

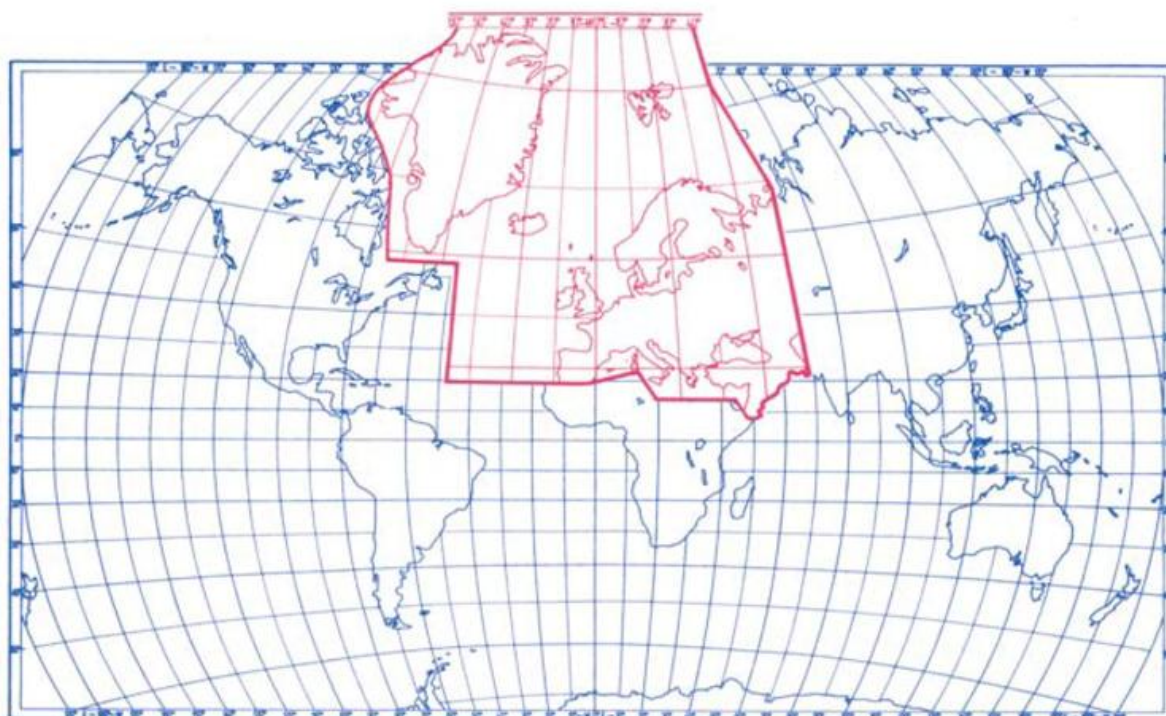
The Network of European
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World Meteorological
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Deutscher
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Department Climate
Monitoring



Annual Bulletin on the Climate in WMO Region VI - Europe and Middle East - 2010



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Annual Bulletin on the Climate in WMO Region VI - Europe and Middle East - 2010

The Bulletin is a summary of contributions
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and was co-ordinated by the Deutscher Wetterdienst, Germany

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Foreword

Climate was again a hot topic in 2010, also in RA VI. This time, it was not only the global warming, but also the extreme winter cold spells which attracted much attention from the public. In fact, large parts of Europe experienced a cold and snowy winter 2009/10 and once more an outstandingly cold and snowy December 2010. On the other hand, an extremely long and intense heat wave affected particularly the European part of Russia and neighbouring countries in summer, and mild weather in the Arctic region caused again a very low sea ice extent.

It has become clear that the extremely negative values of the Arctic Oscillation were a main contributor to annual climate variability. In this context, the year 2010 showed very clearly that even in a time of global warming, extreme warm and cold periods can still occur repeatedly, which has to be considered when talking about adaptation strategies.

In terms of precipitation, some areas were equally affected by repeated extremes, such as flooding in eastern central Europe in May and in August and September. As for storms, we still have not forgotten the storm Xynthia crossing France and Germany in late February 2010.

All these examples show that a good co-operation of the national meteorological and hydrological services of our Region in climate issues is essential for monitoring and, as far as possible, forecasting regional climate variability. The development of a Regional Climate Centre (RCC) Network in RA VI is the right step in this direction. I was very pleased to attend the "WMO Workshop on Climate Monitoring including the implementation of climate watch systems in RA VI", which was jointly organised by the WMO and the Deutscher Wetterdienst (DWD) in Germany in 2010, and where representatives of the members of the RCC-Network and of the National Meteorological and Hydrological Services as well as other interested participants came together. The Network is now in its pilot phase, with the designation procedure in progress.

