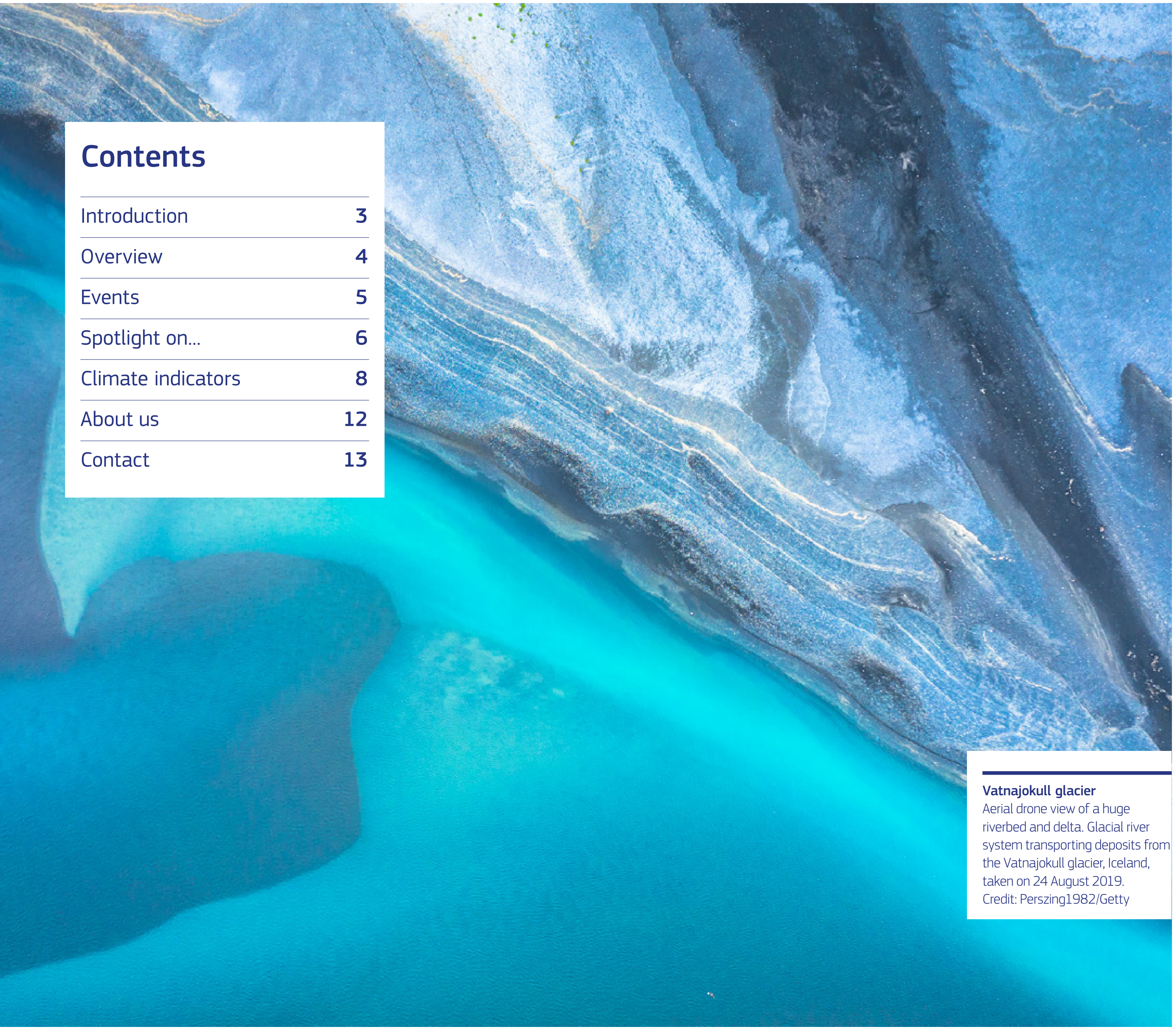
EUROPEAN STATE OF THE CLIMATE 2019

SUMMARY

European Commission

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF



Vatnajokull glacier
Aerial drone view of a huge riverbed and delta. Glacial river system transporting deposits from the Vatnajokull glacier, Iceland, taken on 24 August 2019.
Credit: Perszing1982/Getty

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Welcome to the summary of the European State of the Climate 2019, compiled by the Copernicus Climate Change Service (C3S), implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission.

EUROPEAN STATE OF THE CLIMATE 2019

INTRODUCTION

Tromsø, Norway
Snow over the surrounding mountains near northern Norway's largest city. Credit: contains modified Copernicus Sentinel data (2019), processed by ESA, CC BY-SA 3.0 IGO

What the ESOTC provides

The European State of the Climate (ESOTC) is an annual report. The ESOTC's findings are based on data and expertise from across the C3S community, as well as other Copernicus services and external partners. The ESOTC is published soon after the main data collection for the previous year has concluded. It provides an analysis of the monitoring for Europe for the past calendar year, with descriptions of climate conditions and events. In addition, it explores the associated variations in key climate variables and indices from across all parts of the Earth system. Further, the ESOTC gives updates on key global climate indicators for Europe and the rest of the world.

