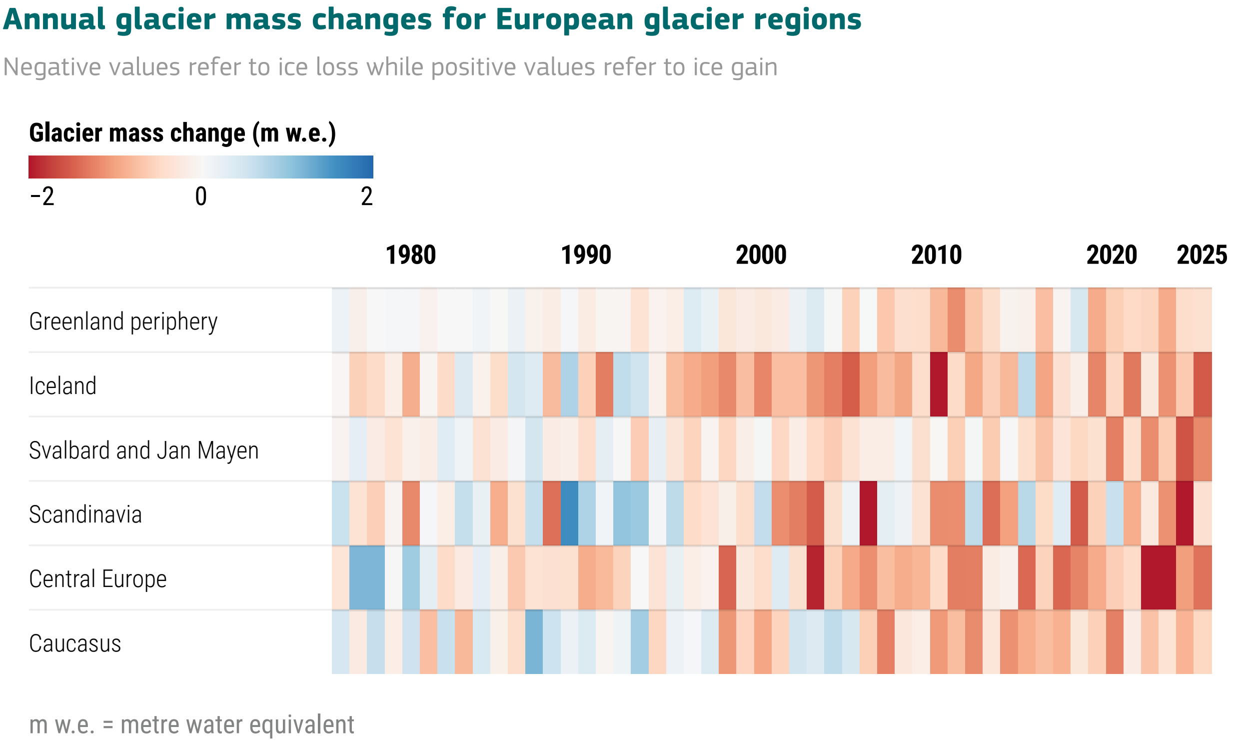


Figure 14.2. Climate stripes of annual glacier mass changes for hydrological years from 1976 to 2025. The positive (blue) and negative (red) annual net mass changes in metre water equivalent are shown for the Greenland periphery, Iceland, Svalbard and Jan Mayen, Scandinavia, central Europe and Caucasus. Information for other areas is shown in the Glacier Indicator Section. Data: WGMS. Credit: WGMS/C3S/ECMWF.

Multiplying the average mass change in each region by its area gives the total change in glacier mass for that region. In Europe, the largest glacier mass losses came from Svalbard (-39 ± 11 Gt), the Greenland periphery (-29 ± 16 Gt) and Iceland (-16 ± 2 Gt).

Long-term trends

The 2025 hydrological year was the fourth in a row in which all 19 glacier regions worldwide experienced a net mass loss. In 2025, the total global glacier mass loss was about 410 Gt, equivalent to 1.1 mm of sea level rise. For regional timeseries, the 2025 net mass loss ranked second in southwestern Asia (since 1957), third in western Canada and the USA (since 1946) and in central Asia (since 1957), and fourth in Iceland (since 1949), Svalbard (since 1946) and the Russian Arctic (since 1946).

The global cumulative mass loss since 1976 is around 9580 ± 620 Gt, equivalent to about 26.4 ± 1.7 mm of sea-level rise. The largest contributions are from glaciers in Alaska (30%), the Canadian Arctic (19%), High Mountain Asia (13%), the southern Andes (10%) and at the Greenland Ice Sheet periphery (9%).

Glaciers across Europe and globally are projected to continue to lose mass throughout the 21st century, regardless of the emission scenario.[38] This glacier loss will impact roughly two billion people who depend on mountain waters, while also increasing hazards such as floods and landslides and contributing to sea level rise.

Since global records began in 1975, cumulative glacier mass loss is around 9580 Gt, equivalent to 26.4 mm of sea-level rise.

Cumulative glacier mass change globally

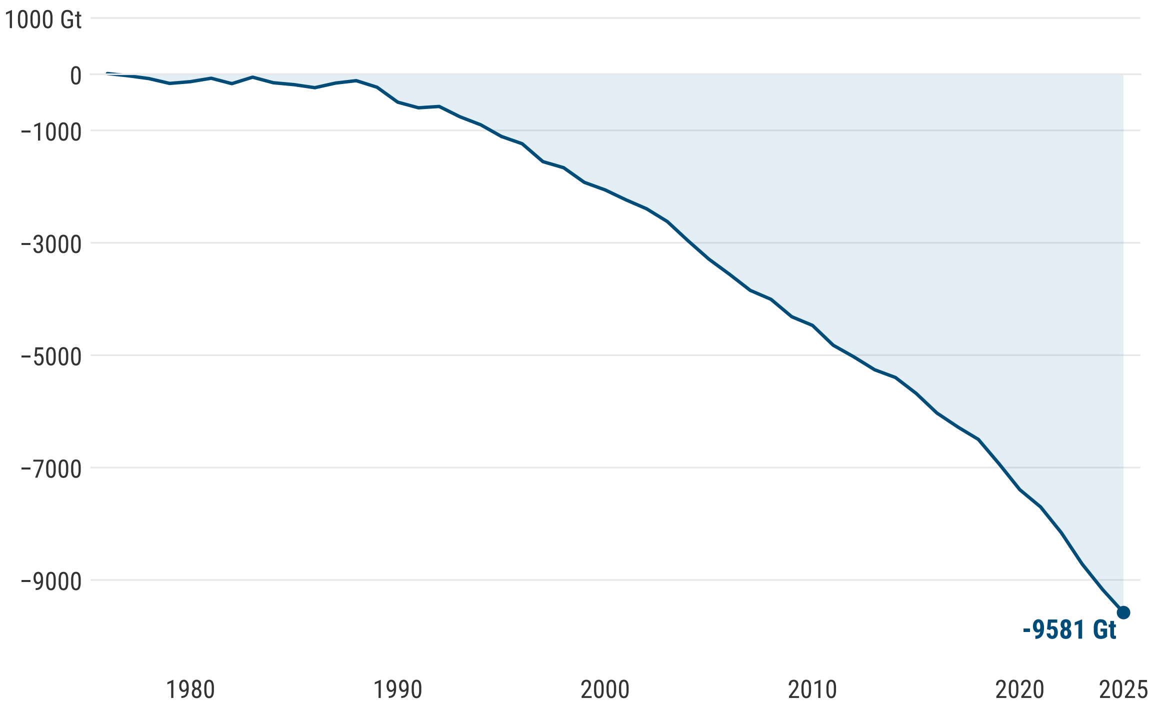
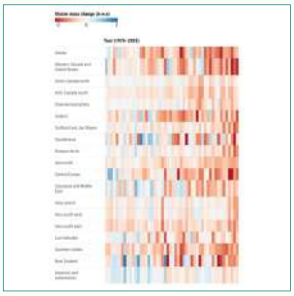


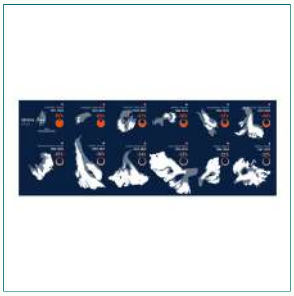
Figure 14.3. Cumulative global glacier mass changes from 1976 to 2025. Data: WGMS. Credit: WGMS/C3S/ECMWF.

38 Plausible 'what if' narratives and numerical representations of future greenhouse gas emissions, based on assumptions about socio-economic development.

Supplementary figures



Climate stripes of glacier mass changes globally



Melting glaciers infographic

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

15.

Greenland Ice Sheet

Gt = gigatonnes = 1 billion tonnes

The Greenland Ice Sheet (GrIS) covers roughly 80% of the island and is one of only two ice sheets[39] on Earth. Although significantly smaller than its counterpart in Antarctica, the GrIS still contains enough fresh water to raise the global mean sea level by about seven meters.

The Greenland Ice Sheet lost around 139 Gt of ice in the 2025 hydrological year. This net mass loss is equivalent to about 1.5 times the amount of ice stored in all the glaciers in the European Alps and raised the global mean sea level by 0.4 mm.

The GrIS was close to a state of balance in the 1970s but lost mass at an accelerating pace in the following decades. Ice losses from the GrIS contribute about 20% to global sea level rise [R15.1].

Ice sheet mass balance

The GrIS mass balance results mainly from two distinct processes.[40] First, surface processes, dominated by snow accumulation and meltwater runoff, determine the surface mass balance (SMB). Second, ice flow moves ice under its own weight to the ocean, where it is lost through calving and underwater melting. While SMB generally has a positive contribution to ice sheet mass balance, ice discharge, by definition, has a negative impact.

Ice sheet mass balance estimates are typically reported based on the hydrological year rather than the calendar year. This ensures that the full natural cycle of snow accumulation in winter and melting in summer is accounted for. For the GrIS, September to August is used.

For the 2025 hydrological year, the GrIS lost 139 ± 79 Gt of mass, making it the 29th consecutive year of net mass loss. While the loss rate was 9% below the average of 152 ± 11 Gt per year, it was still significant. It is equivalent to about 1.5 times the amount of ice stored in all the glaciers in the European Alps, and raised global mean sea level by 0.4 mm.

39 A perennial mass of ice resting on bedrock and covering an area greater than 50,000 km^2.

40 Basal melting also has a small impact on total ice mass balance estimates. Around -23 Gt in 2025.

The current rate of global sea level rise seen since 1993 is approximately 3.6 mm per year. The peripheral glaciers and ice caps not included in the GrIS mass balance lost around 30 Gt of ice in 2025. *The total ice mass balance estimates in this section use data from IMBIE, also used for the 'Ice Sheets' Indicator.*

Surface processes

The processes driving mass changes at the GrIS surface are dominated by solar radiation, air temperature and precipitation, which falls primarily as snow with some rain. The positive GrIS mass anomaly in 2025 was due to higher-than-average mass gains from precipitation and lower-than-average melt. The SMB was 405 Gt, 23% above average [R15.2].

2025 surface mass balance (SMB) higher than average due to anomalous spring and summer precipitation

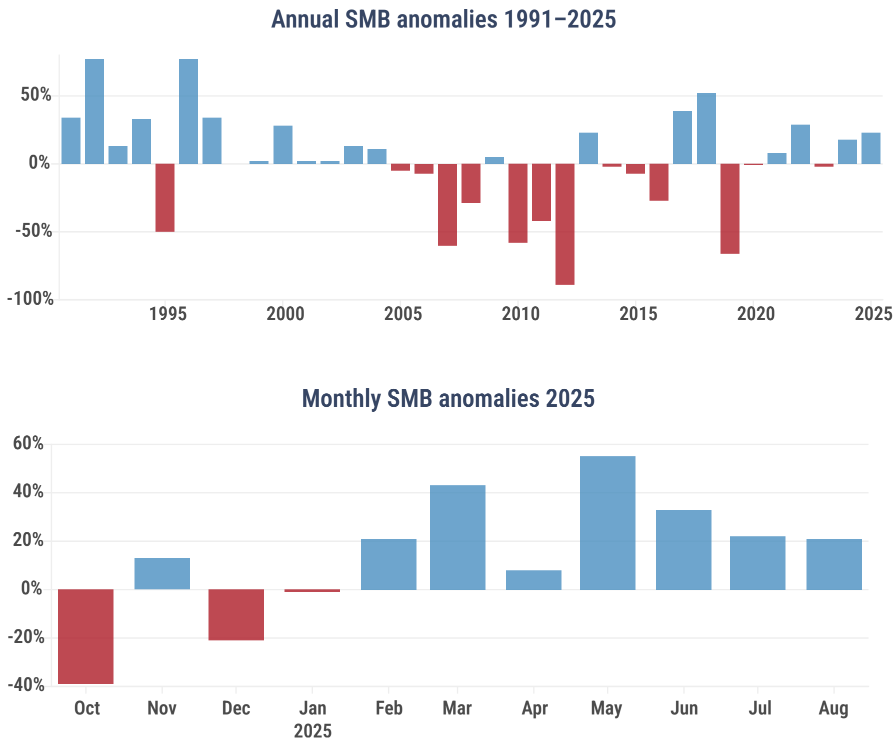


Figure 15.1. (Top) Annual long term and (bottom) 2025 hydrological year monthly SMB anomalies (%) for the GrIS. SMB is mostly driven by meltwater runoff and snow accumulation. Data: PROMICE. Credit: C3S/ECMWF/GEUS.

Precipitation was 14% lower than average from September to January, resulting in a below-average SMB during that period. The negative anomaly was particularly apparent in the southeastern part of the ice sheet, which usually sees the most precipitation. In contrast, 27% more precipitation than average was seen from February, at the end of the accumulation season, to August 2025, at the end of the melt season, bringing the total for the hydrological year close to average. The positive spring and summer precipitation anomaly was predominantly driven by snowfall at the western and northern coastal regions, where it reduced summer melting by increasing the surface reflectivity ('albedo') while adding a meltwater absorbing layer.

The 2025 ice mass loss was 9% lower than the average of around 152 Gt per year, due to higher-than-average spring and summer precipitation, which buffered summer melt despite record spring and summer temperatures.

The anomalies were driven by atmospheric circulation patterns that diverted warm air away from the ice sheet throughout much of the summer. The 2025 melt season also saw heatwaves in late May, and in June and July, with short-lived temperature and melt extent extremes. These heat anomalies predominantly affected the upper plateau and produced no additional meltwater runoff as temperatures remained below freezing.

Anomalies and extremes for the 2025 hydrological year

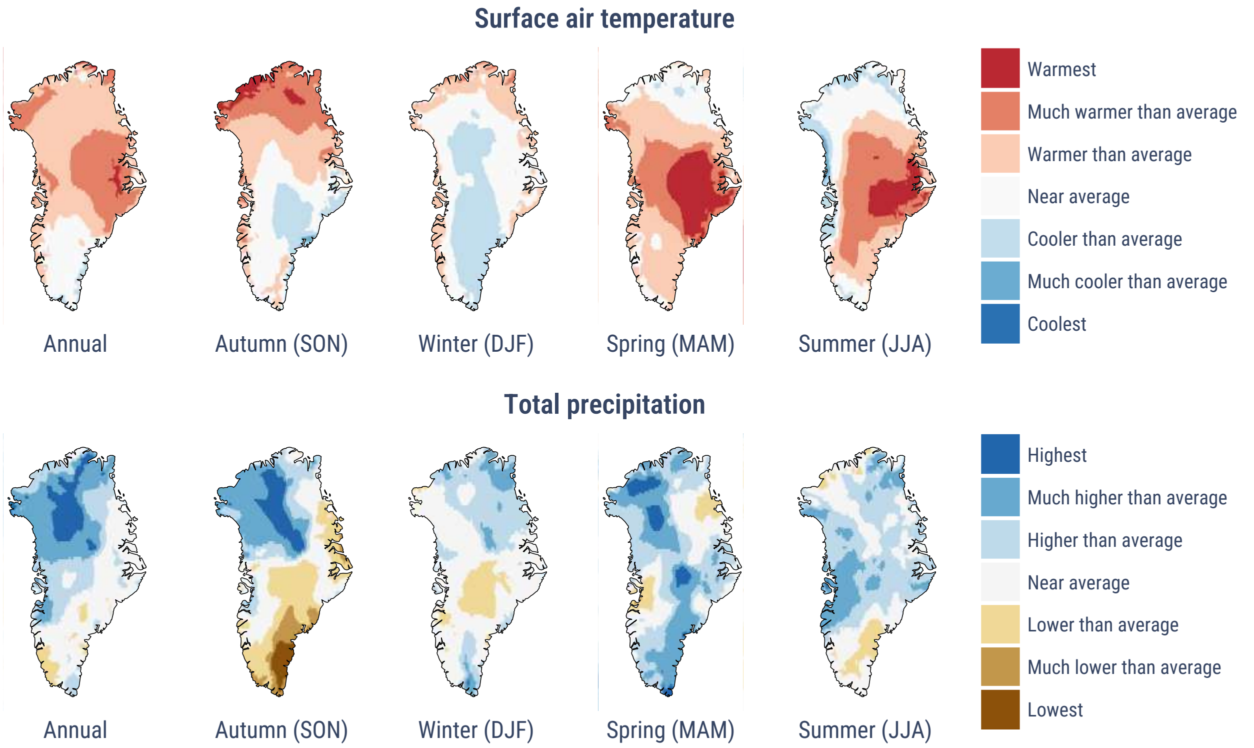


Figure 15.2. Anomalies and extremes in (top) surface air temperature and (bottom) precipitation for the 2025 hydrological year. Data: ERA5. Credit: C3S/ECMWF.