The Annual Bulletin on the Climate in RA VI, which is on its 17th issue this year, continues to be an important backbone within the RCC product suite. Considering the requests of some of our Members to extend our assessments beyond the area of our Region, a global overview of temperature and precipitation anomalies has been added. As in previous years, the Annual Bulletin also presents an extensive summary of all important climate events of 2010 in our Region, compiled from the excellent material provided by many of our Members.

Once again, it is a pleasure for me to thank all the Members for their contributions. My special thanks go to the editorial team of DWD, namely Dr Peter Bissolli, for compiling and writing all the texts and Volker Zins for his technical support as well as to all reviewers.

I wish you a pleasant reading and hope this Bulletin will be helpful for your work in climatology.



Ivan Cacic
President of WMO Regional Association VI

Outstanding Events and Anomalies in 2010

Temperature

- Long and intense heat wave in July and August in European Russia and adjacent areas
- Cold winter 2009/10 and cold December 2010 in large parts of Europe

Precipitation

- Several flooding events in eastern central Europe (May, August, September)
- Long summer drought periods in central European Russia and in the Middle East
- Extensive snow cover in large parts of Europe in winter 2009/10 and in December 2010

Storm

- Heavy storm (Xynthia) over south-western, western and central Europe at the end of February 2010

Annual Survey

1. Atmospheric circulation

The main features of the global atmospheric circulation in 2010 were a transition from El Niño to a very strong La Niña and a strongly negative Arctic Oscillation and North Atlantic Oscillation in particular during the cold season in RA VI, associated with the domination of meridional patterns over Europe.

1.1. El Niño / La Niña

2010 started with El Niño conditions stronger than those at the end of 2009. They were most distinct in February and then weakened rapidly in early spring (Fig. 0.1). A typical feature of El Niño is the stronger subtropical jet and a dislocation of the Icelandic low to a far more southerly position, which was very pronounced in February. As a consequence, wet conditions prevailed over Iberia and the Mediterranean in the winter 2009/10, whereas it was cold and dry particularly in northern Europe.

In April 2010, the Southern Oscillation index entered into a La Niña phase, which became gradually stronger during the course of the year. Full La Niña conditions had arrived in August 2010. The highest value was achieved in December with 2.9 (standardised), which is also the highest value ever reached in at least 60 years (according to data from NOAA) and was assessed as one of the five strongest La Niña events since the beginning of the 20th century. Nevertheless, the impact on the surface pressure field over the North Atlantic and Europe was masked by a strong negative North Atlantic Oscillation and Arctic Oscillation.

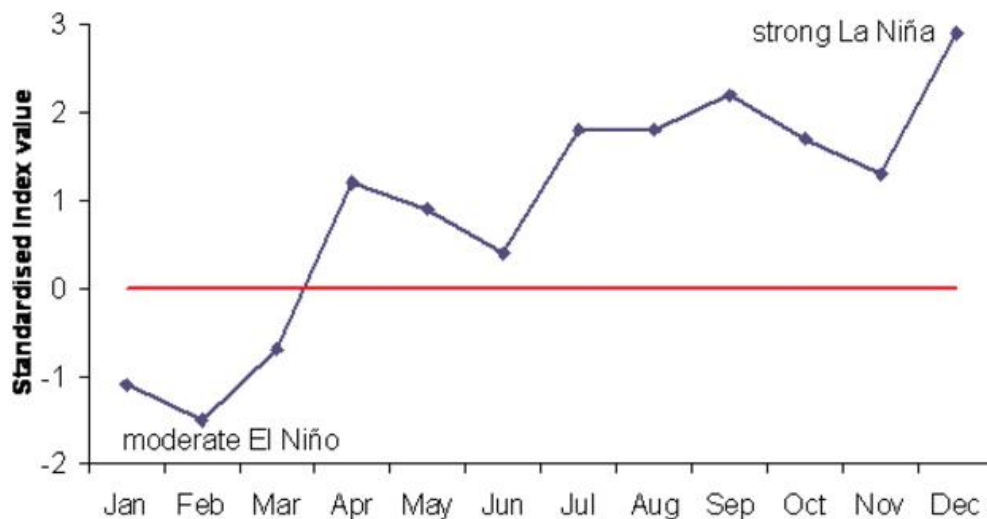


Fig. 0.1: Standardised Southern Oscillation index for 2010, as expressed by the difference of standardised sea level pressure anomalies in Tahiti and Darwin (Australia)