Explore the complete ESOTC

The complete report is available online at: climate.copernicus.eu/ESOTC2019

A summary of ESOTC findings for 2019

The European State of the Climate 2019 shows that last year was the warmest on record for Europe, albeit by a small margin. Precipitation was close to average for the year as a whole, though there were large regional differences. Generally warm and dry conditions, as well as two major heatwaves during summer, contributed to a drought in central Europe, as reflected by soil moisture and vegetation anomalies, and to high levels of heat stress across most of western Europe. At the end of the year, precipitation was much higher than average across the western and southern part of the continent, with a large number of heavy rainfall events resulting in high river discharge. The latest data for all global climate indicators show values in line with the trends of recent decades, with greenhouse gases continuing to increase, while glaciers and ice sheets are losing mass, further contributing to sea level rise.

How the ESOTC relates to other activities

Additional information about the global climate during 2019 can be found in the World Meteorological Organization (WMO) statement on the State of the Global Climate in 2019, to which the Copernicus services contributed.

Producing the data behind the ESOTC

The majority of the data come from operational Copernicus activities, but a number of datasets are from other monitoring initiatives. The operational data services build upon extensive research and development undertaken by institutions across Europe and the rest of the world.

Reference periods

By comparing 2019 against a reference period, we can see how the year fits within a longer-term context. Generally, the reference period used is 1981–2010, but where less extensive data records are available, more recent and shorter periods are used as indicated by this symbol.

Types of data used in the report

Satellites
Providing information about the Earth's surface and its atmosphere from spaceborne orbit.

Reanalysis
Using a combination of observations and computer models to recreate historical climate conditions.

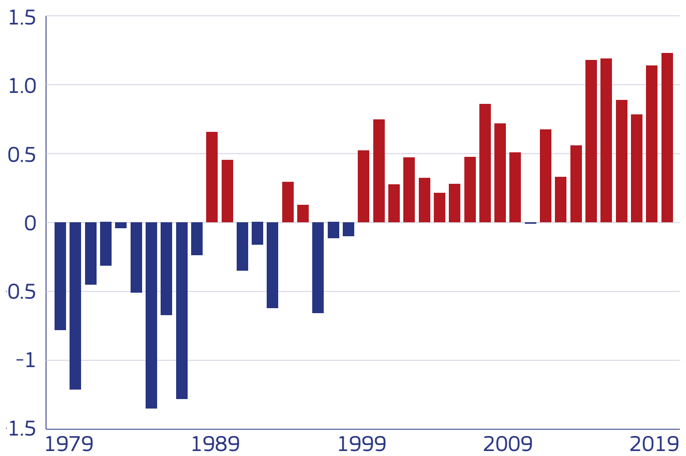
In situ
Measurements from an instrument located at the point of interest, such as a land station, at sea or in an aeroplane.

Model-based estimates
Using the laws of physics and statistics to build large-scale models of environmental indicators.

THE CLIMATE IN 2019 OVERVIEW

A review of annual and seasonal conditions in Europe and the European Arctic compared to the long-term average.

Europe annual temperature anomalies 1979-2019 (°C)



Surface air temperature anomaly for Europe, relative to 1981–2010.
Data source: ERA5. Credit: C3S/ECMWF

11 of the 12 warmest years have occurred since 2000

European temperature

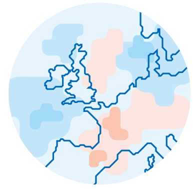
Over the last four decades, temperatures in Europe have shown a clear warming trend.

In 2019, the annual temperature for Europe was the highest on record, though closely followed by 2014, 2015 and 2018. It was warmer than average over almost the whole of Europe. Central and eastern areas saw the most above-average temperatures; it was cooler than average only over a very small part of northern Europe.

All seasons were warmer than average. Summer was the fourth warmest since at least 1979, with temperatures in some areas as much as 3°C to 4°C higher than normal. Two intense heatwaves in June and July brought record-breaking temperatures to some European countries.

The annual means of both minimum and maximum daily temperatures were above average almost everywhere in Europe, with maximum temperatures generally showing larger anomalies than minimum temperatures.

1981–2010



Soil moisture values in 2019 were the second lowest since at least 1979

European wet and dry conditions

There is no clear trend in annual precipitation for Europe, and 2019 values were close to average. The number of precipitation days was up to 30 days more than average in the north, west and south, whereas central and eastern Europe saw below-average values.

In winter, spring and summer, precipitation was below average in the southwest, however, this changed during autumn and December when for large parts of this region it became much above average.

Soil moisture shows a downward trend, with values for 2019 being the second lowest since at least 1979. Most of continental Europe saw below-average soil moisture throughout the year, especially in central Europe during summer and in the southeast during autumn. During autumn, parts of western, northern and southern Europe saw soil moisture anomalies becoming closer to or even above average, concurrent with the above-average precipitation in these regions.