These precipitation patterns and atmospheric circulation resulted in an above-average surface mass gain from February onwards and, consequently, slightly less-than-average ice mass loss for 2025 as a whole. These increases in precipitation and temperature are in line with predictions for a warming climate, as the atmosphere holds 7% more moisture for each additional degree of warming.

Ice flow dynamics

The GrIS is not a static block of ice but an interconnected system of glaciers through which ice constantly flows towards the margins, driven by its own weight. At the margins, the ice flow is channelled into fast-moving outlet glaciers, through which ice is discharged into the ocean by iceberg calving and submarine melting. Total ice mass changes therefore consider ice discharge at the ice-ocean interface as well as surface processes.

Ice discharge remained at an accelerated rate in 2025

Ice flow velocity, ice discharge and relative ice discharge anomalies for the 2025 hydrological year.

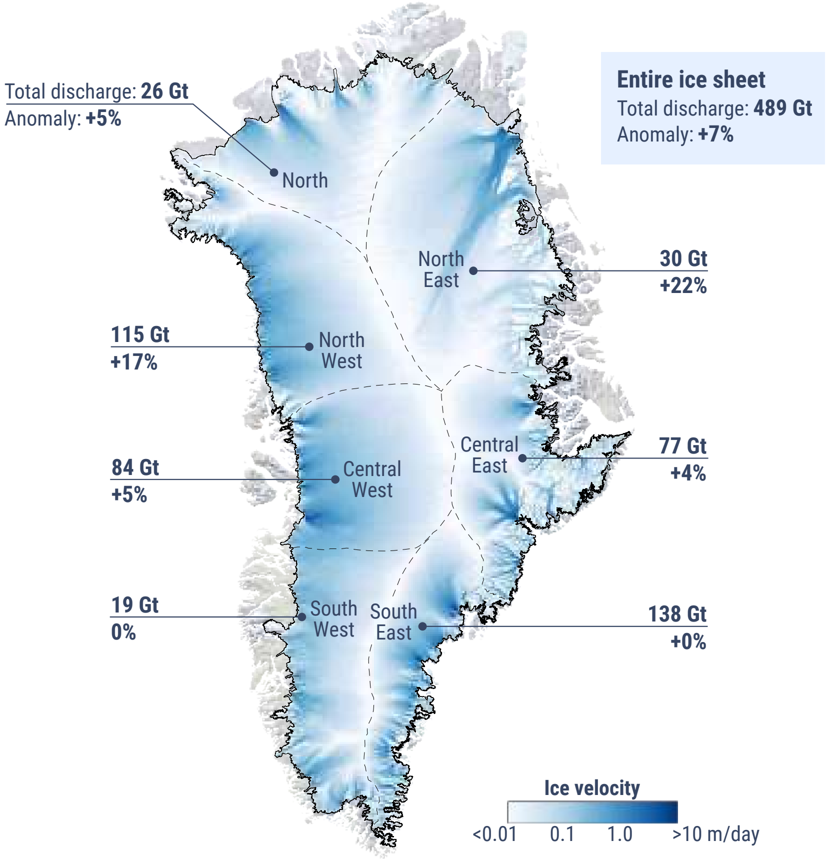


Figure 15.3. Ice flow velocity, ice discharge and relative ice discharge anomalies for the 2025 hydrological year. Ice discharge is calculated on a regional scale using drainage basins that define the calculation areas [R15.4]. Data: PROMICE, ENVEO. Credit: C3S/ECMWF/ENVEO/GEUS.

In the 2025 hydrological year, the GrIS discharged 489 Gt of ice into the ocean [R15.3]. Ice discharge is mostly compensated for by precipitation and the resulting positive SMB. However, the rate of ice discharge has exceeded the SMB since the mid-1990s, with a sharp increase in the early-to-mid-2000s. The ice discharge anomaly of 7% above average for the 2025 hydrological year is similar to that seen in the previous two decades.

Since the 1970s, the Greenland and Antarctic Ice Sheets have lost over 10,000 Gt of ice, causing the sea level to rise by about 3 cm. Projections indicate that ice mass loss will continue and potentially accelerate in the future.

Ice discharge is primarily through glaciers at the central-western and northwestern, as well as the central-eastern and southeastern margins of the GrIS. Ice discharge from the GrIS is dominated by a small number of large, fast-flowing glaciers. For 2025, the highest ice discharge was estimated at Sermeq Kujalleq (Jakobshavn Isbræ) (41 Gt; 8% higher than average), Helheim Gletsjer (27 Gt; 2% higher than average) and Kangerlussuaq Gletsjer (24 Gt; 3% lower than average). These three glaciers account for 19% of the 2025 ice discharge.

Long-term trends

Earth's polar ice sheets cover most of Greenland and Antarctica, and store about 68% of the planet's fresh water. If the ice sheets were to melt entirely, they would raise global mean sea level by around 7.4 m for the ice in Greenland and around 57.9 m for the ice in Antarctica [R15.5]. Since the 1970s, ice mass loss of these ice sheets has caused sea level to rise by around 3 cm. It is estimated that for every centimetre of sea level rise, around six million people across the planet are exposed to coastal flooding. The rate of ice loss has increased by around three times (Antarctica) to five times (Greenland) since the 1980s and is expected to continue increasing beyond the end of the century.

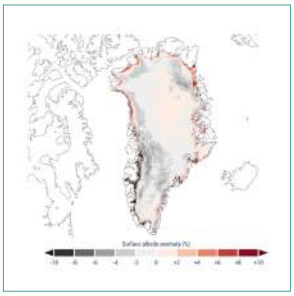
Since the 1970s, there has been a loss of ice sheet of around:

Greenland (1972–2025): -5,747 Gt
Antarctica (1979–2024): -4,876 Gt

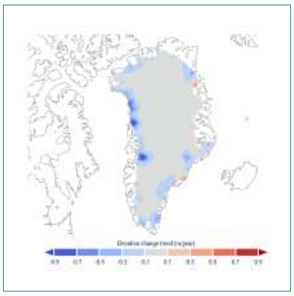
Data for 1972–2025 for Greenland, and 1979–2024 for Antarctica.
Data: IMBIE.

Projections indicate that both the Greenland and Antarctic ice sheets will continue to lose mass throughout this century, regardless of the emission scenario.[41] In Greenland, as marine terminating glaciers are retreating, this projected ice loss is increasingly dominated by surface melt. Antarctica, however, is projected to experience increased ocean-driven dynamic ice mass losses that are likely to outpace increasing snowfall.

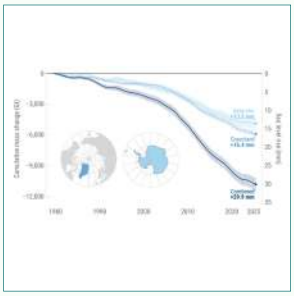
Supplementary figures



Greenland Ice Sheet summer albedo anomaly



Ice sheet elevation change trend



Contribution to sea level rise from ice sheet mass loss

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

41 Plausible 'what if' narratives and numerical representations of future greenhouse gas emissions, based on assumptions about socio-economic development.

Cold environments in a warming climate

From the Alps to the Arctic, Europe's ice and snow cover are shrinking

The area of Europe experiencing winter days with freezing temperatures is shrinking.

In 2025, end-of-season snow cover extent and mass were the third lowest in the 42-year record.

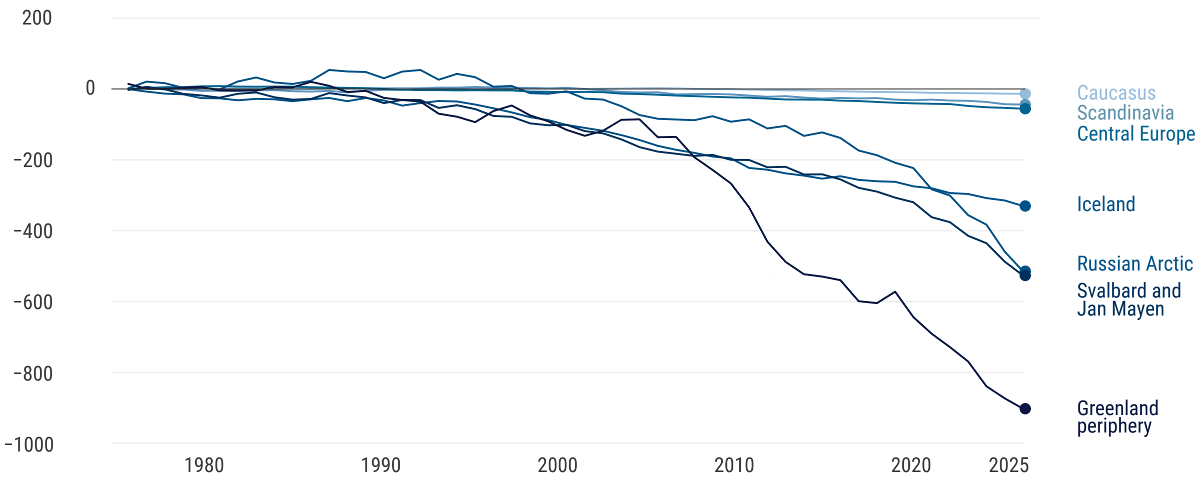
Glaciers in Europe saw a net mass loss in 2025. The most negative mass balances were observed in Iceland.

The Greenland Ice Sheet lost around **139 gigatonnes (Gt = gigatonnes = 1 billion tonnes) of ice in 2025** – equivalent to around 1.5 times the amount of ice stored in all the glaciers in the European Alps.

In March 2025, the snow covered area was about **1.32 million km² below average** – approximately the area of France, Italy, Germany, Switzerland and Austria combined.

Cumulative glacier mass change for European glacier regions

Annual data by region, in gigatonnes



Data: ENVEO, WGMS • Reference period: 1991–2020 • Credit: ENVEO/WGMS/C3S/ECMWF

16.

Sea ice

The European Arctic sector of the Arctic Ocean has experienced some of the fastest warming on Earth in recent decades. This warming has been closely linked to sea ice retreat: less ice cover allows the ocean to absorb more heat in summer through reduced surface reflectivity ('albedo') and release more heat back to the atmosphere in autumn and winter, which further contributes to the warming and can delay or suppress winter sea ice formation.

The European Arctic seas also play an important role in the climate system, as they are among the few regions contributing to deep-water formation, whereby surface waters cool, become dense and sink to depth. Sea ice formation contributes to this process by increasing the salinity and density of surrounding waters as salt is expelled during ice growth. Sinking water helps drive the large-scale ocean circulation that redistributes heat around the globe.

2025 saw contrasting sea ice conditions across the European Arctic, particularly at the beginning and end of the year, with average or above-average ice cover in the Greenland Sea and much below-average ice cover in the Barents Sea.

This section examines the evolution of European Arctic sea ice cover, ocean surface temperatures over both sea ice and ice-free waters, as well as sea ice thickness and volume in 2025, and provides a summary of long-term sea ice trends.

Sea ice cover

The assessment of sea ice extent in the European Arctic presented here focuses on the Greenland Sea, the Barents Sea and the Svalbard region in between. Although geographically connected, these areas can experience markedly different sea ice conditions due to variations in ocean circulation, ice transport and atmospheric influences. The Greenland Sea is strongly affected by sea ice drifting southwards from the central Arctic through the Fram Strait, while the Barents Sea is more heavily influenced by the inflow of relatively warm Atlantic water.

Contrasting sea ice conditions in the Greenland Sea and the Barents Sea

Daily sea ice extent by year in million km²

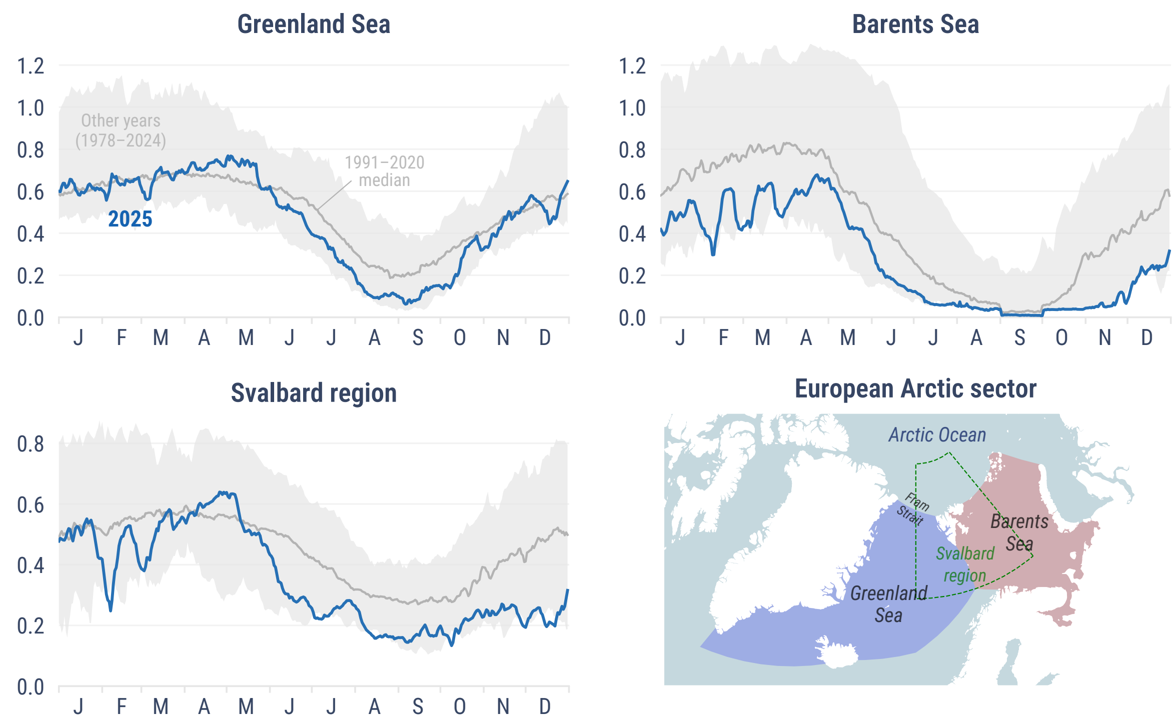


Figure 16.1. Daily sea ice extent (million km²) for three ocean sectors within the European Arctic: (top left) the Greenland Sea, (top right) the Barents Sea and (bottom left) the Svalbard region. (Bottom right) The three sectors are outlined in a map. Data: OSI SAF Sea Ice Index v3.0. Credit: EUMETSAT/C3S/ECMWF.

These contrasting influences were evident in 2025, particularly at the beginning and end of the year. In the Greenland Sea, sea ice extent was generally close to average from January to March, before rising above average in April and May in part due to persistent strong southward drift through the Fram Strait. The May monthly extent was 10% above average, the second highest since 2002. The daily extent fell below average in June and remained well below average until mid-October.

From January to April, sea ice extent in the Barents Sea and Svalbard region showed large variability, linked to the passage of storms and associated ice drift.

It recovered to near-average levels until the end of the year, except for a temporary drop in mid-December.

In contrast, sea ice extent in the Barents Sea was well below average throughout the year, particularly from January to April and in November–December. In March, the monthly extent was the second lowest on record for the month, while October, November and December each recorded their lowest extent.

The daily extent in the Barents Sea and the Svalbard region showed marked variability during the first four months of the year, linked to storms that led to strong ice drift either away from or towards these ocean sectors. In late January and early February, sea ice extent in both regions briefly fell to record lows for February before recovering rapidly within a few days. This period also coincided with a new record low in global sea ice extent, to which ice conditions in the Barents Sea contributed.

Variability was much lower from October to December. The record-low extents observed during this period were likely linked to much warmer-than-average sea surface temperatures, which delayed freeze-up.

Sea ice surface temperature

The temperature at the ocean's surface plays an essential role in heat and moisture exchange with the atmosphere, as well as in sea ice processes. Where sea ice is present, the ice surface, rather than the water surface, interacts directly with the atmosphere. Sea surface temperature (SST) over ice-free water and sea ice surface temperature (IST) can both be estimated from satellite observations.[42] Here, they are combined (SST/IST) to characterise the temperature of the ocean surface in the European Arctic.[43] IST typically exhibits much larger fluctuations than SST, reflecting the differences in physical properties between seawater and the ice surface, which is more directly influenced by atmospheric conditions.

In 2025, the annual average SST/IST for the European Arctic was −1.7°C (1.9°C above average). This was the second-highest value in the satellite data record, which begins in 1982, after the record set in 2016 (2.2°C above average). The 2025 anomaly was also markedly higher than the anomalies of the previous eight years (2017–2024), exceeding them by 0.8–1.3°C. Annual temperatures were much above average across most of the region, reaching record highs in the northern Norwegian Sea (ice-free), northern Baffin Bay (partly ice-covered) and north of Greenland (ice-covered throughout the year).[44] Over the central Arctic Ocean, annual temperatures were generally 3–5°C above average, and as much as 6°C above average north of Svalbard.

The annual average sea surface and sea ice temperature for the European Arctic was the second highest on record, behind 2016.

42 Sea surface temperature under sea ice cannot be measured from space. It is often assumed to be -1.8°C, the freezing point of seawater.

43 The WMO RA VI (Europe) ocean region north of 66.6°N.

44 The type of surface determines whether the temperature reflects mainly sea surface temperature or sea ice surface temperature.

During 2025, the monthly SST/IST for the region was above average in all months. The largest anomalies occurred in February–March and October–December, reaching up to 4.4°C in February and 3.8°C in December. Temperature anomalies are typically smaller during the melt season (April–August) because most of the additional energy goes into melting the ice rather than raising its surface temperature, keeping it close to the melting point. In addition, during this period, a larger share of the ocean surface is open water, and its temperature varies less than that of the sea ice surface. Temperatures reached record highs for the month in February, September, October and December; they were second highest in March, July and August, and third highest in November.