Source: NOAA, www.cpc.ncep.noaa.gov/data/indices/soi, 8 February 2012

1.2. Arctic Oscillation (AO) and North Atlantic Oscillation (NAO)

The Arctic Oscillation index (Fig. 0.2) was highly negative during the winter months January and February 2010 and once again at the beginning of the next winter in December 2010. This implies that a mainly meridional circulation pattern prevailed in the northern hemisphere during all winter months. As a consequence, there was a strong meridional exchange of Arctic air masses and milder air masses from more southern latitudes. Thus, most of Europe saw colder winter months than normal, whereas the Arctic was relatively mild. During the rest of the year, the AO index was close to zero, implying only weak impact. Averaged over the whole year 2010, however, the pressure gradient between middle and high latitudes of the northern hemisphere decreased compared to 2009.

The NAO index was negative during almost the whole year, except July when the index was close to zero. This implied the existence of a stronger-than-normal meridional circulation component over the North Atlantic; westerly airflows from the Atlantic to Europe were quite rare. Annual mean air pressure was up to 10 hPa higher in Greenland and the Icelandic low was dislocated towards Newfoundland while the Azores high was weaker than normal. Sea level pressure in Iceland reached its highest annual average on record since 1823 (1014 hPa). Like the AO, the NAO too had an extremely negative phase in the winter months, when the impact of the NAO on Europe is very strong. Iceland was often dominated by high pressure whereas low pressure prevailed over the Azores, which is the quite the reverse of normal conditions. This facilitated the arrival of cold continental air from the east in western Europe and prevalence of moist conditions over the Mediterranean countries.

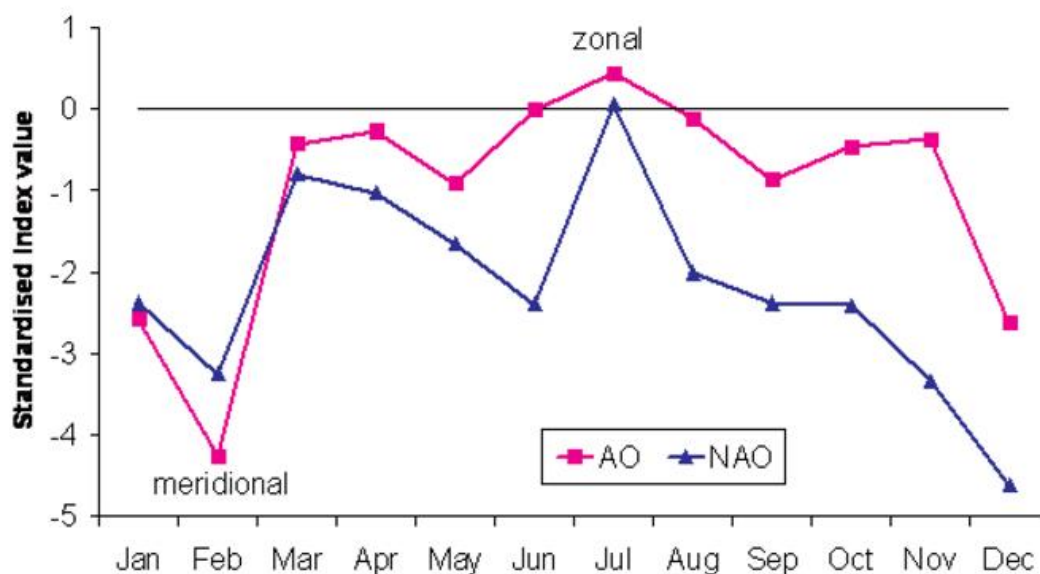


Fig. 0.2: Standardised Arctic Oscillation (AO) index and North Atlantic Oscillation (NAO) index for 2010, as expressed by the difference of standardised sea level pressure anomalies between southern and northern latitudes over the whole northern hemisphere (AO) and the North Atlantic (NAO).