1981–2010 1991–2010

Cooler and more sea ice than in recent years

European Arctic

The European sector of the Arctic has seen an upward trend in temperature and a downward trend in sea ice cover over the last 40 years. 2019 saw surface air temperatures over sea and land at 0.9°C above average. However, as the 14th warmest in the 41-year dataset, the year was relatively cold compared to recent years, with the lowest annual temperature since 2010.

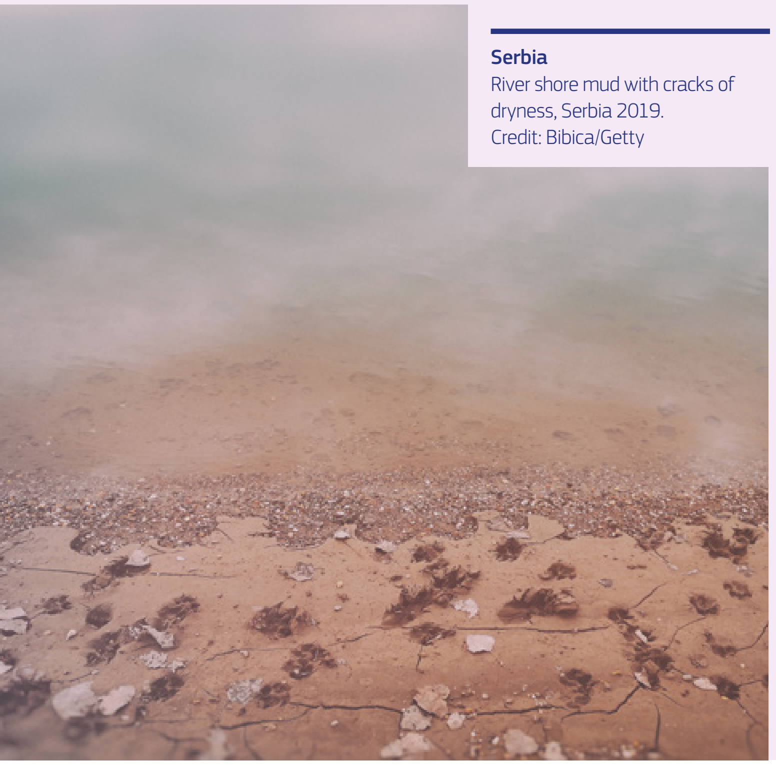
At the end of July, all-time temperature records were broken in northern Scandinavia when a short heatwave travelled across Europe; it also led to record surface melting in Greenland. However, the summer season as a whole had temperatures relatively close to average.

Sea ice extent was lower than average, as it has been consistently for the past 15 years, but markedly above the values recorded in six of the preceding seven years.

1981–2010

THE CLIMATE IN 2019 EVENTS

Here we focus on two types of extreme events – heatwaves and heavy rainfall which affected the continent during 2019.



Serbia
River shore mud with cracks of dryness, Serbia 2019.
Credit: Bibica/Getty

One of the wettest Novembers on record brought precipitation of up to four times the normal amounts

Wet end to the year in western and southern Europe

Western Europe and much of southern Europe experienced a wetter than average end to the year. Over October, November and December, exceptionally high amounts of precipitation hit regions bordering the northern Mediterranean and Atlantic coasts.

For most of the regions with above-average precipitation, November was particularly exceptional, both in terms of the total rainfall amounts and the number of days with heavy rainfall. This was due to several discrete storm events accompanied by abundant rains. In Italy, precipitation values were up to four times the normal amounts in places, and it was the wettest November on record. France saw its third wettest November since 1959, and Austria its third wettest November since 1858, with twice the normal amounts of precipitation.

October and December also saw exceptional rainfall amounts, but over less extensive areas than November.

1981–2010

Three periods of exceptionally warm weather led to record-breaking high temperatures