Second-highest sea and sea ice surface temperatures (SST/IST) for the European Arctic

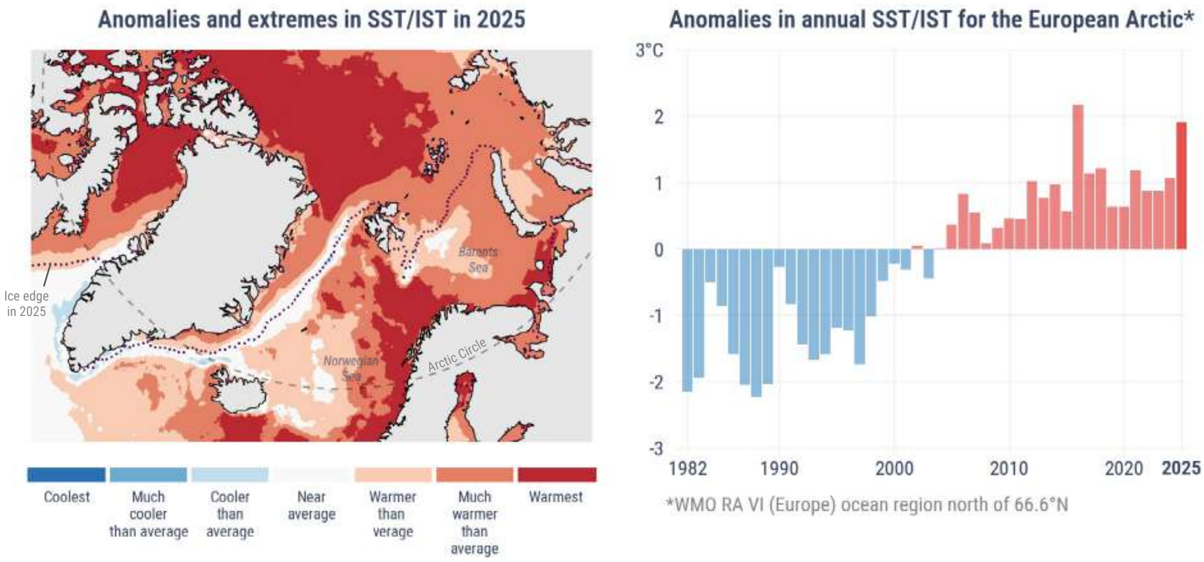


Figure 16.2. (Left) Anomalies and extremes in annual sea surface temperature (SST) and sea ice surface temperature (IST) in 2025. The extreme categories ('coolest' and 'warmest') are based on rankings for 1982–2025. The other categories describe how the temperatures compare to their distribution during the 1991–2020 reference period. 'Much cooler/warmer than average' – cooler/warmer than 90% of temperatures; 'cooler/warmer than average' – than 66% of temperatures; 'near average' – within the middle 33%. (Right) Annual SST/IST anomalies for the WMO RA VI (Europe) ocean region north of the Arctic Circle from 1982 to 2025, relative to the average for the 1991–2020 reference period. Data: C3S Global Sea and Sea Ice Surface Temperature v1.0. Credit: DMI/C3S/ECMWF.

Sea ice thickness and volume

Sea ice thickness varies across the Arctic Ocean. It is generally thickest north of Greenland and the Canadian Arctic Archipelago, where older, multi-year ice accumulates, and thinnest in peripheral seas such as the Barents and Kara seas, where ice is mostly seasonal.

Thickness changes throughout the year as sea ice grows and thins with the seasons, while winds and ocean currents redistribute the ice and can export it out of the Arctic. Combined with sea ice extent, thickness can be used to infer sea ice volume, which represents the total amount of ice present in a given ocean sector.

Sea ice volume in the European Arctic was above average at the end of the growth season in April but much below average by the end of the year.

Much below-average sea ice thickness in the European Arctic at the end of 2025

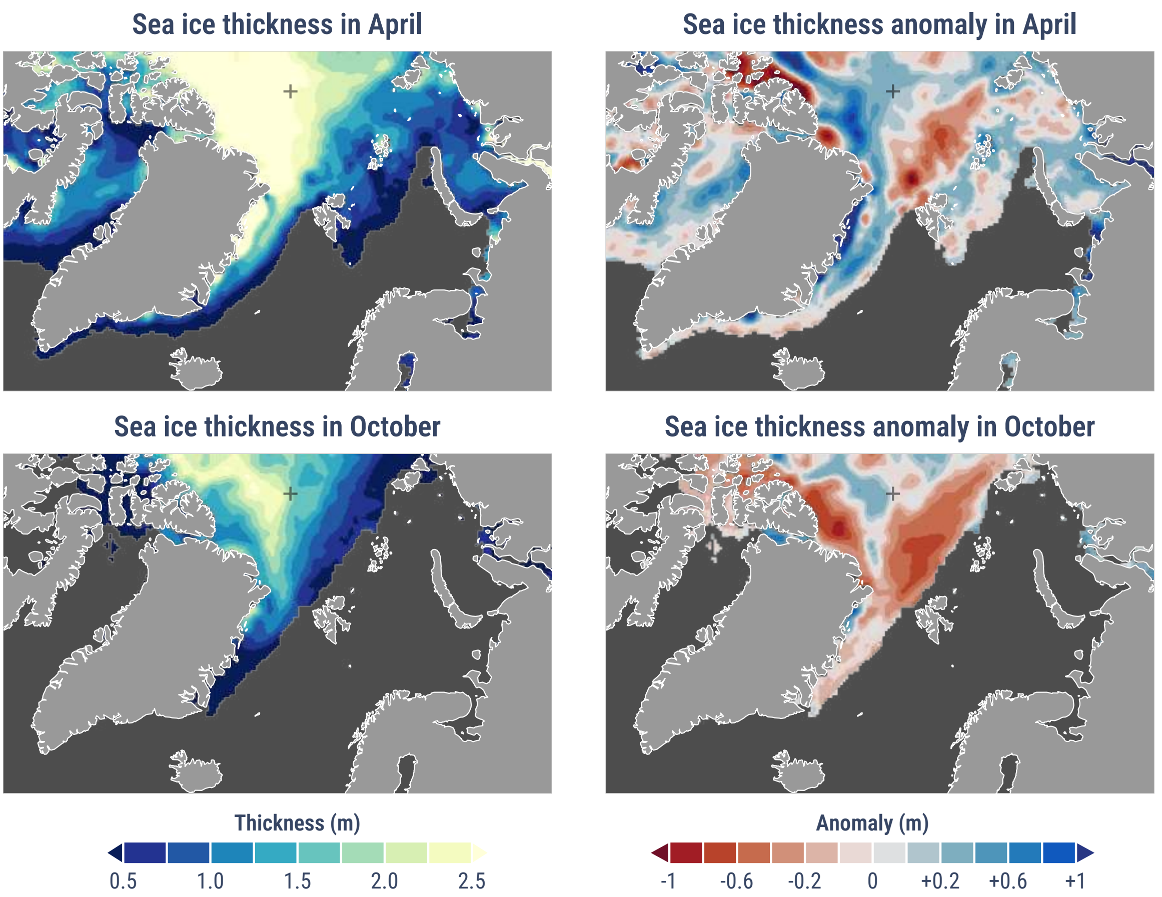


Figure 16.3. (Left) Sea ice thickness and (right) anomalies (both in metres) for (top) April and (bottom) October 2025. Anomalies are relative to the average for the 2011–2021 reference period for April and to the average for the 2010–2020 reference period for October. Data: ESA Level-4 CryoSat-2/Sentinel-3/SMOS Sea Ice Thickness v.1.1. Credit: AWI/C3S/ECMWF.

In April, at the end of the sea ice growth season, ice was thicker than average[45] north of Greenland, in the Greenland Sea, and to a lesser extent in the northern Barents Sea. It was much thinner than average north of Svalbard. The corresponding total ice volume was 35% above average for the Greenland Sea and 12% above average for the Barents Sea.

In October, at the start of the following growth season, ice was thinner than average across most of the ice-covered European Arctic, particularly north of Greenland and north of the Barents Sea. In the Barents Sea region, total ice volume was exceptionally low, at 98% below average in October, and was 75% below average in December, in line with the record-low ice extent for the time of year. In the Greenland Sea, total ice volume was 36% below average in October, recovering to 9% below average by December.

Long-term trends

Since the late 1970s, Arctic sea ice extent has declined in all months, with the largest reductions in late summer and early autumn, particularly around the annual minimum in September, with widespread retreat across the region. Over the same period, average Arctic sea ice thickness has also decreased due to the widespread loss of thick, multi-year ice, resulting in younger, thinner and more seasonal ice cover. Climate projections indicate continued declines in extent and thickness, with at least one nearly ice-free[46] September likely before mid-century under all emission scenarios.[47]

Antarctic sea ice extent has exhibited large year-to-year variability and contrasting regional changes, but with little overall change until the mid-2010s. Around 2016–2017, Antarctic sea ice shifted to predominantly below-average levels, with successive record lows at its annual minimum in February in 2022 and 2023, and near-record lows in 2024 and 2025. Confidence in projections of future Antarctic sea ice change remains low, because models do not currently agree well with observations and show a wide range of results.

45 Anomalies are relative to a 2010/2011–2020/2021 winter average, reflecting the availability of satellite data (October–April only). Accordingly, the reference period is 2010–2020 for October and 2011–2021 for April.

46 Conventionally defined as having less than 1 million km² of sea ice extent in September. Some sea ice is expected to remain in coastal and sheltered areas even under strong warming.

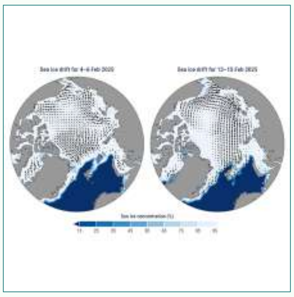
47 Plausible 'what if' narratives and numerical representations of future greenhouse gas emissions, based on assumptions about socio-economic development.

Sea ice loss since the 1980s:

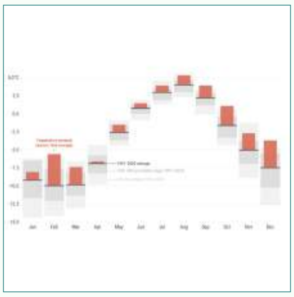
Arctic (September): -2.6 million km² (-33%)
Antarctic (February): -0.6 million km² (-20%)

Last five years, relative to the 1980s.
Data: EUMETSAT OSI SAF.

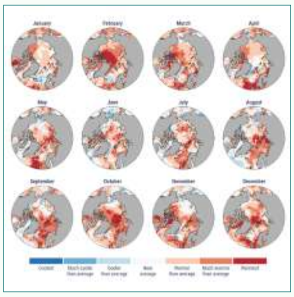
Supplementary figures



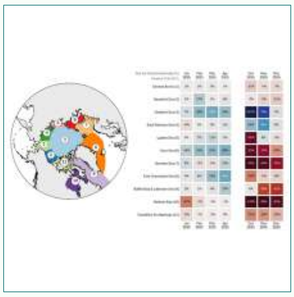
Arctic Ocean sea ice drift



Monthly sea and ice surface temperature



Anomalies in sea and ice surface temperature

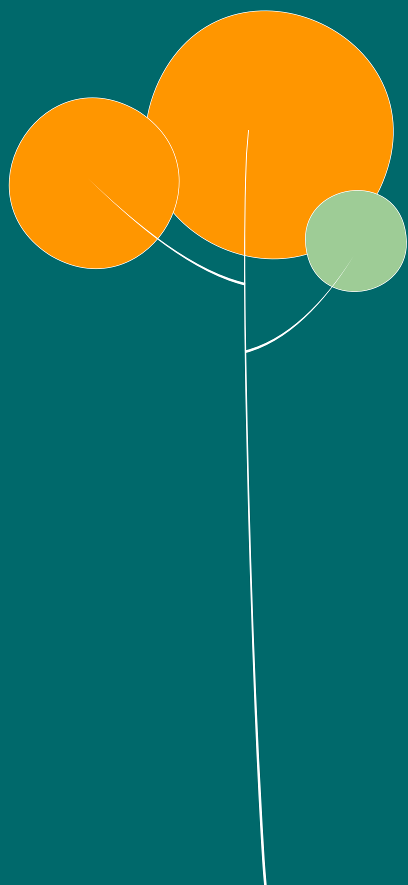


Anomalies in monthly sea ice volume

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

17.

Ocean



The ocean regions surrounding Europe play a crucial role in shaping the continent's weather and climate. The North Atlantic exerts a strong influence, as the prevailing westerly winds carry air from the basin towards Europe. Variations in sea surface temperature (SST) influence storm tracks and precipitation patterns, while warmer waters increase evaporation and can supply additional moisture and energy for heavy rainfall events.

As the temperature of the global ocean increases, periods of exceptionally warm conditions, known as marine heatwaves, are becoming more frequent, intense and widespread. These events disrupt marine ecosystems and fisheries, affect coastal economies and can intensify heatwaves over nearby land. Several European seas, including the Mediterranean and Barents Seas, have warmed faster than the global ocean average, contributing to warming over adjacent land areas. Beyond regional impacts, the European Arctic seas contribute to global ocean circulation through deep-water formation,[48] while the subpolar North Atlantic is an important sink for atmospheric carbon dioxide.

The annual average sea surface temperature (SST) for the European region was the highest on record for the fourth consecutive year. For the Mediterranean Sea, the annual SST was the second highest, behind 2024.

This section provides an overview of annual SST anomalies and marine heatwave conditions across the European region in 2025, including a notable event in the Norwegian Sea in summer, as well as anomalies in chlorophyll a concentrations, an indicator of ocean primary productivity. It concludes with an overview of long-term trends in key ocean climate indicators.

48 The process by which surface waters cool, become denser and sink to depth, forming a key component of global ocean circulation.

Annual overview

In 2025, the annual SST averaged across the European ocean region[49] reached a record high for the fourth consecutive year, at 10.94°C. This is 0.65°C above average and 0.07°C higher than the previous record set in 2024 (10.88°C). The 2025 record extends the marked increase in the annual SST observed since 2021. For the Mediterranean Sea, the annual SST in 2025 was the second highest on record, at 21.35°C, 1.03°C above average, behind the record value from 2024 (21.50°C).

Record-high sea surface temperature over European seas in 2025

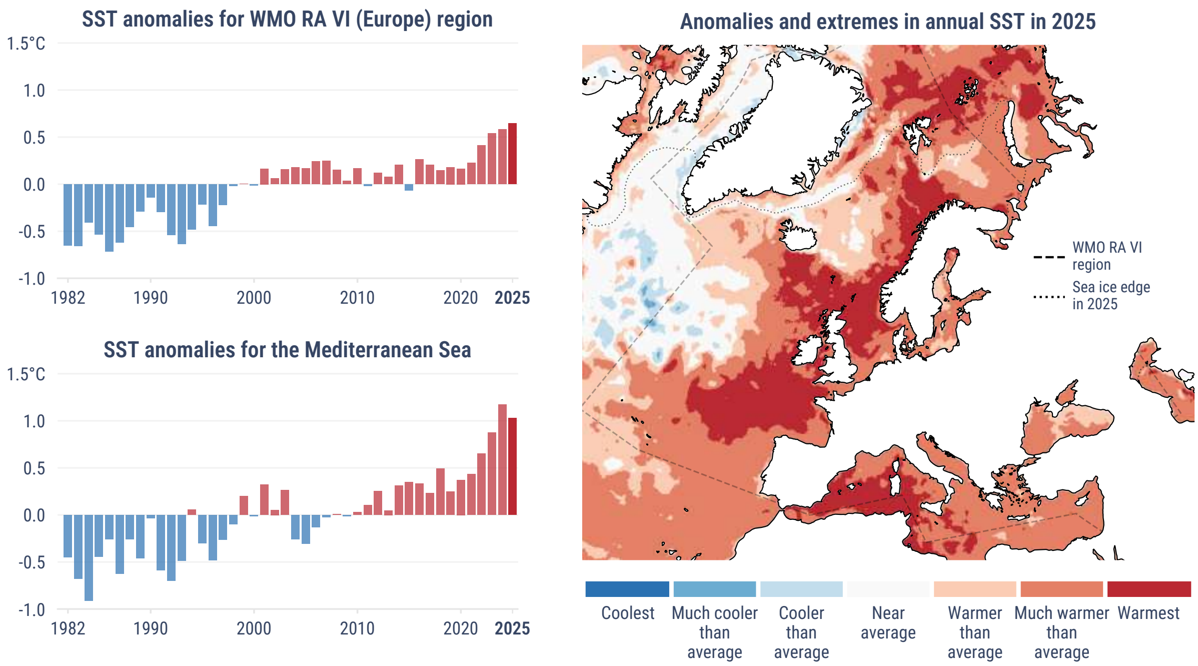


Figure 17.1. (Left) Annual average sea surface temperature (SST) anomalies (°C) for 1982–2025, relative to the average for the 1991–2020 reference period, for (top) the WMO RA VI (Europe) region and (bottom) the whole Mediterranean Sea. (Right) Anomalies and extremes in annual SST in 2025. The extreme categories ('coolest' and 'warmest') are based on rankings for 1982–2025. The other categories describe how the temperatures compare to their distribution during the 1991–2020 reference period. 'Much cooler/warmer than average' – cooler/warmer than 90% of temperatures; 'cooler/warmer than average' – than 66% of temperatures; 'near average' – within the middle 33%. Data: C3S Global Sea and Sea Ice Surface Temperature v1.0. Credit: DMI/C3S/ECMWF.