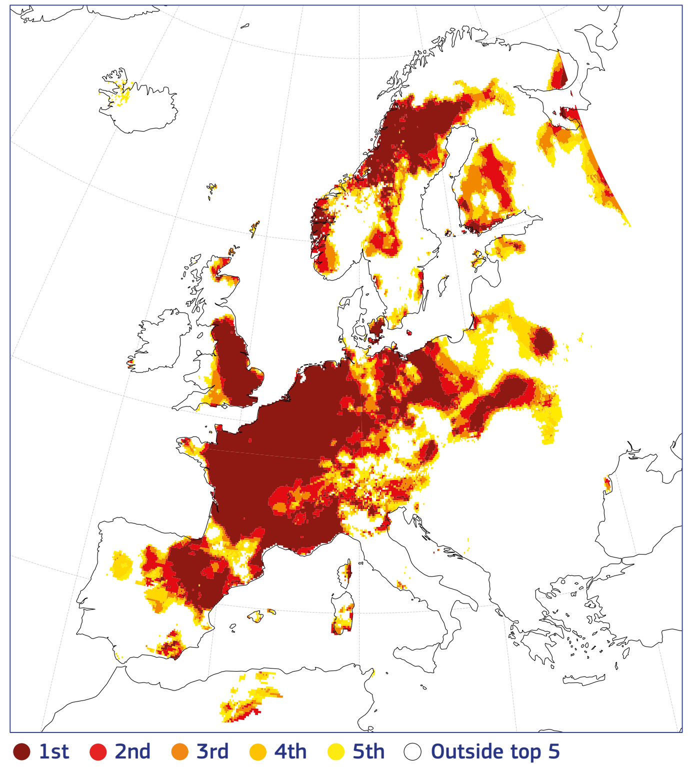
Winter warm spell and summer heatwaves

During the year, three periods of exceptionally warm weather occurred across Europe, leading to record-breaking high temperatures.

In late February, temperature records for all February months, or even entire winters, were broken in several countries. The warm spell was due to a high pressure over western Europe, which led to warm winds from the south and an almost cloudless atmosphere with abundant sunshine. In the last week of June, exceptionally high temperatures occurred over central and southwestern parts of Europe. Locally, maximum temperatures reached 40°C or more. Numerous June records and all-time records for daily maximum temperature were broken at individual stations; some country-wide records were also broken.

In late July, another heatwave occurred over a large part of western Europe. All-time records for daily maximum temperatures, which had been broken by the heatwave just the month before, were again surpassed. Both summer heatwaves led to 'strong heat stress' or 'very strong heat stress' across large parts of the continent.

1981–2010



Ranking of the highest temperature recorded during June and July 2019 compared to the highest temperatures recorded for all June and July months since 1950, where the dark red colour indicates that 2019 ranks highest in the series.
Data source: E-OBS. Credit: C3S/KNMI

THE CLIMATE IN 2019

SPOTLIGHT ON...

Heat and cold stress

The number of days with high heat stress levels are increasing in both northern and southern Europe.

Most of continental Europe saw some level of heat stress during the summer months, including areas which on average saw 'no thermal stress' during the longer-term reference period. The maximum heat stress levels recorded for large parts of western and northern Europe were 'strong heat stress' to 'very strong heat stress'. During winter 2019, most parts of Europe experienced no unusual cold stress spells.

1981–2010

Sunshine duration and clouds

Sunshine duration shows a clear upward trend over the past 40 years for Europe as a whole.

2019 saw the largest number of sunshine hours since at least 1983, just above the value for 2015. Across almost all of Europe, above-average sunshine duration was seen for the whole year and below-average cloud cover was seen for the first six months. The anomalous annual sunshine duration values were largest in an area from northern France to central Europe and into most of eastern Europe.

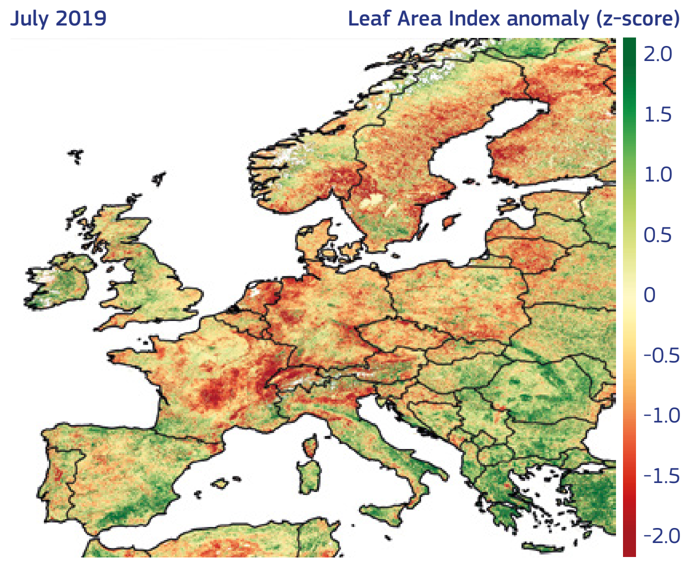
1983–2012

Vegetation

Drought conditions across Europe became noticeable in June, bringing an impact on vegetation, as shown by below-average Leaf Area Index (LAI) values, particularly in northern Germany.

As the dry conditions persisted through the summer, LAI was below average in several regions of western Europe, the Baltic and Scandinavia. By autumn, vegetation had started to recover in western Europe, other than in central France and the Iberian Peninsula. However, in southeastern Europe (around the Black Sea) LAI started to show below-average values.

1998–2014



Leaf Area Index anomalies for July 2019 as estimated from satellites
Data source: VGT/PROBA-V (PROBA-V_2018 anomaly given a climatology from VGT). Credit: C3S/VITO

Lithuania
Barren field in Lithuania in May 2019. Credit: ljphoto7/Getty

Wildfires

Almost all years since 2000 show above-average fire danger in both southern and northern Europe, but it was close to average in 2019.

Flammability conditions, number of fires and estimated emissions were above average in late winter to early spring, but below average in summer. This meant that the year as a whole was relatively close to average. The total estimated wildfire emissions were slightly higher than average for northern Europe, but one of the lowest for southern Europe since monitoring began in 2003.

Wildfire danger 1981–2010
Wildfire emissions 2003–2018

Sweden
Forest wildfire Sweden, April 2019. Credit: Björn Forenius/Getty

Lake surface temperatures

During the summer of 2019, the combined average surface temperature of the European lakes was 0.34°C higher than normal. This is lower than the 2018 anomaly, which was a record high.

However, this was not due to widespread lower temperatures, but because of cooler lakes in Ireland, Scandinavia, Finland and the Karelia region of Russia. The largest positive anomaly of +1.5°C was the Chiemsee in Germany; the largest negative anomaly of -0.6°C was Lough Derg in Ireland. European lakes have been warming at a faster rate than the global average.

1997–2016

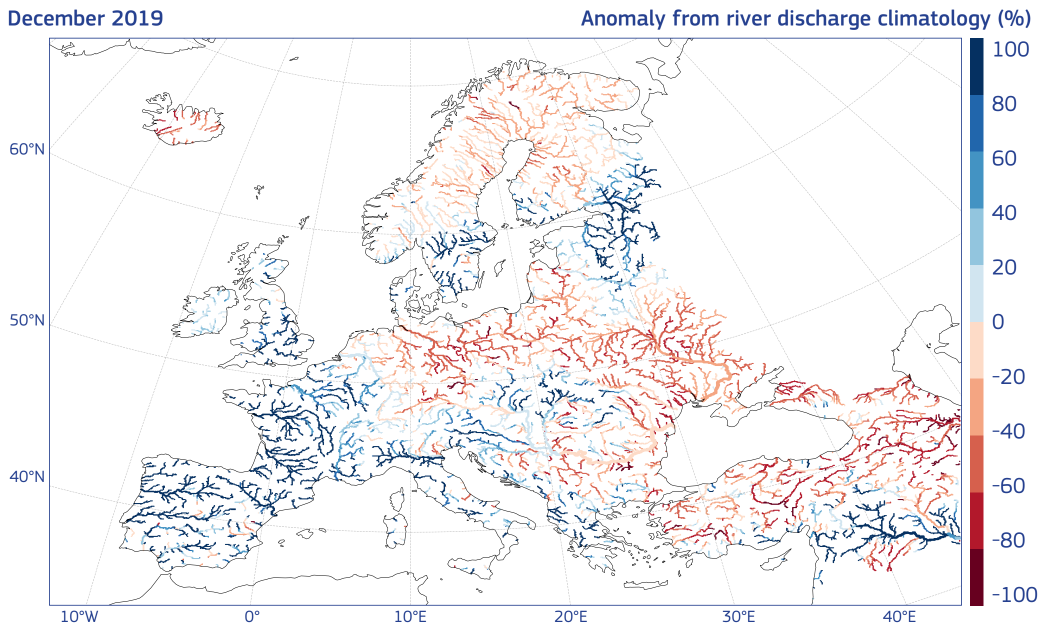
River discharge

Across Europe, river discharge was lower than average for two thirds of the year.

The lowest river discharge occurred during spring and throughout the mid-summer to early autumn months, and was most severe in central Europe. In November and December there was a transition to high river discharge in western Europe, with low discharge remaining in eastern Europe.

1991–2016

River discharge
Solway Firth. Credit: NASA images by Norman Kuring/NASA's Ocean Color Web, using Landsat data from the U.S. Geological Survey



Average river discharge anomaly for December 2019, as percent change from the median for 1991–2016.
Data source: Copernicus EMS model-derived river discharge.
Credit: Copernicus EMS/ECMWF

CLIMATE INDICATORS

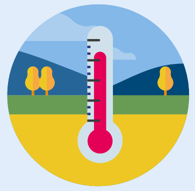
The headline climate indicators show the long-term evolution of several key climate variables. These can be used to assess the global and regional trends of a changing climate.

Surface temperature

The aim of the Paris Agreement of 2015 is to hold the increase in the global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C.

The latest five-year average global temperature is the highest on record, and shows warming of around 1.1°C. Since the mid-1970s, temperatures over land have been rising on average about twice as quickly as those over the sea.