Annual SSTs were much above average across two thirds (65%) of the region, including 98% of the Mediterranean Sea. The main exceptions were in the central and western North Atlantic, where annual SSTs were near or below average. Record highs occurred over 23% of the region, including large parts of the northeastern North Atlantic, the North Sea, the Norwegian Sea and the western Mediterranean Sea. These areas of record warmth differed from those in 2024, when records were mainly seen in the subtropical North Atlantic and the eastern Mediterranean Sea.

49 The SST values are calculated for the entire European ocean region, including areas covered by sea ice for part or all of the year. This differs from the approach used in the ESOTC 2024 report, where areas covered with any sea ice during the 1982–2024 period were excluded.

From January to May, SSTs were much above average across most of the European region, except in an area east of Iceland, where they were below average. During this period, monthly SSTs reached record highs for the time of year over much of the northeastern North Atlantic, including just over half (55%) of the Mediterranean Sea in March. In the second half of the year, conditions in the North Atlantic were less extreme, with cooler-than-average SSTs spreading across the central and western parts of the basin. Meanwhile, record-high SSTs became more widespread further north in the European Arctic seas, including the Norwegian, Greenland and Barents Seas.

Marine heatwaves

Marine heatwaves are prolonged periods of unusually warm ocean temperatures. Their intensity is classified into four categories: 'moderate', 'strong', 'severe' and 'extreme'. This classification is based on how unusually warm the sea surface is for a given location and time of year rather than fixed temperature thresholds.[50]

During 2025, a record 86% of the European ocean region (excluding ice-covered areas) experienced at least one day with 'strong' marine heatwave conditions. For 'severe' or 'extreme' conditions alone, the proportion was 36%, also a record high.

The proportion of ocean affected by marine heatwaves each year can be assessed by recording the highest heatwave category reached at each location and calculating the total area for each category. This analysis was carried out for the whole European region, excluding areas covered by sea ice.[51] The proportion of the region experiencing marine heatwaves of any intensity has increased markedly over recent decades, from an average of 40% in the 1980s to 98% from 2023 to 2025.

The last three years stand out not only for the marked increase in the total area affected (up from an average of 79% in the 2010s), but also for the sharp rise in the two highest intensity categories, severe and extreme. In 2025, 86% of the region experienced at least strong marine heatwave conditions at some point during

50 This distinguishes the classification of marine heatwaves from the approach used to define heat stress categories. The latter are based on predefined 'feels-like' temperature thresholds that reflect levels of thermal stress on the human body.

51 The presence of sea ice affects the temperature distribution used to define marine heatwave categories. For this reason, areas with any sea ice during the 1982–2025 period are excluded from the analysis.

the year, the highest value on record and on par with 2023. For severe or extreme conditions alone, the proportion was 36%, also a record high and on par with 2024.

In 2025, the proportion of the region experiencing marine heatwave conditions of any intensity on a given day ranged from 52% in January to 19% in October. For strong or more intense conditions alone, it reached 23% in May. Areas experiencing extreme conditions were mainly located in the northeastern North Atlantic, west of Ireland and south of Iceland, and were associated with a marine heatwave event in the second half of May. More scattered areas of extreme conditions were found across the Mediterranean Sea, the largest between southeastern Spain and Algeria, associated with an event in late June and early July.

For the Mediterranean Sea alone, the proportion experiencing marine heatwaves of any intensity in a given year has been 98% or higher since 2014, reaching 100% each year since 2022. Notably, in each of the last three years, the entire sea experienced at least strong marine heatwave conditions. In 2025, just over half (51%) of the sea experienced severe or extreme conditions, the third-highest value after 2024 (65%) and 2023 (53%). During 2025, the proportion of the sea experiencing marine heatwave conditions of any intensity on a given day ranged from 85–90%, mainly between January and March, and 6–10% in May, August and September. For at least strong heatwave conditions, the proportion reached up to 51% in March and 39% in July.

Record 86% of European seas saw at least ‘strong’ marine heatwaves in 2025

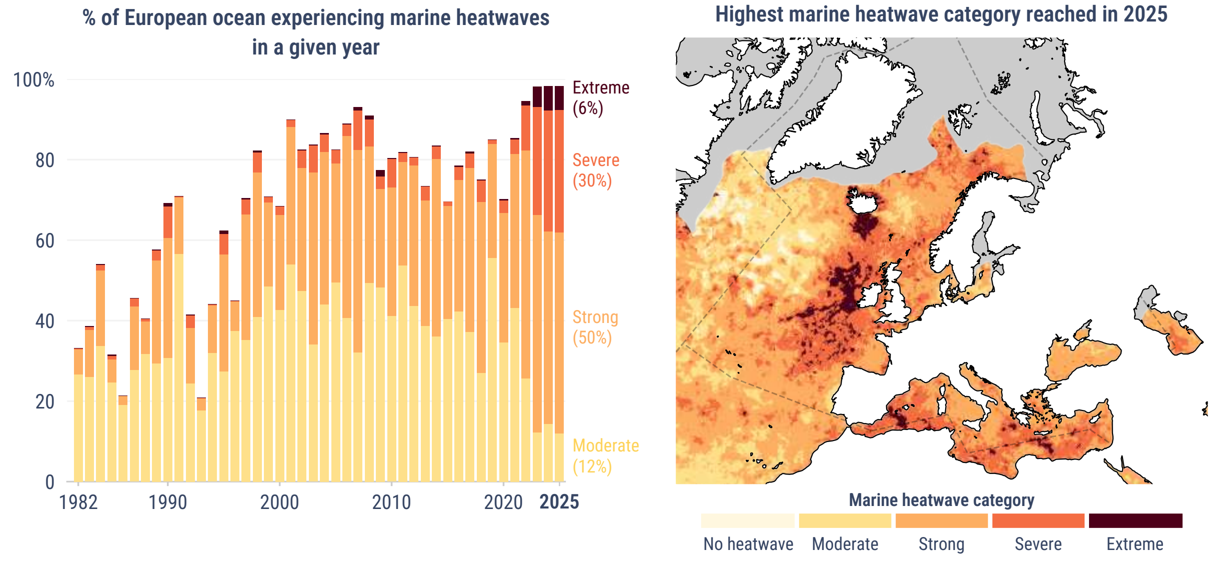


Figure 17.2. (Left) Percentage of the area of the WMO RA VI (Europe) ocean region experiencing marine heatwave conditions each year from 1982 to 2025, shown for four intensity categories: ‘moderate’ (yellow), ‘strong’ (light orange), ‘severe’ (dark orange) and ‘extreme’ (brown). For each year, the percentage is based on the highest intensity reached at each location within the region. (Right) Map showing the highest marine heatwave category experienced at each location during 2025. Marine heatwaves are defined relative to the 1991–2020 reference period. Data: C3S Global Sea and Sea Ice Surface Temperature v1.0. Credit: DMI/C3S/ECMWF.

Marine heatwave in the Norwegian Sea

During summer 2025, Fennoscandia experienced an exceptional heatwave from mid-July to early August. For more details, see the ‘Long heatwave in sub-Arctic Fennoscandia’ section. The event coincided with a marine heatwave in the Norwegian Sea, parts of the North Sea and the northern Baltic Sea that lasted around three to four weeks, depending on the area.

On 24–25 July, the daily SST averaged over the Norwegian Sea sector reached a record high of 15.5°C, slightly exceeding the previous record of 15.4°C from August 2003. This was 3°C above average, the largest daily anomaly recorded for this ocean sector in any month. At the peak of the event, SSTs were 3–5°C above average across much of the Norwegian Sea, and up to 5°C above average along the Norwegian coast, where water temperatures reached around 19°C. Marine heatwave conditions were classified as strong or severe across much of the region.

‘Severe’ marine heatwave in the Norwegian Sea in July 2025

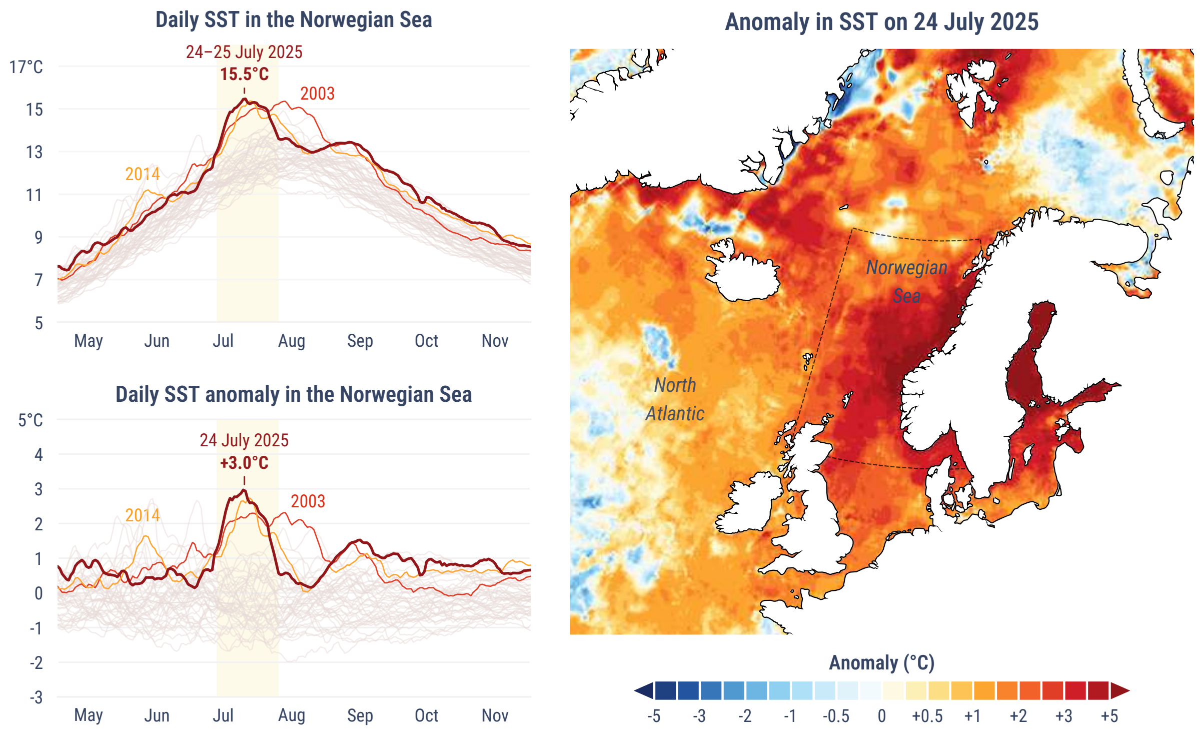


Figure 17.3. (Left) Daily sea surface temperatures (°C, top) and corresponding daily anomalies (°C, bottom) averaged over the Norwegian Sea for 2003 (orange), 2014 (yellow), 2025 (dark red), and all previous years since 1982 (grey). (Right) Daily sea surface temperature anomalies (°C) on 24 July 2025, the day of the highest SST across the Norwegian Sea. All anomalies are relative to the average for the 1991–2020 reference period. Data: C3S Global Sea and Sea Ice Surface Temperature v1.0. Credit: DMI/C3S/ECMWF.

July SST anomalies exceeding 2°C in this sector were last observed in 2003 and 2014, both linked to strong marine heatwave conditions. The 2003 event, while less intense than 2025, was notable for its duration, lasting more than six weeks. The 2025 marine heatwave likely helped reinforce the unusual warmth over adjacent land, particularly along Norway's western coast.

From mid-July to early August, 'severe' marine heatwave conditions occurred in the Norwegian Sea, coinciding with a heatwave over Fennoscandia, during which the daily SST over the area reached a record high.

Ocean primary productivity

Ocean primary productivity is the process by which phytoplankton use sunlight, carbon dioxide and nutrients to produce organic matter through photosynthesis, forming the base of the marine food web. It can be monitored from space using satellite measurements of ocean colour, from which chlorophyll a (Chl a), a photosynthetic pigment found in phytoplankton, is estimated. Chl a concentration can reflect ocean health and its response to climate change, but is influenced by multiple factors, including nutrient and light availability, ocean circulation, vertical mixing and water temperature, making interpretation complex. Higher Chl a concentrations can indicate increased productivity, but may also reflect ecosystem imbalances or environmental stress.

In the North Atlantic and most European seas, primary productivity typically peaks between April and June during the spring phytoplankton bloom, extending into July in northern seas, which is why the analysis focuses on these four months. In 2025, April and May saw above-average Chl a concentrations across the eastern North Atlantic, contrasting with below-average conditions in 2024. In May, concentrations were much above average west of Ireland and south of Iceland. These areas experienced severe marine heatwave conditions during the second half of the month, and abundant sunlight and reduced vertical mixing may have contributed to phytoplankton growth. Much above-average concentrations were also observed further north along the sea ice edge in the Greenland Sea. In June, the largest positive anomalies were across the Greenland, Norwegian and Barents Seas, while in July they were east and south of Iceland and in the Norwegian Sea. In the Mediterranean, Chl a concentrations were mostly below average, similar to 2024 and unlike the widespread positive anomalies of 2022 and 2023.

Long-term trends

Sea surface temperature

The average SST over the global ocean has increased markedly since the 1970s, reflecting the rise in ocean heat content driven by greenhouse gas emissions. Superimposed on this long-term warming are year-to-year variations associated with internal climate variability, particularly the El Niño Southern Oscillation (ENSO), with El Niño and La Niña events having temporary warming and cooling effects, respectively.

In each of the last three years, all areas within the Mediterranean Sea experienced at least one day with 'strong' marine heatwave conditions.

Within the European region, the Arctic seas, particularly the Barents Sea, as well as the Baltic, Black and Mediterranean Seas, have warmed most rapidly. In contrast, parts of the North Atlantic south of Greenland and Iceland show cooling trends. Since around 2021, annual SST across the region has increased sharply, leading to successive records in 2022 to 2025.

Since the 1980s, there has been an increase in SST of around:

Global (non-polar ocean, 60°S–60°N): +0.6°C
WMO Regional Association VI (Europe): +1.1°C
Mediterranean Sea: +1.4°C

Latest five-year averages.
Data: HadSST4.2.0.0, COBE2, ERSSTv5, ERA5, C3S Global Sea and Sea Ice Surface Temperature v1.0.

Ocean heat content

Ocean heat content refers to the total amount of heat stored in the ocean. The global ocean has absorbed about 90% of the excess heat caused by human-induced greenhouse gas emissions. Long-term trends show that most of this additional heat has accumulated in the upper 700 m, with some gradually spreading into the deeper layers. Even small temperature increases represent large energy gains because of the ocean's vast volume. In 2025, global ocean heat content reached a new record high, surpassing the previous record set in 2024.

Since 1993, there has been an increase[52] of:

Global: +0.16°C
Northeastern Atlantic: +0.05°C

In the upper 2000 m.
Data: ORAS5.

Sea level

Since 1999, global mean sea level has risen by around 9.4 cm. The rise has accelerated from about 2.9 mm per year during 1999–2009 to about 3.8 mm per year during 2015–2025. Around 30% of the rise is due to ocean warming, which causes seawater to expand, and about 60% is due to melting glaciers and the Greenland and Antarctic ice sheets. The remaining 10% comes from changes in land water storage, such as soil moisture, surface water and groundwater. At a regional scale, sea level rise can differ substantially from the global average due to ocean currents and uneven heat distribution.

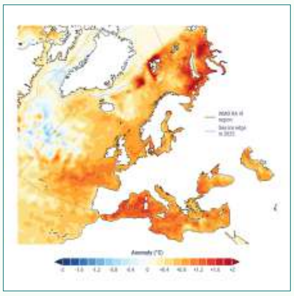
Since 1999, there has been an average annual sea level rise of around:

Global: +3.6 mm
European: 2–4 mm

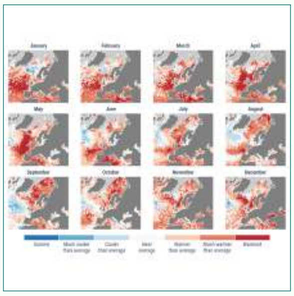
February 1999 to August 2025.
Data: CMEMS monitoring indicator and C3S sea level product.

52 Ocean heat content is traditionally expressed in joules, as it represents the total energy stored in the ocean. However, to provide a more intuitive understanding of temperature-related changes, this report presents these statistics in °C. The conversion from joules to °C accounts for the specific heat capacity of seawater – approximately 4,000 joules per kilogram per degree Celsius – and the vast mass of the ocean.

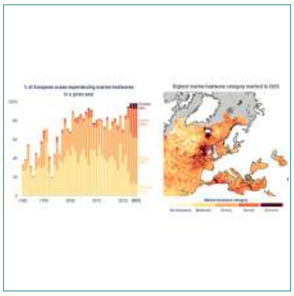
Supplementary figures



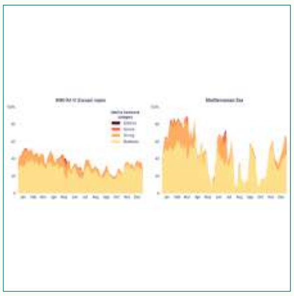
Annual sea surface temperature anomalies



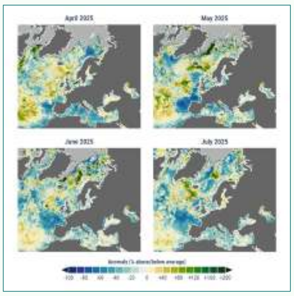
Anomalies and extremes in monthly SST



Mediterranean Sea marine heatwave conditions



Daily area with marine heatwave conditions



Monthly chlorophyll a concentration anomalies

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

18.