Five temperature datasets covering all or parts of 1850–2019



Increase globally of around

1.1°C ▲

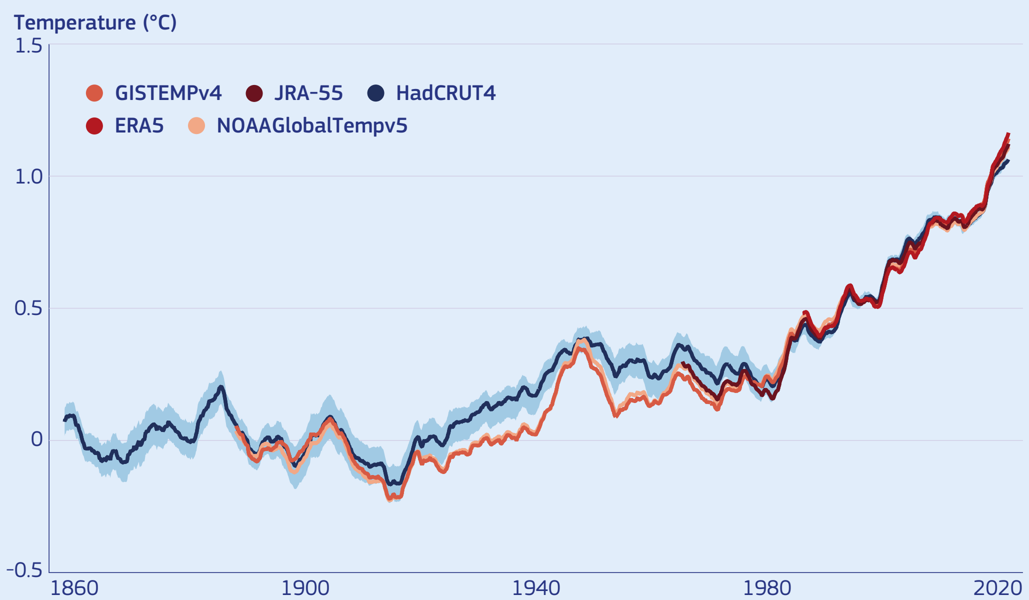
since pre-industrial era

Increase in Europe by almost

2.0°C ▲

since latter half of the 19th century

Iceland
Icebergs in Jokulsarlon lagoon, Iceland. Credit: kanicon/Getty



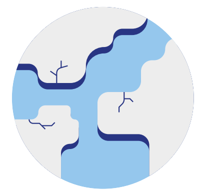
Estimated change in global surface air temperature since the pre-industrial era, according to several different datasets.
Credit: C3S/ECMWF

Sea ice

In the Arctic, sea ice extent has declined markedly since 1979. The trend can be seen for all months of the year but especially in September, the time of year when the ice cover reaches its annual minimum.

However, after accelerating in the late 1990s and early 2000s, the September retreat has been levelling off since the late 2000s. In the Antarctic, the total sea ice extent has shown no clear long-term trend since 1979, although more prominent changes have occurred in certain sectors of the Southern Ocean.

Sea ice data record covering 1979–2019



In the Arctic, March sea ice extent

–3.2 ± 0.2% ▼

per decade during 1979–2019 (relative to the 1981–2010 average)

In the Arctic, September sea ice extent

–14.5 ± 1.2% ▼

per decade during 1979–2019 (relative to the 1981–2010 average)

In the Antarctic, no clear trend in total sea ice extent

Greenhouse gases

Concentrations of atmospheric carbon dioxide (CO_2) and methane (CH_4) are increasing. We would have to look back millions of years in history to find concentrations as high as they were in 2019.

Greenhouse gas concentrations

The amount of a gas contained in a certain volume of air.

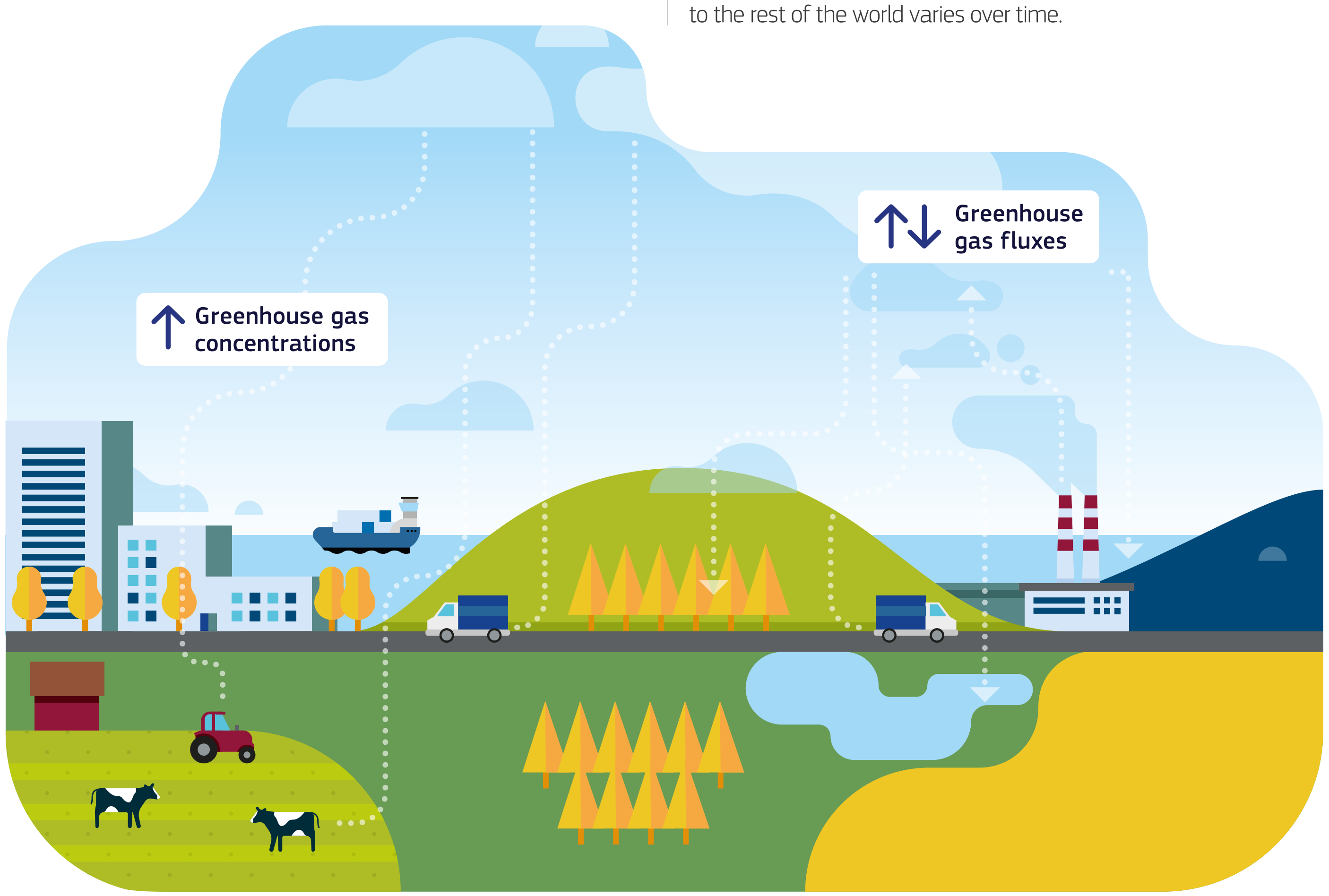
CO_2 increase by about
0.6% per year ▲
in atmospheric concentrations

CH_4 increase by about
0.4% per year ▲
in atmospheric concentrations

Concentrations (column-averaged mixing ratios) estimated from satellite data for CO_2 and CH_4 covering 2003–2019

The estimated net surface fluxes of the greenhouse gases CO_2, CH_4 and N_2O have also been increasing during recent decades.

Anthropogenic emissions of CO_2 have been partly compensated for by a natural uptake by oceans and vegetation. In some countries, the variation in these fluxes is mainly driven by fossil fuel burning, while for others the dominant process is the natural uptake by vegetation through photosynthesis. It is estimated that, across Europe as a whole, vegetation does not fully compensate for anthropogenic emissions. The scale of the European sink relative to the rest of the world varies over time.



Greenhouse gas net flux

The difference between the amount of a gas added to the atmosphere by emissions from various 'sources' and the amount taken up by various 'sinks', which remove that gas from the atmosphere.

CO_2 annual net emissions about
5 PgC per year ▲
at the Earth's surface

CH_4 annual net emissions about
420 TgC per year ▲
at the Earth's surface

N_2O annual net emissions about
18 TgN per year ▲
at the Earth's surface

Estimated net flux data for
CO_2: 1979–2018
N_2O: 1996–2017
CH_4: 1990–2018

Greenland
Greenland glacier.
Credit: Miralex/Getty

The link between ice sheets, glaciers and sea level rise

Sea level rise is mainly due to land ice melt – including the ice sheets of Greenland and Antarctica, and glaciers worldwide – and thermal expansion of ocean waters.

To estimate their respective and total contributions to sea level rise requires consistent data records that cover corresponding time periods. During the period from 2005 to 2015, ocean thermal expansion explains more than one third of the sea level rise. The majority of the other two thirds was related to land ice melt. The remaining contribution comes from land water storage, such as ground reservoirs.

Ice sheet and glacier mass change

Ice sheets and glaciers gain mass through snowfall and lose ice through ablation, melting or calving. In the case of ice sheets, ice is transported from the centre of the ice sheet towards the ocean by glaciers and ice streams, forming floating ice shelves in Antarctica or breaking off icebergs from the edge of glaciers in Greenland.

The mass change of ice sheets and glaciers is converted to an equivalent sea level contribution by assuming that around 360 Gt* of ice is equivalent to 1 mm of sea level rise.

* 1 gigatonne (Gt) = 1 000 000 000 tonnes

Ice sheets

Together, the Greenland and Antarctic ice sheets have lost 6400 Gt of ice between 1992 and 2017, causing global sea levels to rise by nearly 2 cm.

In Greenland, just over half of this ice loss has been through reduced surface mass balance and half from ice discharge. In Antarctica, increased ice losses have been driven by increased glacier discharge in West Antarctica and the Antarctic Peninsula.