Greenhouse gases driving climate change

Greenhouse gases (GHGs) in the atmosphere trap heat close to Earth's surface. As concentrations increase, the near-surface temperature also rises, with significant impacts. Human activities lead to the emission of GHGs in various ways, including the combustion of fossil fuels for energy, deforestation, the use of fertilisers in agriculture, livestock farming and the decomposition of organic material in landfills. Of all the long-lived GHGs that are emitted by human activities, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have the largest impact on the climate. For information on how these gases are measured, what the main sources and sinks are as well as the processes driving their variability, and how emissions and uptake are estimated, see the 'Greenhouse gas' explainer. The 'Greenhouse gas concentrations' and 'Greenhouse gas fluxes' Indicator pages describe their long-term evolution.

The atmospheric concentrations of carbon dioxide and methane continue to increase.

Greenhouse gas concentrations

The concentration of a gas, the amount present in a given volume of air, can be estimated indirectly by satellites measuring solar radiation that is reflected (or 'back scattered'), by Earth's surface and the lower atmosphere, and on its way through the atmosphere absorbed by the gas. This provides the average amount of gas in a vertical air column above a specific location.[53]

Carbon dioxide is increasing in concentration by around 2.6 ppm per year and methane by around 11.6 ppb per year, since 2020.

53 Column-averaged dry-air mole fractions of gas in the atmosphere, excluding any water vapour present. The quantities observed are denoted XCO_2 and XCH_4.

Based on such satellite estimates, global average atmospheric concentrations of CO_2 and CH_4, continued to increase in 2025. Preliminary analyses[54] show that the 2025 annual average was the highest in the satellite record for both gases. Confirmed by additional data sources, the CO_2 concentrations were higher in 2025 than at any time in at least two million years and CH_4 concentrations were higher in 2025 than at any time in at least 800,000 years. Since 2020, the global average CO_2 concentration has seen an average annual increase of 2.6 ppm. Over the same period, the increase rate of CH_4 concentrations was 11.6 ppb/year.

Global atmospheric concentration of greenhouse gases continues to increase

Column-average concentrations from satellite measurements

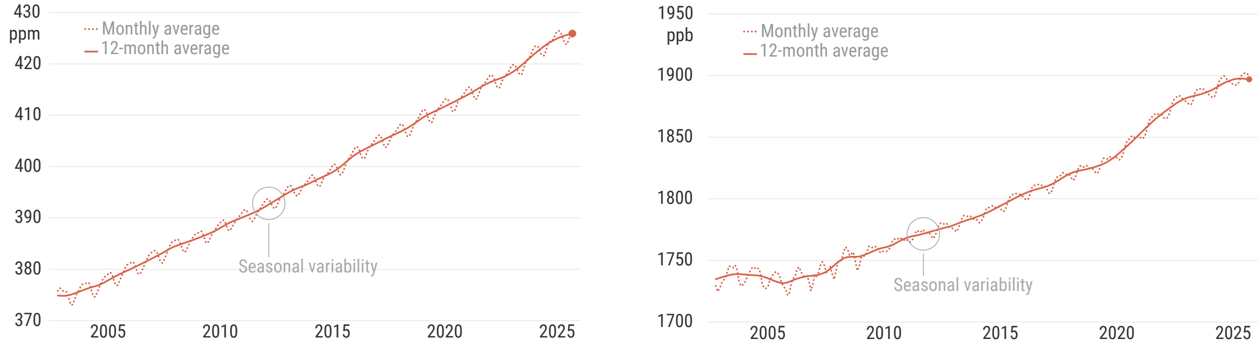


Figure 18.1. Global concentration of atmospheric column-averaged carbon dioxide (ppm) and methane (ppb) as measured by satellites for 2003–2025, with (dotted line) or without the seasonal cycle (solid line). Data: C3S/Obs4MIPs (v5.1) consolidated (2003–2024), CAMS preliminary near real-time data (2025) from GOSAT-1 records. Spatial range: 60°S–60°N over land. Credit: CAMS/C3S/ECMWF/University of Bremen/SRON.

Greenhouse gas fluxes

The difference between the amount of a gas added to the atmosphere by emissions from ‘sources’ and the amount taken up by ‘sinks’ is known as ‘net flux’. An approach called atmospheric inversion is used by the Copernicus Atmosphere Monitoring Service (CAMS) to estimate the net surface fluxes of CO_2, CH_4 and N_2O. This combines observations of these greenhouse gases from near the ground or from satellites with models of atmospheric transport and chemistry.

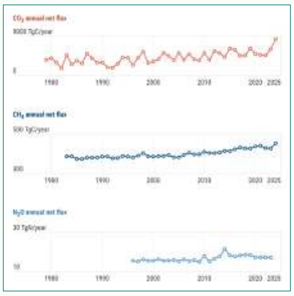
54 The reported increases for 2025 are preliminary due to the nature of the near real-time data used. These estimates, released in April 2026, are based on XCO_2/XCH_4 (see Footnote 53) retrieved from GOSAT-1 (figures released for ESOTC 2024 were based on GOSAT-2).

Although there is some year-to-year variation, the concentrations of CO_2, CH_4 and N_2O in the atmosphere have been increasing over recent decades, while the estimated net fluxes are increasing (CO_2, CH_4) or stable (N_2O). Around half of anthropogenic emissions of CO_2 has been absorbed by land vegetation and the ocean and around half remains in the atmosphere. Europe as a whole currently captures the equivalent of about 15% of the global net emission of atmospheric CO_2.

Net emissions of the greenhouse gases carbon dioxide and methane have been increasing over recent decades, with some year-to-year variation.

Over the last decade, average annual net fluxes of greenhouse gases at Earth's surface were around +5000 TgC for CO_2, +420 TgC for CH_4 and +16 TgN for N_2O.

Supplementary figures



Greenhouse gas fluxes

Head to the ESOTC 'Graphics gallery' online to view all the figures and download the associated data.

19.

Climate policy and action: Biodiversity

Biodiversity – the variety of life on Earth – is vital for a sustainable future. It underpins the health, resilience and functioning of ecosystems essential to life. Diverse species and habitats help maintain clean air and water, fertile soils and pollination. As such, biodiversity supports food security, livelihoods and human health [R19.1]. A diverse ecosystem also aids climate regulation and offers natural protection against extreme events such as storms, floods and droughts [R19.2]. As climate change intensifies, increasing pressure impacts the ability of these carefully balanced ecosystems to adapt to environmental change [R19.3].

Climate change is a major cause of degradation in biodiversity.

Europe saw a range of extreme events throughout 2025, impacting and stressing the biodiversity of both marine and terrestrial ecosystems. Biodiversity and climate change are closely connected and influence each other. Climate change drives biodiversity decline, which in turn accelerates climate change. Concurrently, biodiversity resilience aids the adaptive capacity of ecosystems to withstand the impacts of climate change [R19.4].

Increasing temperatures, changing precipitation patterns and warming and acidifying oceans directly affect species and ecosystems through stresses such as shrinking and moving of habitats, and disruption of seasonal timing. This results in reduced species richness, degraded ecosystems, habitat loss and higher extinction risks [R19.5].

Healthy ecosystems help regulate the climate, in part by acting as carbon sinks. As biodiversity declines, so does this essential function. The capacity of ecosystems to store carbon is reduced and their capacity to buffer climate impacts is compromised. In some cases, ecosystems can reverse their role from absorbing carbon to releasing it, which undermines climate objectives and increases vulnerability to climate change. Healthy ecosystems therefore offer the advantages of both helping to slow climate change (mitigation) and strengthening the capacity to withstand its effects (adaptation) [R19.4, R19.6].

Climate and biodiversity are strongly connected within European policy and frameworks.

Environmental governance has increasingly aligned biodiversity conservation and climate policy under a unified 'nature-climate' model, which treats biodiversity and climate as interconnected systems requiring coordinated action.

Climate resilience and biodiversity protection are widely recognised as interdependent, making integrated policy essential. In Europe, current policy and legislation embed biodiversity resilience, protection and restoration within climate frameworks [R19.4, R19.6, R19.7], ensuring that climate mitigation and adaptation are treated as integral to biodiversity preservation rather than as secondary considerations.

Climate change and biodiversity are interconnected with key systems

Cascading impacts can lead to major risks for ecosystems, as well as sectors such as food, health and the economy

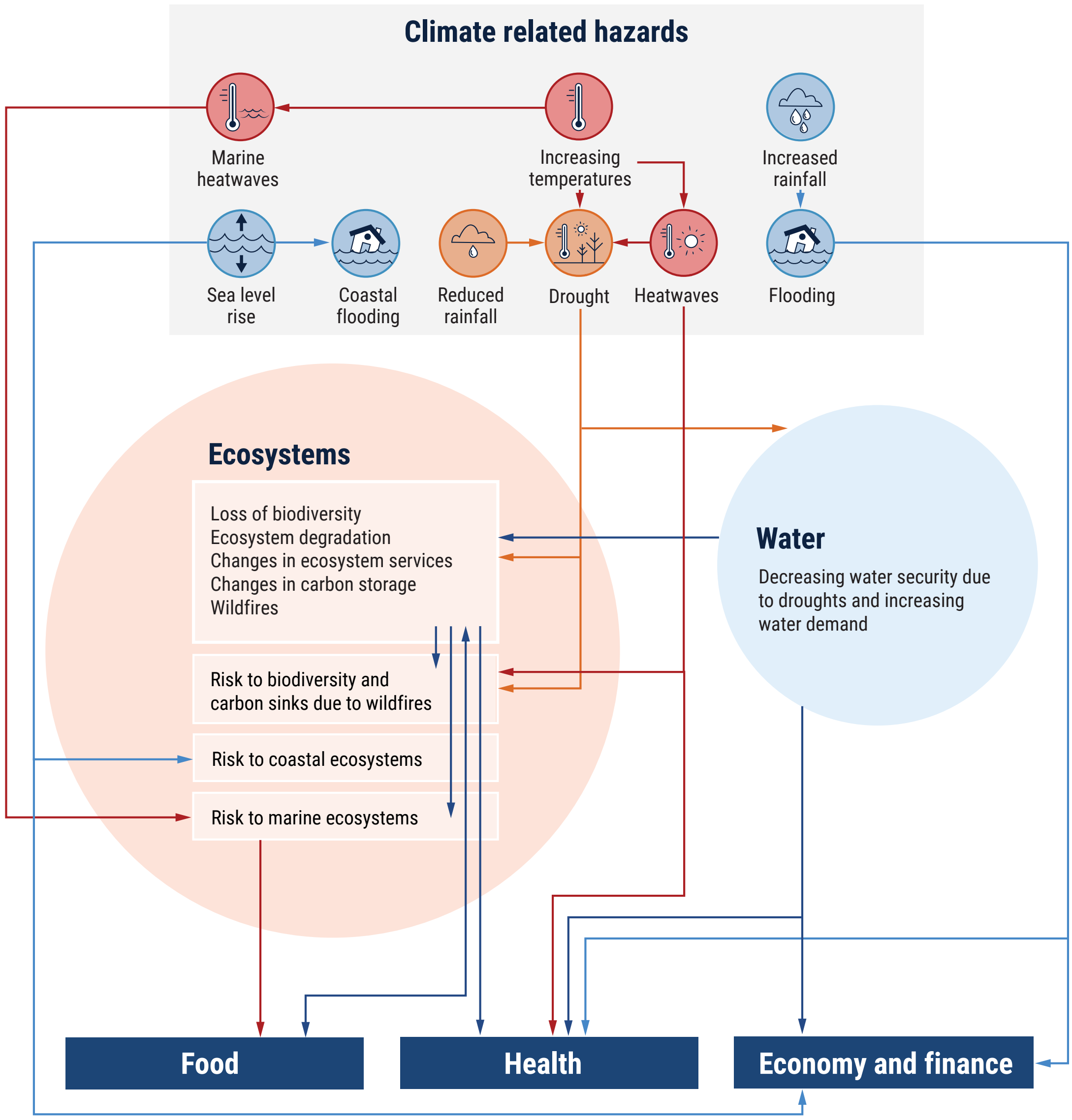


Figure 19.1. The interconnectedness between climate change, biodiversity and other key systems such as food, health and economy. Adapted from the European Climate Risk Assessment [R19.6].

Policy overview: an integrated framework for Europe

Climate and biodiversity policies and initiatives since 2019

2019
EU Green Deal
Establishes climate change and biodiversity loss as interconnected challenges

2020
Biodiversity Strategy 2030
Frames ecosystem protection and restoration as climate mitigation and adaptation measures

2021
EU Climate Law
Explicitly recognises ecosystem resilience, legal requirement to support adaptation and avoid undermining ecosystem integrity

Fit for 55 package
LULUCF and Effort Sharing regulations embed ecosystem management within EU climate target architecture

EU long-term budget 2021–2027
Allocates funding to support climate action and biodiversity projects

Horizon Europe
Funds research to tackle climate change impacts and protect ecosystems and biodiversity

Next Generation EU
Funding to support climate resilience and biodiversity conservation

EU Adaptation Strategy
Promotes ecosystem based adaptation

New European Bauhaus
Encourages sustainable and nature-inclusive design in architecture and urban planning to support biodiversity

2022
Kunming-Montreal Global Biodiversity Framework
Emphasises that biodiversity loss and climate change are interlinked, with healthy ecosystems both mitigating climate impacts and being vulnerable to them

2024
Nature Restoration Law
Restoring nature becomes a climate obligation, not just an environmental one

EUCRA
Supports biodiversity by identifying it as a critical policy priority, emphasising that the conservation and restoration of resilient ecosystems are essential to provide natural 'buffers' that mitigate climate risks

Figure 19.2. Climate and biodiversity policy, legislation and initiatives adopted in Europe since 2019.

The European Green Deal [R19.8] sets out the basis for treating climate change and biodiversity as interconnected systems, while the EU Climate Law [R19.9] provides a binding framework for achieving climate neutrality and ensuring policy coherence across related sectors. The EU Biodiversity Strategy for 2030 sits at the centre of this approach, framing climate change both as a driver of biodiversity loss and as a key rationale for large scale nature restoration.

Underpinning the strategy, the EU Nature Restoration Law [R19.7] introduces legally binding targets to restore at least 20% of the EU's land and sea areas by 2030, and all degraded ecosystems by 2050. These targets cover a wide range of habitats, including wetlands, forests, grasslands, rivers, lakes and marine areas, supporting both Europe's biodiversity recovery and climate adaptation. Other initiatives, such as Fit for 55 [R19.10], Horizon Europe [R19.11] and the European Climate Risk Assessment (EUCRA) [R19.6], reinforce the EU's commitment to maintaining and restoring biodiversity in a climate-smart way. EUCRA, for example, identifies major climate risks to biodiversity, helping policymakers refine and prioritise biodiversity protection and restoration actions under the 2030 Biodiversity Strategy, according to where risks are most severe.

Identified climate risks for key biodiversity systems

Climate risks for ecosystems	Urgency to act	Risk severity			Policies	
		Current	*Mid-century*	*Late century (low/high warming scenario)*	*Horizon*	*Readiness*
Coastal ecosystems	Urgent action needed	Critical •••	Critical •••	Critical/Catastrophic •••	Medium	Medium
Marine ecosystems	Urgent action needed	Critical •••	Critical •••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to wildfires (hotspot region: southern Europe)	Urgent action needed	Critical •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to wildfires	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to droughts and pests	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Long	Medium
Species distribution shifts	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Ecosystems/society due to invasive species	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Aquatic and wetland ecosystems	More action needed	Substantial •••	Critical ••	Critical ••	Medium	Medium
Soil health	More action needed	Substantial •••	Substantial ••	Substantial/Critical ••	Medium	Medium
Cascading impacts from forest disturbances	Further investigation	Substantial •	Critical •	Critical •	Long	Medium

Figure 19.3. Climate risks for key biodiversity systems, including urgency to act, projected severity in the current, mid- and late-century, and related policy characteristics.

Climate extremes impacting biodiversity in 2025

Europe can be divided into biogeographical regions, which reflect shared ecological characteristics. Climate-change driven temperature increases, intense and prolonged precipitation, heatwaves, droughts, floods, wildfires and storms have had wide-ranging negative impacts on species and habitats across these regions, reducing ecosystem resilience and altering species distributions.

In 2025, these regions faced many climate-related challenges, including from a range of extreme events throughout the year, amplifying pressures on biodiversity and ecosystems. Across Europe, freshwater ecosystems showed greater stress from altered water availability and quality resulting from drought and floods [R19.11], while forests and grasslands faced increased fire risk and drought pressure. Aquatic ecosystems were affected by warming waters and marine heatwaves, and acidification that disrupted key ecological processes. More information on key events, including likely impacts on biodiversity, alongside examples of biodiversity initiatives, can be found on the interactive 'Key events map'.

Progress

2025 marks the halfway point of the European Biodiversity Strategy 2030. The strategy aims to protect and restore biodiversity and put it on a path to recovery by 2030, linking this to climate resilience and the provision of ecosystem services. Targets are set out around nine themes: protected areas, ecosystem restoration, pollinators, forests, agriculture, marine and coastal ecosystems, urban ecosystems, invasive alien species, and financing and governance. Many of these address a range of biodiversity pressures, including challenges relating to climate resilience and ecosystem functioning.