In Greenland

–3902 ± 342 Gt ice ▼

between 1992 and 2018

In Antarctica

–2720 ± 1390 Gt ice ▼

between 1992 and 2017

Satellite data from 11 missions 1992–2018

SPOTLIGHT ON...

Greenland ice sheet

In summer 2019, the Greenland ice sheet experienced record melting, with close to 96% of the surface experiencing melting at least once.

As a result, the surface mass balance was the lowest ever recorded, at 320 Gt below the 1981–2010 average. Below-average snowfall and an early start to the melting season resulted in the early exposure of bare ice. This further enhanced melting, as bare ice reflects less solar energy than fresh snow, in what is termed melt-albedo feedback.

1981–2010

> **In Greenland, just over half of this ice loss has been through reduced surface mass balance and half from ice discharge.**

Iceland
Glacier river from Eyjafjallajokull.
Credit: HRAUN/Getty

Glaciers and sea level rise

The world's glaciers have lost about 9625 Gt of ice since 1961, raising the global sea level by nearly 3 cm. Their current mass loss is around 335 Gt a year, corresponding to a sea level rise of almost 1 mm per year.

In Europe, the largest contributions to global sea level rise come from the peripheral glaciers in Greenland, and the glaciers located in Svalbard and Iceland. The other European glaciers cover a relatively small area and only constitute a minor contribution to sea level rise.

Glaciers

Both globally and in Europe, glaciers are seeing a substantial and prolonged loss of ice mass.

Over most of the 20th century, the rate of mass loss was lower, and some periods of mass gain were observed at both regional and decadal scales. Since 1997, the monitored glaciers in Europe have lost 10 to 29 m of mass, with a regional average loss of around 16 tonnes of freshwater per square metre. of around 16 tonnes of freshwater per square metre.

Ice thickness loss

Globally around

30 m loss ▼

in ice thickness since 1957

In Europe observed

4–35 m loss ▼

in ice thickness in southwestern Scandinavia and the Alps respectively, since the 1960s

Reference glacier network with more than 30 years of ongoing observations

Sea level

Between 1993 and 2019, the global mean rise in sea level has been around 3.3 mm ± 0.4 mm per year; a total increase of around 8 cm.

Regional trends can deviate considerably from global mean. For example, across Europe, sea level changes differ between the open ocean and coastal areas due to various geophysical processes.

Between 1993 and 2019

Globally around

3.3 mm per year ▲

mean sea level increase

In Europe by

2–4 mm per year ▲

mean sea level increase

Sea level data record covering January 1993 to October 2019

ABOUT US

ECMWF COPERNICUS SERVICES

Vital environmental information for a changing world

The European Centre for Medium-Range Weather Forecasts (ECMWF) has been entrusted by the European Commission to implement two of the six services of the Copernicus programme: the Copernicus Climate Change Service (C3S) and the Copernicus Atmosphere Monitoring Service (CAMS). In addition, ECMWF provides support to the Copernicus Emergency Management Service (Copernicus EMS).

To meet the challenge of global climate change, accurate, reliable and timely data are key. The Copernicus Services at ECMWF routinely monitor data on a global scale, including surface air temperature, precipitation, sea ice area and atmospheric greenhouse gases.

The Copernicus Climate Change Service (C3S)

The Copernicus Climate Change Service adds value to environmental measurements and provides free access to quality-assured, traceable data and applications, all day, every day. We offer consistent information on the climate anywhere in the world, and support policymakers, businesses and citizens to deal with the consequences of climate change and help them prepare for the future.

The Copernicus Atmosphere Monitoring Service (CAMS)

The Copernicus Atmosphere Monitoring Service adds value to air quality and atmospheric composition measurements, and provides free access to quality-assured, traceable data and applications.

With contributions from:

The EU Copernicus services:
C3S, CAMS, Copernicus EMS, CMEMS, CLMS

International organisations and initiatives:
ECMWF, EC JRC, EEA, ESA, EUMETSAT SAF Network, GCOS, WMO RA VI RCC Network and European NMHSs

Universities and research organisations:
University of Bremen (Germany), CEA/LSCE (France), CLS (France), DMI (Denmark), DWD (Germany), EODC (Austria), JAXA (Japan), KNMI (Netherlands), University of Leeds (United Kingdom), University of Leicester (United Kingdom), NASA (USA), NILU (Norway), NIES (Japan), Met Norway, SRON (Netherlands), University of Reading (United Kingdom), University of Zurich (Switzerland), TNO (Netherlands), TU Wien (Austria), VanderSat (Netherlands), VITO (Belgium), VU Amsterdam (Netherlands), WGMS (Switzerland)

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Copernicus User Services
copernicus-support@ecmwf.int

Copernicus communication
copernicus-communication@ecmwf.int

Media enquiries
copernicus-press@ecmwf.int

European Centre for Medium-Range Weather Forecasts
Shinfield Park
Reading
RG2 9AX
United Kingdom

#ESOTC