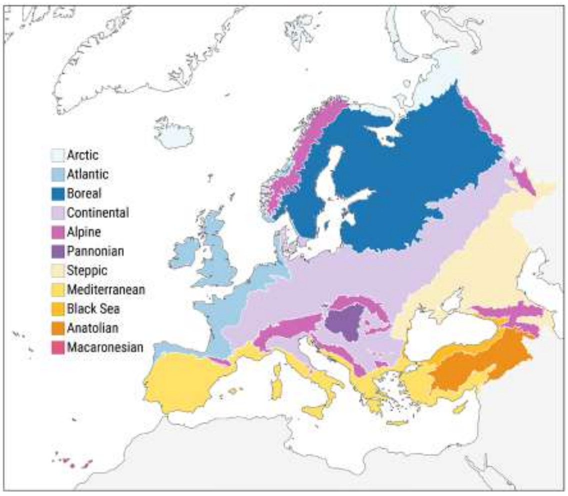
By the end of 2025, around half of the Biodiversity Strategy's recommended actions were in place or completed, with many of the remainder underway. Key legislation has been established and adopted, including the 2024 Nature Restoration Law. Action tracking and indicator dashboards have expanded to include climate indicators, and steps have been taken to improve access to funding across the whole region. However, overall progress is lagging, and by the end of 2025, Europe was not on track to meet many of its 2030 targets [R19.25]. Protected area coverage is increasing but remains below the 20% land and sea targets for 2030. Indicator species, including pollinators and common birds, continue to decline and data gaps mean many sub-targets cannot yet be fully evaluated [R19.26].

Impacts of key events in 2025 on biodiversity

Region	Event	Hazard	Likely biodiversity impact
Alpine	**Storm Hans** France, Eastern Pyrenees and Catalonia (April)	• Heavy rainfall • Snowfall • Avalanches at higher elevations	• Stressed mountain streams and river ecosystems • Soil erosion • Disrupted habitats [R20.13]
Atlantic	**Storm Éowyn** Ireland, the United Kingdom, Western Scandinavia and coastal zones (21–27 January) **Storm Amy** Northwestern Europe (1–6 October)	• Powerful windstorm	• Coastal erosion • Wind-throw (uprooting or breaking of trees) • Saltwater intrusion into coastal ecosystems [R20.14, R20.6]
Boreal	**Fennoscandian Heatwave** Northern and central Europe (July, August)	• Long periods of consecutive days with extreme temperatures	• Wildlife stress and mortality • Drought stress • Increased fire risk in forests and peatlands • Widespread algal blooms in the Baltic Sea and lakes [R20.15]
Continental	**Drought** Western and central Europe (February–September)	• Much below-average rainfall over a large area	• Crop stress due to heat and drought • Reduced terrestrial and aquatic plant productivity • Altered species distributions – favouring drought tolerant species [R20.16]
Mediterranean	**Wildfires** (June–August) **Hurricane Gabrielle remnants** Eastern Spain and the Balearic Islands (Late September–early October)	• Extreme heat – temperatures reaching 40°C or higher in many regions • Below-average rainfall causing widespread drought • Heavy rainfall • Flooding	• Loss of vegetation and habitat • Soil degradation • Floods • Altered coastal lagoon salinities affecting fish/shellfish nursery habitats [R20.17, R20.18]
Macaronesian	**Warm Mediterranean and Atlantic heat anomalies, marine heatwaves** (May–September)	• Elevated wildfire risk • Elevated drought risk • Water stress	• Drought stress on endemic vegetation • Marine temperature anomalies affecting nearshore algae and fish species composition [R20.16, R20.19, R20.20]
Pannonian	**Heatwaves and wildfires** (June–September)	• High temperatures • Below-average rainfall • Drought and wildfire conditions	• Flooding in lowlands • Stress on endemic vegetation and wildlife [R20.21, R20.16]
Steppic	**Drought** (February–October)	• High temperatures • Seasonal heatwaves	• Desertification • Reduced soil moisture • Reduced grassland productivity [R20.18]
Black Sea	**Wildfires** (July–August)	• High temperatures • Prolonged heatwaves • Wildfire conditions	• Desertification • Reduced soil moisture • Reduced grassland productivity [R20.18]
Arctic	**Heatwave** Iceland (July)	• Record-high daily temperatures • Long-term warming leading to faster ice melt	• Habitat loss • Conditions that favour invasive species • Alteration and shift of marine species [R20.22, R20.23, R20.24]
Marine	**Marine heatwaves** Baltic, northeastern Atlantic, and the Mediterranean and Black Seas (May–September)	• Anomalously high or record-high sea surface temperatures	• Stress on marine life and coastal ecosystems • Altered species distributions • Coral and algal stress • Fishery impacts • Habitat degradation [R20.19, R20.20]

Figure 19.4. Key events across Europe in 2025 and their likely impacts on biodiversity in the relevant biogeographical region. Further information on these events can be found in the interactive 'Key events map'.

Biogeographical regions and their main climate hazards



Biogeographical region (ecosystem characteristics)	Key climate pressures	Biodiversity impact
Arctic (tundra, grassland, forest)	• Increasing temperature • Permafrost thaw • Snow/ice loss	• Habitat loss for cold-specialist species • Carbon release • Food-web disruption
Atlantic (forest, peatland, wetland, estuary)	• Increasing temperature • Flooding • Storms • Sea level rise	• Wetland degradation • Peat drying • Invasive species spread
Boreal (forest, peatland)	• Increasing temperature • Increased risk of wildfires • Hydrological change	• Peatland carbon loss • Forest composition shifts • Fire-related habitat loss
Continental (forest, wetland, grassland)	• Heatwaves • Droughts • Flood extremes	• Forest dieback • Altered river ecosystems • Seasonal timing shifts
Alpine (grassland, forest, glacier)	• Increasing temperature • Snow/glacier loss • Extreme events	• Upward range shifts • Loss of cold-adapted endemics • Forest stress
Pannonian (forest, grassland, wetland)	• Increasing temperature • Drought	• Wetland loss • Grassland degradation • Stress on steppe species
Steppic (grassland)	• Increasing temperature • Drought	• Reduced productivity • Habitat fragmentation • Species decline
Mediterranean (forest, grassland, coastal)	• Extreme heat • Drought • Wildfires	• Habitat loss from fires • Tree mortality • Desertification
Black Sea (wetland, forest)	• Sea level rise • Flooding	• Altered river sediment flows • Coastal habitat loss • Salinisation • Stress on wildlife
Anatolian (grassland, forest, wetland)	• Increasing temperature • Drought	• Desertification • Water stress • Steppe degradation • Wetland loss
Macaronesian (inc. Azores) (forest, scrubland)	• Drought • Increased fire risk • Sea level rise	• Loss of endemic habitats • Invasive species risk • Coastal erosion and saltwater intrusion
Marine (North Sea, Arctic Ocean, northeastern Atlantic, Baltic Sea, Caspian Sea, Black Sea, Mediterranean Sea)	• Marine heatwaves	• Marine biodiversity decline

Figure 19.5. Map of biogeographical regions of Europe, highlighting their primary ecological characteristics and the main climate hazards that have impacted each region in recent years.

Outside the EU, the Convention on Biological Diversity [R19.27] and Kunming-Montreal Global Biodiversity Framework (GBF) [R19.28] provide a legally binding international treaty and implementation plan, respectively, that set the global agenda for nature conservation. The supporting core United Nations Development Programme programmes [R19.29] that assist countries worldwide in assessing, protecting and restoring biodiversity in a climate-smart and sustainable way, include: The Nature Pledge, a commitment supporting over 140 countries to put GBF targets into action; the Biodiversity Finance Initiative, which supports countries in closing the biodiversity financing gap; GBF Early Action Support, a joint project with the United Nations Environment Programme to fast track GBF implementation in 138 countries; and the Biodiversity and Ecosystem Services Network, which enhances science-policy-practice interaction for biodiversity. Other global initiatives include the International Union for Conservation of Nature Global Biodiversity Programme [R19.30], which focuses on providing scientific data, global standards and practical tools for governments and organisations to meet international biodiversity targets and the United Nations Framework Convention on Climate Change-linked Nature and Climate initiatives [R19.31].

Actions are delivering results, but progress is slow.

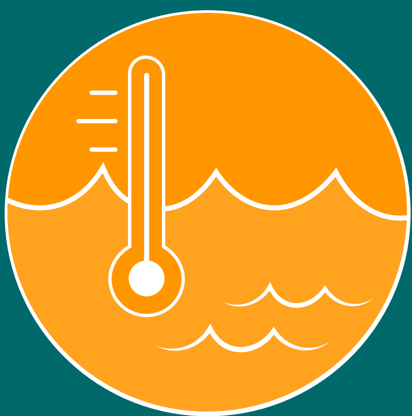
Despite slow overall progress, there are many examples of action across the WMO Regional Association VI (Europe) region, spanning EU and non-EU countries. These efforts aim to protect and restore biodiversity in a climate-smart way, drawing on interconnected policies and initiatives, and making use of available funding.

Biodiversity policy in action

Figure 19.6. Examples of biodiversity policy in action to strengthen climate resilience and adaptation across Europe. More information on the highlighted case studies can be found in the interactive 'Key events map'.

20.

Marine heatwaves impacting Mediterranean biodiversity



Climate change is a major source of pressure on marine and coastal biodiversity. Sustained above-average sea surface temperatures can harm the health, resilience and functioning of marine ecosystems. Marine heatwaves are increasingly linked to mass mortality events, shifts in species distributions and seasonal timing, and disruption to ecosystem functioning, including food web dynamics, productivity and biogeochemical cycles.

***Posidonia oceanica* is the most ecologically important Mediterranean seagrass species, forming extensive meadows that cover around 19,000 km^2 along Europe's coasts, providing ecological and economic benefits.**

Posidonia oceanica, the dominant seagrass species in the Mediterranean, and protected under the EU Habitats Directive, forms extensive meadows covering about 19,000 km^2 along Europe's coasts [R20.1]. These meadows are highly productive, surpassing even tropical rainforests and storing carbon up to thirty times faster [R20.2]. They also serve as biodiversity hotspots, housing up to 40,000 fish per acre [R20.3] and providing critical nursery habitat for 20% of the world's largest fisheries [R20.4]. They act as a natural barrier, stabilising the seafloor and buffering coastlines against erosion and storm surges [R20.5].

The meadows also improve water quality by trapping sediments and filtering out bacterial pathogens by over 50% [R20.6]. As habitats that extend across national waters underpin marine food webs and strengthen ecosystem resilience, their coordinated conservation has become a central focus within EU biodiversity and climate policy frameworks. Alongside climate change, other anthropogenic impacts also pose a threat to these vital marine meadows, and so most conservation measures take this into account. For example, mooring in seagrass, dredging, coastal development and pollution are themes associated with several initiatives across the Mediterranean.

Climate change is driving major changes in biodiversity and ecosystems in the Mediterranean Sea, with marine heatwaves acting as one of the most destructive forces.

Where can *Posidonia oceanica* meadows be found?

Posidonia oceanica locations alongside the highest marine heatwave category experienced in the Mediterranean Sea during 2025

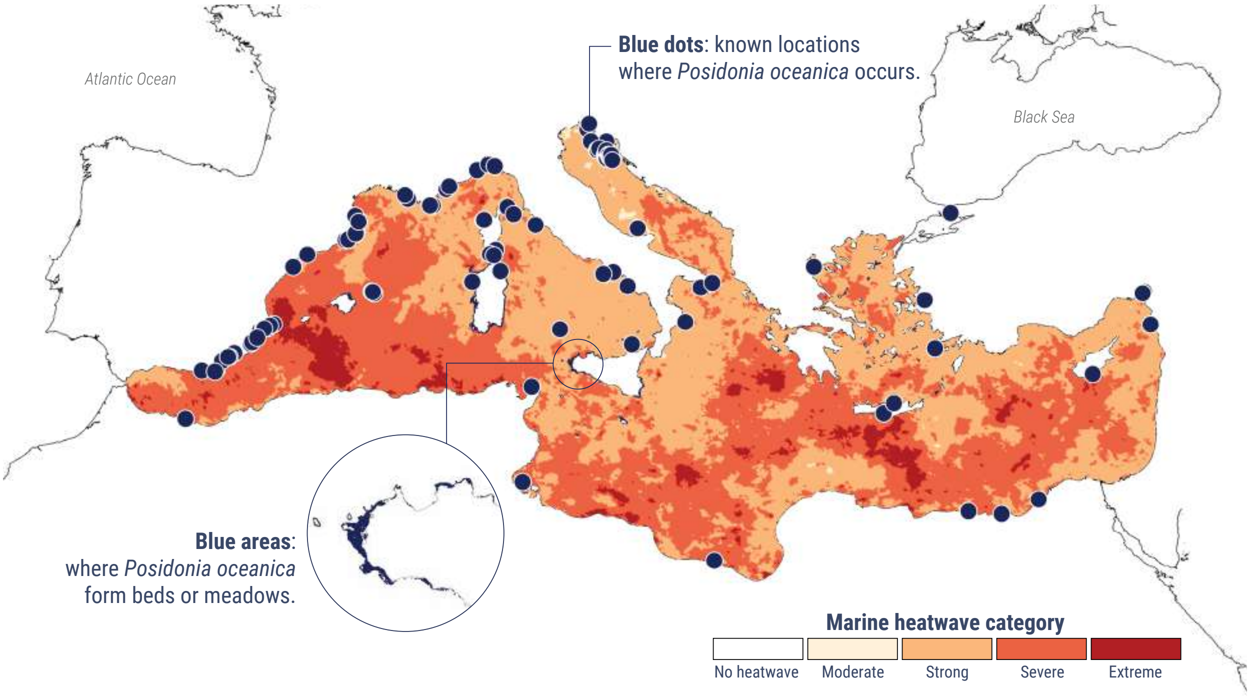


Figure 20.1. A map showing the highest marine heatwave category experienced across the Mediterranean Sea during 2025 and locations of Posidonia oceanica meadows. Marine heatwaves are defined relative to the 1991–2020 reference period. Data: UNEP-WCMC, C3S Sea and Sea Ice Surface Temperature v1.0. Credit: C3S/ECMWF/WMO/DMI

Vulnerability to marine heatwaves

Temperatures in the Mediterranean Sea are rising faster than the global average, increasing the vulnerability of an already fragile ecosystem. Over the past decade, marine heatwaves have shifted from occasional events to recurring annual episodes affecting the entire basin. In 2025, the Mediterranean Sea saw its second warmest year on record, with an average sea surface temperature of 21.35°C. This was 1.03°C higher than average, behind the record value from 2024 (21.50°C). In each of the past three years (2023–2025), the whole Mediterranean Sea experienced at least 'strong' marine heatwave conditions and at least half the basin experienced 'severe' or 'extreme' conditions. Both the severity of marine heatwaves and the area affected have increased. More information about sea surface temperatures and marine heatwaves in the European region can be found in the 'Ocean' section.

Impacts on biodiversity and ecosystem services

Climate change is driving major changes in Mediterranean biodiversity and ecosystem dynamics, with marine heatwaves one of the most destructive pressures [R20.7]. These persistent, widespread sea surface temperature anomalies have increased in frequency, intensity and geographic extent. They have also been linked to recurrent mass mortality events in coastal ecosystems across the basin, including impacts on key marine vegetation such as *P. oceanica*. Meadows of this seagrass are particularly sensitive to high sea surface temperatures and sustained temperature anomalies, which have been associated with thermal stress, increased mortality rates and decreasing growth and productivity [R20.8].

Recent marine heatwaves in the Mediterranean Sea have caused severe physiological stress to marine life. Foundational species, which are key to the structure of a community, such as *P. oceanica*, have been heavily affected across thousands of kilometres of coastline.

Basin-wide studies indicate that *P. oceanica* meadows have declined by up to 34% over the past 50 years due to climate change and anthropogenic impacts [R20.2]. Studies suggest that under a high greenhouse gas emissions scenario,[55] associated with high levels of warming, up to 75% of suitable habitat could be lost

55 RCP8.5 (Representative Concentration Pathway 8.5) assumes continued increases in fossil fuel use and limited climate policy, leading to relatively high levels of warming by 2100.

by 2050, placing the species at risk of extinction by the end of the century, while under a low greenhouse gas emissions scenario (RCP2.6) the species will remain highly vulnerable [R20.8]. These trends indicate a rapid transformation of the Mediterranean Sea's core marine ecosystems.

This widespread decline of *P. oceanica* is associated with a rapid restructuring of marine habitats in the Mediterranean Sea. As a foundation habitat, *P. oceanica* supports a wide range of marine life. Research shows that its decline is associated with biodiversity loss and habitat fragmentation, leading to reduced species richness and abundance, as well as a lower ecosystem resilience [R20.2]. Protecting and restoring these meadows is therefore important not only for individual species, but for maintaining the structure, function and long-term stability of Mediterranean marine ecosystems.

Policy and management responses

Under the European Green Deal and the EU Climate Law, EU biodiversity and marine policies are increasingly aligned with European climate objectives. For example, *P. oceanica* meadows are recognised for their long-term carbon storage, supporting both mitigation and conservation goals. Restoration is framed as a nature-based solution that can strengthen coastal resilience to climate impacts, and protecting *P. oceanica* is linked to climate adaptation, aligning with EU priorities on ecosystem-based adaptation. This policy alignment has helped embed *P. oceanica* conservation within broader EU sustainability and climate frameworks and initiatives.

The EU Biodiversity Strategy for 2030 commits Member States to restoring marine habitats. The strategy supports *P. oceanica* conservation by highlighting its meadows as priority ecosystems for restoration because of their biodiversity and climate mitigation value. It supports restoration projects across the Mediterranean and encourages Member States to integrate *P. oceanica* restoration into national biodiversity strategies and marine spatial planning. The subsequent EU Nature Restoration Law strengthens this approach by introducing legally binding targets for marine ecosystem restoration. This policy coherence builds on earlier frameworks, including the EU Habitats Directive (1992), Natura 2000 and the Marine Strategy Framework Directive (2008).

As a result of such policy coherence, European funding mechanisms have been established to support marine biodiversity resilience and have become important enablers of P. oceanica conservation. Programmes such as L'Instrument Financier pour l'Environnement , the European Maritime, Fisheries and Aquaculture Fund and Horizon Europe have facilitated local and regional climate-smart conservation projects. Regional frameworks, such as the Mediterranean Action Plan,[56] have also supported transboundary cooperation between countries.

Mediterranean seagrass – *Posidonia oceanica* – conservation initiatives

Projects across the region funded or supported by European policy and frameworks.

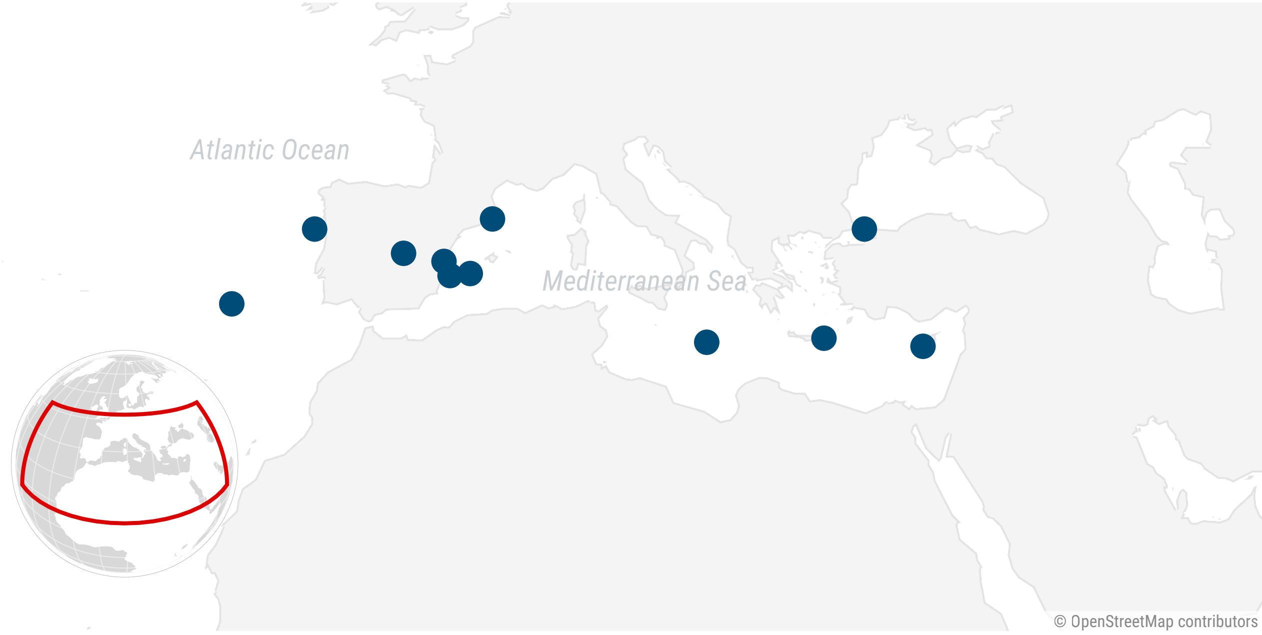


Figure 20.2. Examples of Posidonia oceanica conservation initiatives across the Mediterranean region, funded or supported by European policy and frameworks.

56 Established in 1975 as a multilateral environmental agreement under the United Nations Environment Programme Regional Seas Programme. Mediterranean countries and the European Community approved MAP as a framework for cooperation to address common challenges related to marine environmental degradation.

Conclusion

Over the past decade, conservation of *P. oceanica* meadows in the Mediterranean Sea has delivered measurable benefits for both biodiversity and climate resilience. Measures such as marine protected areas and restoration initiatives have helped stabilise or restore meadows, supporting increased species richness, more complex seabed communities and nursery habitats for fish [R20.9; R20.10]. Conserved meadows also act as important carbon sinks and provide natural coastal protection by reducing erosion and strengthening ecosystem resilience to marine heatwaves and storms [R20.11; R20.12].

These outcomes demonstrate that *P. oceanica* conservation can serve as an effective nature-based solution, supporting biodiversity and contributing to climate mitigation and adaptation. Continued implementation and scaling of these measures are essential to maintaining the integrity of Mediterranean ecosystems and for achieving EU biodiversity and climate objectives [R20.13; R20.14].

Over the past decade, conservation of Posidonia oceanica meadows in the Mediterranean has delivered measurable benefits for biodiversity and climate resilience. Sustaining and scaling up these measures is essential.

21.

Peatland wildfires impacting biodiversity

Peatlands are important ecosystems that provide unique habitats and store large amounts of carbon, making them central to addressing the crises of climate change and biodiversity loss. However, degradation through fire, drainage, or other human pressures can shift them from carbon sinks to major sources of greenhouse gas emissions. Fire is a particularly severe disturbance: carbon emissions from peat fires are estimated to be 500–800 times higher than typical carbon losses from intact peatlands [R21.1].

Peatlands are essential ecosystems that provide unique habitats and store large amounts of carbon, playing a key role in addressing the crises of climate change and biodiversity loss.

Europe has experienced the greatest proportional peatland loss globally [R21.2], largely due to high population density and conversion of land for agriculture. The remaining peatlands are therefore of high conservation importance. Among them are Deurnsche Peel and Mariapeel in the Netherlands, ecologically rich remnants of a once extensive high peatland[57] landscape, covering around 2,700 hectares. Formed under high groundwater conditions, these areas contain peat layers up to 6–8 metres thick. They are now designated as Natura 2000 sites, a status that supports the protection of active raised bog[58] habitats within the two sites [R21.3].

57 Peatlands with thick (6–8 m) peat layers.

58 Active raised bogs are a specific type of habitat that exist within high peatlands.

Together with other peatlands across Europe, these sites play an important role in climate mitigation as major terrestrial carbon stores [R21.4; R21.5]. Climatic pressures, alongside drainage and cultivation, are predicted to substantially reduce peat accumulation and the associated carbon sink capacity [R21.6].

Europe has experienced the greatest proportional peatland loss globally, largely due to high population density and the conversion of land for agriculture.

Vulnerability to fire hazard

The Deurnsche Peel and Mariapeel are vulnerable to climate-driven wildfire risk because of their peat soils, hydrology and surrounding land use. During prolonged dry periods, falling groundwater levels allow peat to dry out, transforming normally wet landscapes into highly flammable systems. Once ignited, fires can spread rapidly and smoulder underground for months, making them difficult to extinguish.

This vulnerability was demonstrated in April 2020, when a 710-hectare fire burned in the Deurnsche Peel for four days and continued to smoulder in the peat for nearly two months, making it one of the most destructive peat fires in Europe in recent years [R21.7]. At the same time, a 200-hectare cross-border fire occurred in the nearby Meinweg area, illustrating the regional susceptibility of peatlands to large fires during prolonged drought. A wildfire affecting 41.5 hectares in the Mariapeel in August 2022 caused additional damage [R21.7]. Together, these events highlight the persistent fire hazard facing European peatlands under dry conditions. More information on wildfires across Europe in 2025 can be found in the 'Wildfires' section.

Impacts on biodiversity and ecosystem services

Periods when heat and drought occur together are among the main climatic drivers of extreme peatland fires, with cascading effects that amplify carbon losses [R21.8]. Wildfires can reduce carbon uptake in northern peatlands by up to 35% [R21.9] while shifting them from carbon sinks to net sources of greenhouse gas emissions [R21.10]. Anthropogenic pressures, particularly peatland drainage and land-use change, further exacerbate this trend [R21.11]. Fire also increases future vulnerability. Degraded, drier peat becomes more prone to ignition [R21.12], while peat combustion can cause volume loss, compaction, soil subsidence and risks to infrastructure. Damage to peat structure may also impair water regulation and local hydrology [R21.10].

Peatland wildfires can smoulder for months, with severe impacts on biodiversity and ecosystem services, including reduced capacity for carbon storage.

Peatland fires have wide-ranging impacts on biodiversity. For example, they can cause high mortality among less mobile species, including amphibians, reptiles, small mammals, invertebrates and ground-nesting birds [R21.13]. Smouldering fires can destroy Sphagnum mosses, disrupting peat formation, vegetation composition and habitat structure. The loss of Sphagnum can shift vegetation toward grasses, shrubs or birch, altering species composition and ecological interactions [R21.12]. This may reduce habitat suitability for bog-specialist plants, insects and birds, while favouring more generalist species. Reduced biodiversity can also increase vulnerability to climate-related disturbances, such as droughts and insect outbreaks, creating feedback that accelerates carbon loss. Integrated peatland restoration and management can enhance resilience by restoring ecosystem functions while supporting climate mitigation [R21.14].

Climatic and non-climatic risks and impacts on peatlands in Europe

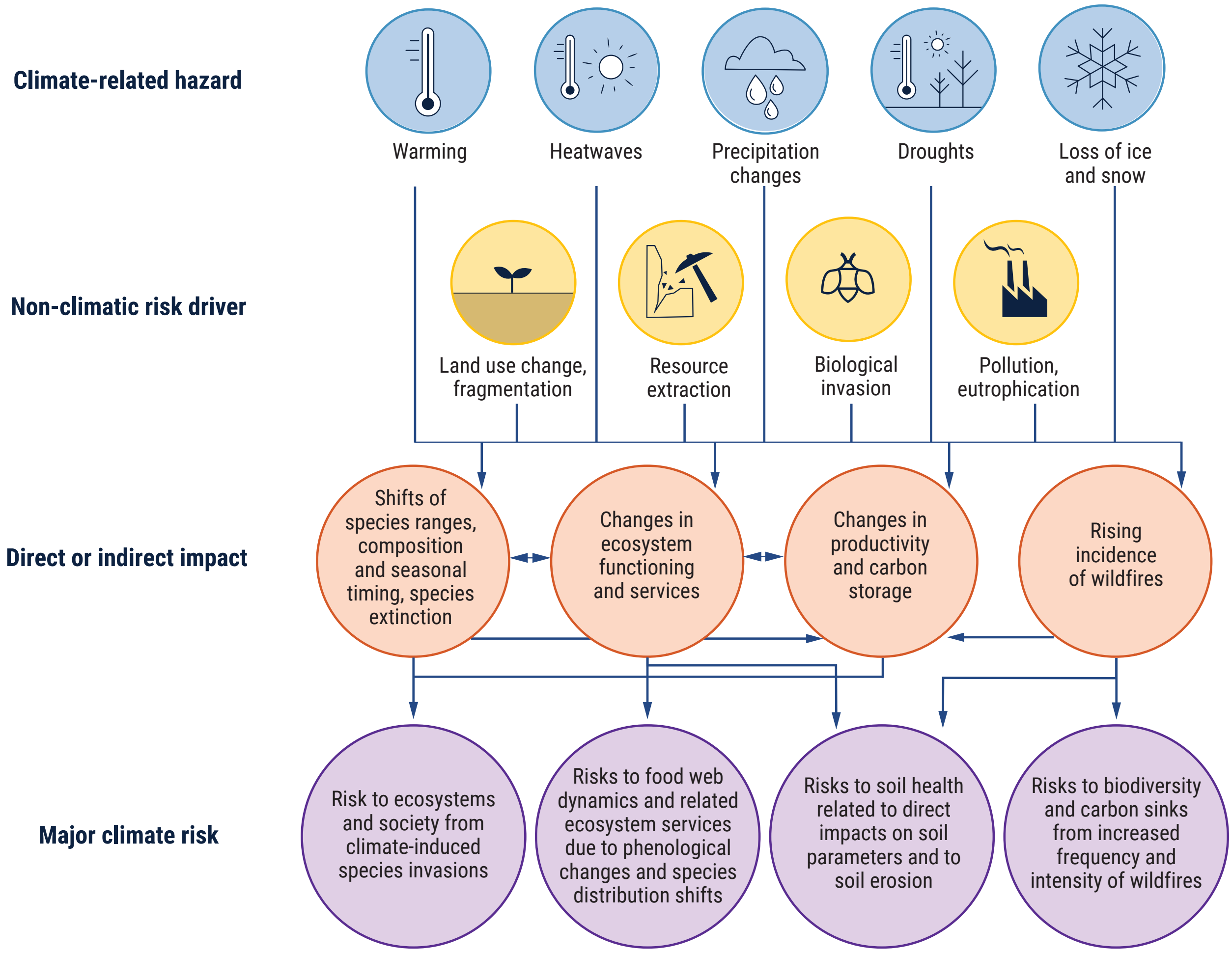


Figure 21.1. Impact chain of biodiversity and ecosystems to which farmed and protected peatlands are exposed in Europe. Adapted from EEA, 2023 [R21.8].

Policy and management responses

Wildfire risk in the Deurnsche Peel and Mariapeel peatland areas is being mitigated through a range of integrated nature-based solutions and forestry strategies [R21.15]. Green infrastructure, including green firebreaks, ecological corridors and buffer zones, can provide landscape-scale barriers that slow fire spread while maintaining habitat connectivity. Green corridors planted with deciduous or broadleaved species can help retain moisture and create natural fire-resistant zones. Reforestation and afforestation using native, diverse species can further reduce vulnerability, especially in areas affected by pests or previous disturbance.

Close-to-nature and adaptive forestry practices can support long-term ecosystem health by promoting natural regeneration, maintaining soil moisture and reducing reliance on monocultures that are more prone to pests and fire. Buffer zones and green corridors can also support biodiversity and ecosystem services such as carbon storage, water regulation and habitat for wildlife. Together these measures aim to reduce fire risk while maintaining ecological integrity.

Lessons learned and scaling opportunities

Scaling wildfire risk reduction measures in the Deurnsche Peel and Mariapeel depends on a combination of biophysical, socioeconomic and governance conditions [R21.15]. The region is characterised by dry, sandy, nutrient-poor soils that support pine, fir, Douglas fir, larch and diverse broadleaved deciduous species. These conditions favour the development of mixed forests and green infrastructure, such as buffer zones and ecological corridors, which can help slow fire spread.

Socioeconomic conditions also play an important role. Forests are managed both as investment assets and as recreational areas, creating incentives for owners to maintain forest health and resilience. NGOs actively support sustainable forest management, while legal obligations and public subsidies encourage reforestation following pest outbreaks.

Nature-based solutions can provide multifunctional approaches to reducing fire risk while maintaining ecological integrity. Coordinated landscape-scale planning and adaptive forestry are essential to strengthen wildfire resilience.

Governance structures include a mix of small-scale private owners and owner consortia. This enables local engagement but can limit the implementation of measures at larger scales. Although nature-based solutions offer clear environmental and biodiversity benefits, wider uptake is constrained by strict conservation regulations, the need for owner consent and limited funding. Addressing these barriers is essential for scaling implementation in other regions.

Conclusion

The Deurnsche Peel and Mariapeel peatlands highlight the high wildfire risk associated with drained peatlands, which are a priority for integrated climate and biodiversity strategies in Europe. Peat fires can smoulder for months, causing severe damage to biodiversity and ecosystem services, including reduced carbon storage capacity. Nature-based solutions, such as green firebreaks, buffer zones, ecological corridors and mixed-species reforestation, can reduce fire risk while maintaining ecological integrity. Scaling up these measures depends on suitable ecological conditions, engaged forest owners, NGO support and public funding, but can be constrained by strict conservation rules, ownership requirements and limited funding. Coordinated landscape-scale planning and adaptive forestry are therefore essential for strengthening wildfire resilience.

About the data

The data behind ESOTC 2025

The ESOTC 2025 relies extensively on datasets provided operationally and in near real-time by the Copernicus Services. The operational data are freely accessible via data catalogues such as the C3S Climate Data Store (CDS). Explore the full ESOTC online to download data and explore other resources.

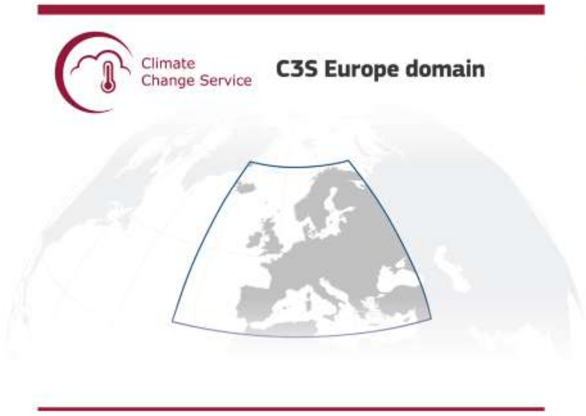
The 'About the data' section online describes the datasets and methods used in the ESOTC 2025, with links to download the original data and documentation for each dataset.

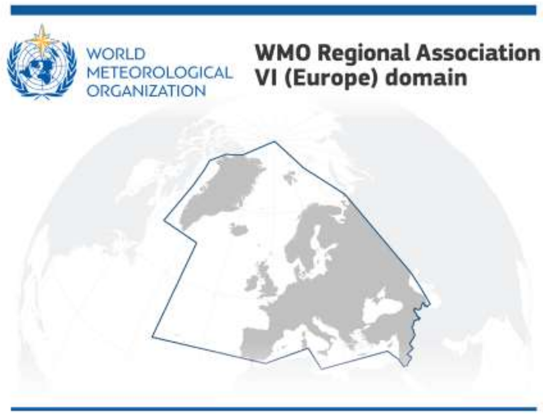
Averages

Throughout the report, use of the word 'average' refers to the mean, unless stated otherwise.

Reference periods

By comparing 2025 against the average for a reference period, we can see how the year fits within a longer-term context. Generally, the reference period used is 1991–2020, but where less extensive data records are available, other periods may be used, and this will be stated in the associated figures. Some variables are compared to the pre-industrial level, for which the reference period used is 1850–1900.





ESOTC 2025 is jointly produced by C3S, implemented by ECMWF, and the WMO. C3S supports the adaptation and mitigation policies of the European Union, by providing consistent and authoritative information about climate change, while the WMO Regional Office for Europe serves its 50 Member States, covering Europe, Greenland, the South Caucasus and part of the Middle East. They therefore cover overlapping geographical domains, indicated on the maps above. The size and climatic zones of each domain differ, so variations in the statistics are expected. The ESOTC makes use of a wide range of datasets, for which geographical coverage varies. Several sections of the report provide information for both the C3S and WMO RA VI domains, where possible based on the geographical coverage of the data.

About us

Acknowledgements

The ESOTC's findings are based on expertise from across the C3S and WMO communities, as well as other Copernicus Services and external partners. The report is authored by experts at ECMWF, the WMO and data providers from institutions across Europe, edited by the ECMWF ESOTC editorial team and supported by communications teams at C3S/ECMWF and WMO.

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References

[R1.1] Zhang, R. *et al.*, 2020: Increased European heat waves in recent decades in response to shrinking Arctic sea ice and Eurasian snow cover, *npj Climate and Atmospheric Science*, 3 (7). doi.org/10.1038/s41612-020-0110-8

[R1.2] Noël, B. et al., 2022: North Atlantic cooling is slowing down mass loss of Icelandic glaciers, *Geophysical Research Letters*, 49 (3). doi.org/10.1029/2021GL095697

[R3.1]. Aalto, J. *et al.*, 2026: A new era of bioclimatic extreme in the terrestrial Arctic, Science Advances, 12 (2). doi.org/10.1126/sciadv.adw5698

[R5.1] Bednar-Friedl, B. *et al.*, 2022: Europe. In: Pörtner et al. (eds.) Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter13.pdf

[R6.1] Bedia, J. *et al.*, 2015: Global patterns in the sensitivity of burned area to fire-weather: Implications for climate change, *Agricultural and Forest Meteorology*, 214–215, pp 369–379. doi.org/10.1016/j.agrformet.2015.09.002

[R6.2] Sedano, F. *et al.*, 2026: Advance report on forest fires in Europe, Middle East and North Africa 2025, *Publications Office of the European Union.* data.europa.eu/doi/10.2760/3859043

[R6.3] Rogers, B. M. *et al.*, 2020: Focus on changing fire regimes: interactions with climate, ecosystems and society, *Environmental Research Letters*, 15 (3). doi.org/10.1088/1748-9326/ab6d3a

[R6.4] EEA, 2021: Forest fires in Europe, European Environment Agency Indicators. eea.europa.eu/en/analysis/indicators/forest-fires-in-europe

[R6.5] Di Giuseppe, F. *et al.*, 2026: Emergence of bimodality in Western European fire seasons, *Nature Climate Change* – under review

[R9.1] Lavers, D. A. *et al.*, 2025: How bad is the rain? Applying the extreme rain multiplier globally and for climate monitoring activities. *Meteorological Applications*, 32 (2). doi.org/10.1002/met.70031

[R15.1] Horwath, M. *et al.*, 2022: Global sea-level budget and ocean-mass budget, with a focus on advanced data products and uncertainty characterisation, *Earth Systems Science Data*, 14, pp 411–447. doi.org/10.5194/essd-14-411-2022

[R15.2] Mankoff, K. D. *et al.*, 2021: Greenland ice sheet mass balance from 1840 through next week, *Earth Systems Science Data*, 13, pp 5001–5025. doi.org/10.5194/essd-13-5001-2021

[R15.3] Mankoff, K. D. *et al.*, 2020: Greenland Ice Sheet solid ice discharge from 1986 through March 2020, *Earth Systems Science Data*, 12, pp 1367–1383. doi.org/10.5194/essd-12-1367-2020

[R15.4] Mouginot J. and Rignot E., 2019: Glacier catchments/basins for the Greenland Ice Sheet [Dataset]. Dryad. doi.org/10.7280/D1WT11

[R15.5] Otosaka, I. N. *et al.*, 2023: Mass balance of the Greenland and Antarctic ice sheets from 1992 to 2020, *Earth Systems Science Data*, 15, pp 1597–1616. doi.org/10.5194/essd-15-1597-2023

[R19.1] Kim, H., Lazurko, A., Linney, G. *et al.*, 2024: Understanding the role of biodiversity in the climate, food, water, energy, transport and health nexus in Europe. *Science of The Total Environment*, 925. doi.org/10.1016/j.scitotenv.2024.171692

[R19.2] Mahecha, M., Bastos, A., Bohn, F. *et al.*, 2024: Biodiversity and climate extremes: known interactions and research gaps. *Earth's Future*, 12, pp 1–18. doi.org/10.1029/2023EF003963

[R19.3] Pörtner, H.-O., Scholes, R.J., Agard, J. et al., 2021: IPBES-IPCC co-sponsored workshop report on biodiversity and climate change. IPBES and IPCC. doi.org/10.5281/zenodo.4782538

[R19.4] European Commission, 2020: EU Biodiversity Strategy for 2030 – Bringing nature back into our lives (COM(2020) 380 final). Luxembourg: Publications Office of the European Union. op.europa.eu/en/publication-detail/-/publication/a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1/language-en

[R19.5] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Pörtner, H.-O., Roberts, D.C., Tignor, M. et al. (eds.). Cambridge: Cambridge University Press. doi.org/10.1017/9781009325844

[R19.6] European Environment Agency (EEA), 2024: European climate risk assessment (EEA Report No. 01/2024). Luxembourg: Publications Office of the European Union. doi.org/10.2800/8671471

[R19.7] European Union (EU), 2024: Regulation (EU) 2024/1991 of the European Parliament and of the Council on Nature Restoration. Official Journal of the European Union. eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1991

[R19.8] European Commission, 2019: The European Green Deal. Communication from the Commission (COM(2019) 640 final). Luxembourg: Publications Office of the European Union. eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52019DC0640

[R19.9] European Union (EU), 2021: Regulation (EU) 2021/1119 of the European Parliament and of the Council establishing the framework for achieving climate neutrality (European Climate Law). Official Journal of the European Union. eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1119

[R19.10] European Commission (EC), 2021: Fit for 55: Delivering the EU's 2030 Climate Target. commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal/fit-55_en

[R19.11] European Commission, 2021: Horizon Europe: The EU research and innovation programme (2021–2027). research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[R19.12] European Environment Agency (EEA), 2025: Europe's environment 2025: State and outlook. Copenhagen: European Environment Agency. eea.europa.eu/en/europe-environment-2025

[R19.13] Ortner, G. A. M., and Kropf, C., 2025: Assessing the impacts of climate change on snow avalanche-induced risk in alpine regions. *Natural Hazards*, 121, pp 10877–10904. doi.org/10.1007/s11069-025-07229-9

[R19.14] Bergin, C., Swan, L., Kelly, C. *et al.*, 2025: Human-caused climate change increases potential for flooding in south-eastern counties of Ireland as rainfall intensifies. Report No. 0003. WASITUS Project Report. doi.org/10.48460/MU.MURAL.00020858

[R19.15] Barnes, C., Clarke, B., Rantanen, M. *et al.*, 2025: Intense two-week heatwave in Fennoscandia hotter and more likely due to climate change. World Weather Attribution. doi.org/10.25560/122924

[R19.16] Ciais, P., Reichstein, M., Viovy, N. *et al.*, 2005: Europe-wide reduction in primary productivity caused by the heat and drought in 2003, *Nature*, 437, pp 529–533. doi.org/10.1038/nature03972

[R19.17] Ortiz, A. M. D., Chua, P.L.C., Salvador, D. Jr *et al.*, 2023: Impacts of tropical cyclones on food security, health and biodiversity. *Bulletin of the World Health Organization*, 101(2), pp 152–154. doi.org/10.2471/BLT.22.288838

[R19.18] Panagos, P., Van Liedekerke, M., Borrelli, P. *et al.*, 2023: Wildfires in Europe: Burned soils require attention, *Environmental Research*, 217, 114936. doi.org/10.1016/j.envres.2022.114936

[R19.19] Garrabou, J., Gómez-Gras, D., Medrano, A. *et al.*, 2022: Marine heatwaves drive recurrent mass mortalities in the Mediterranean Sea, *Global Change Biology*, 28, pp 5708–5725. doi.org/10.1111/gcb.16301

[R19.20] Artana, C., Kaplan, A., Ramírez, F. *et al.*, 2026: Marine heatwaves are transforming Western Mediterranean marine ecosystems, *Scientific Reports*, 16. doi.org/10.1038/s41598-026-35813-x

[R19.21] Lim, R. and Tweedley, J.R., 2025: Climate change facilitates the formation of natural barriers in low-inflow estuaries, altering environmental conditions and faunal assemblages, *Journal of Marine Science and Engineering*, 13(10), pp 1978. doi.org/10.3390/jmse13101978

[R19.22] Mason, J. G. *et al.*, 2021: Projecting climate-driven shifts in demersal fish thermal habitat in Iceland's waters, *ICES Journal of Marine Science*, 78(10), pp 3793–3807. doi.org/10.1093/icesjms/fsab230

[R19.23] Finnsson, H., Chambers, C. and Guðbergsson, G., 2025: Invasive species management: The case of pink salmon in Iceland, *Marine Policy*, 173. doi.org/10.1016/j.marpol.2024.106539

[R19.24] Mosoni, C., 2024: Cross-border dimensions of Arctic climate change impacts. *Wiley Interdisciplinary Reviews: Climate Change*. doi.org/10.1002/wcc.905

[R19.25] Robuchon, M., Liquete, C., Hammond, E. *et al.*, 2025: Assessing progress in monitoring and implementing the EU Biodiversity Strategy for 2030. Luxembourg: Publications Office of the European Union. doi.org/10.2760/8970981

[R19.26] European Commission, (no date) EU Biodiversity Strategy Actions Tracker. dopa.jrc.ec.europa.eu/kcbd/actions-tracker

[R19.27] Convention on Biological Diversity (1992): Convention on Biological Diversity. cbd.int/doc/legal/cbd-en.pdf [Accessed: 24 March 2026.]

[R19.28] Convention on Biological Diversity (2022): Kunming-Montreal Global Biodiversity Framework (CBD/COP/DEC/15/4). cbd.int [Accessed: 24 March 2026.]

[R19.29] United Nations Development Programme (no date) Nature: Our flagship initiatives. undp.org/nature/our-flagship-initiatives [Accessed: 24 March 2026.]

[R19.30] International Union for Conservation of Nature (2020): Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of NbS. 1st edition. doi.org/10.2305/IUCN.CH.2020.08.en [Accessed: 24 March 2026.]

[R19.31] United Nations Framework Convention on Climate Change (2025): Nature-based solutions: An approach for joint implementation of climate and biodiversity commitments (Thematic Paper 3). unfccc.int/documents/646277 [Accessed: 24 March 2026.]

[R20.1] Traganos, D. *et al.*, (2022): Spatially explicit seagrass extent mapping across the entire Mediterranean, *Frontiers in Marine Science*, 9. doi.org/10.3389/fmars.2022.871799

[R20.2] Telesca, L., Belluscio, A., Criscoli, A. *et al.*, 2015: Seagrass meadows (Posidonia oceanica) distribution and trajectories of change, *Scientific Reports*, 5. doi.org/10.1038/srep12505

[R20.3] Smithsonian Institution, 2023: Seagrass and seagrass beds. Smithsonian Ocean. ocean.si.edu/ocean-life/plants-algae/seagrass-and-seagrass-beds [Accessed: 24 March 2026.]

[R20.4] Unsworth, R. K. F., Nordlund, L.M. and Cullen-Unsworth, L.C., 2019: Seagrass meadows support global fisheries production, *Conservation Letters*, 12(1). doi.org/10.1111/conl.12566

[R20.5] Guannel, G. *et al.*, 2016: The power of three: Coral reefs, seagrasses and mangroves protect coastal regions and increase their resilience, *PLOS One*, 11(7). doi.org/10.1371/journal.pone.0158094

[R20.6] Lamb, J. B. *et al.*, 2017: Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates, *Science*, 355(6326), pp. 731–733. doi.org/10.1126/science.aal1956

[R20.7] Darmaraki, S., Denaxa, D., Theodorou, I. *et al.*, 2024: Marine heatwaves in the Mediterranean Sea: A literature review, *Mediterranean Marine Science*, 25(3), pp 586–620. doi.org/10.12681/mms.38392

[R20.8] Hassoun, A. E. R., Mojtahid, M., Merheb, M. *et al.*, 2025: Climate change risks on key open marine and coastal Mediterranean ecosystems, *Scientific Reports*, 15. doi.org/10.1038/s41598-025-07858-x

[R20.9] Boudouresque, C. F., Bernard, G., Bonhomme, P. *et al.,* 2012: Protection and conservation of Posidonia oceanica meadows, RAMOGE & RAC/SPA. rac-spa.org/sites/default/files/doc_vegetation/ramoge_en.pdf [Accessed: 9 April 2026.]

[R20.10] de los Santos, C. B., Krause-Jensen, D., Alcoverro, T. *et al.*, 2019: Recent trend reversal for declining European seagrass meadows, *Nature Communications*, 10 (3356). doi.org/10.1038/s41467-019-11340-4

[R20.11] Marbà, N., Díaz-Almela, E. and Duarte, C.M., 2015: Mediterranean seagrass (Posidonia oceanica) loss between 1842 and 2009, *Biological Conservation*, 176, pp. 183–190. doi.org/10.1016/j.biocon.2014.05.024

[R20.12] Jordà, G., Marbà, N. and Duarte, C.M., 2020: Mediterranean seagrass vulnerable to regional climate warming, *Nature Climate Change*, 10, pp. 111–116. doi.org/10.1038/nclimate1533

[R20.13] European Commission, 2020: EU Biodiversity Strategy for 2030 – Bringing nature back into our lives (COM(2020) 380 final). Luxembourg: Publications Office of the European Union. op.europa.eu/en/publication-detail/-/publication/a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1/language-en

[R20.14] European Union (EU), 2024: Regulation (EU) 2024/1991 of the European Parliament and of the Council on Nature Restoration. Official Journal of the European Union.: eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1991

[R21.1] Turunen, J. *et al.*, 2025: The impact of large fires in boreal drained peatlands in western Finland: Ecohydrological drivers and carbon and nitrogen loss, *Geoderma*, 459. doi.org/10.1016/j.geoderma.2025.117358

[R21.2] United Nations Environment Programme, 2022: The Global Peatlands Assessment: The State of the World's Peatlands – Evidence for Action toward the Conservation, Restoration, and Sustainable Management of Peatlands. doi.org/10.59117/20.500.11822/41222

[R21.3] van Veen, I., 2018: After LIFE Conservation Plan. LIFE+ Peelvenen. Deurnsche Peel-Mariapeel. European Commission LIFE11 NAT/NL/777. Provincie Noord Brabant and Staatsbosbeheer. webgate.ec.europa.eu/life/publicWebsite/project/LIFE11-NAT-NL-000777/let-the-raised-bogs-grow-natura-2000-deurnsche-peel-mariapeel

[R21.4] Loisel, J. *et al.*, 2021: Expert assessment of future vulnerability of the global peatland carbon sink, *Nature Climate Change*, 11(1), pp 70–77. doi.org/10.1038/s41558-020-00944-0

[R21.5] Parmesan, C. *et al.*, 2022: Terrestrial and freshwater ecosystems and their services, Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge: Cambridge University Press*, pp 197–377. ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter02.pdf

[R21.6] Gallego-Sala, A. V. *et al.*, 2018: Latitudinal limits to the predicted increase of the peatland carbon sink with warming, *Nature Climate Change*, 8(10), pp 907–913. doi.org/10.1038/s41558-018-0271-1

[R21.7] Stoof, C. R. *et al.*, 2024: In temperate Europe, fire is already here: The case of The Netherlands, *Ambio*, 53, pp 604–623. doi.org/10.1007/s13280-023-01960-y

[R21.8] European Environment Agency, 2023: Annual European Union greenhouse gas inventory 1990–2021 and inventory report 2023. Submission to the UNFCCC Secretariat. eea.europa.eu/publications/annual-european-union-greenhouse-gas-2 [Accessed: 2 February 2026.]

[R21.9] Wilkinson, S. L. *et al.*, 2023: Wildfire and degradation accelerate northern peatland carbon release, N*ature Climate Change*, 13(5), pp 456–461. doi.org/10.1038/s41558-023-01657-w

[R21.10] European Environment Agency, 2024: European Climate Risk Assessment. EEA Report 01/2024. eea.europa.eu/en/analysis/publications/european-climate-risk-assessment/european-climate-risk-assessment-report [Accessed: 28 January 2026.]

[R21.11] Leifeld, J. *et al.*, 2019: Intact and managed peatland soils as a source and sink of GHGs from 1850 to 2100, *Nature Climate Change*, 9(12), pp 945–947. doi.org/10.1038/s41558-019-0615-5

[R21.12] Frolking, S. *et al.*, 2010: Peatlands in the carbon cycle and effects of fire, *Ecological Applications*, 20(3), pp 704–718.

[R21.13] Turetsky, M. R. *et al.*, 2015: Global vulnerability of peatlands to fire and carbon loss, *Nature Geoscience*, 8, pp 11–14. doi.org/10.1038/ngeo2325

[R21.14] Loisel, J. and Gallego-Sala, A., 2022: Ecological resilience of restored peatlands to climate change, *Communications Earth & Environment*, 3(1), pp 208. doi.org/10.1038/s43247-022-00547-x

[R21.15] European Environment Agency, 2025: Nature-based solutions for fire-resilient European forests. EEA Briefing 14/2025. eea.europa.eu/en/analysis/publications/nature-based-solutions-for-fire-resilient-european-forests [Accessed: 27 January 2026.]

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REPORT 2025