Sources (which can also be referred to for more information on the definitions on AO and NAO):

NOAA, www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.shtml

Climate Research Unit, University of East Anglia, United Kingdom,

<http://www.cru.uea.ac.uk/~timo/datapages/naoi.htm>

1.3. Zonality over the North Atlantic and Europe

Like AO and NAO, the zonal index over the North Atlantic and Europe (Fig. 0.3) also reflects the very extreme meridional situation in January, February and December 2010. In March, however, the zonality returned to normal conditions, and followed more or less the typical annual cycle until October, though with a systematic deviation towards a more meridional mean pattern, particularly in September. In November and even more in December, however, the annual cycle shifted again towards unusual meridional conditions. This shows that mainly the winter months had greatly contributed to a stronger meridionality and thus to a significant cooling in Europe, compared to normal conditions.

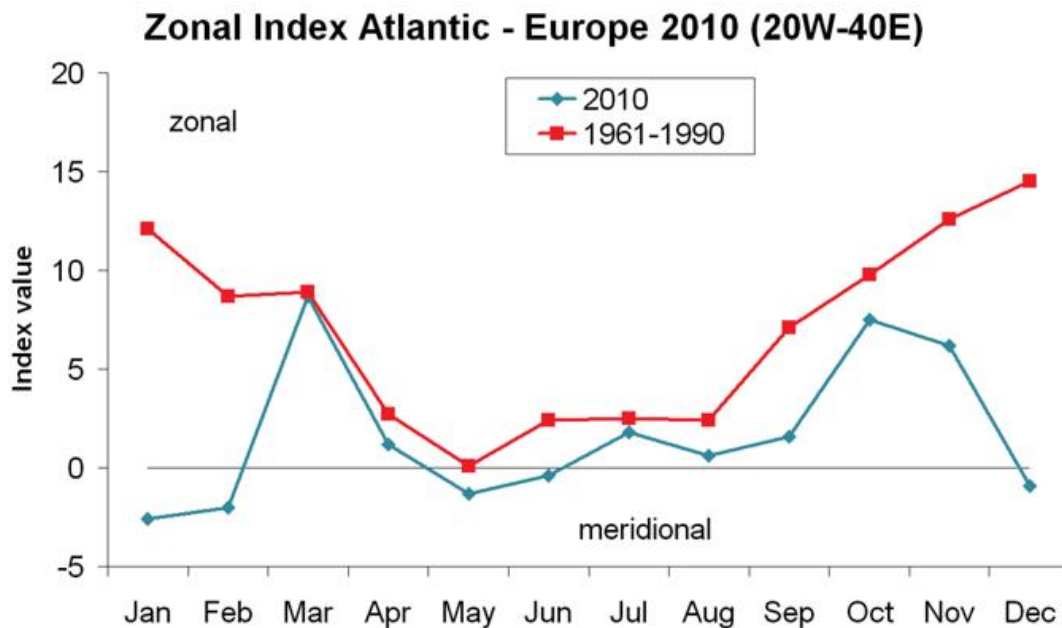


Fig. 0.3: Zonal index over the North Atlantic and Europe (20°W–40°E) for 2010, as expressed by zonally averaged sea level pressure difference between southern and northern latitudes
Source: Deutscher Wetterdienst, www.dwd.de/GWL

1.4. Sub-regional Overview

1.4.1. Central and eastern North Atlantic

The weather over the North Atlantic was conditioned by a negative NAO almost throughout the year. This resulted either in a meridional warm airflow from south or south-west to the north (in most parts of the year) or in a cold easterly flow from the European continent particularly in the winter months February and December. Zonal airflows from west to the east only dominated in July and partly in autumn.

1.4.2. Arctic regions of Europe

The Arctic Oscillation was negative almost throughout the year, which implies an enhanced meridional exchange of arctic and warmer air masses. Especially the western European Arctic, particularly western Greenland, was influenced by a strong flow of warmer air from the south almost over the whole year.

The whole European Arctic saw considerably stronger-than-normal high pressure conditions and subsiding dry air. Only the eastern parts experienced some longer low pressure periods, especially in March and November.

1.4.3. Northern Europe (Baltic countries, northern European Russia, Scandinavia)

Northern Europe was particularly influenced by the negative Arctic Oscillation, especially in the three winter months (January, February and December 2010), but partly also in March and November when cold and dry air came either from the Arctic region or the cold continent in northern Russia. The summer half year, too, saw some periods when cold Arctic air moved to northern Europe, especially in May, June and October.

Several times over the year, large parts of northern Europe were under strong high pressure influence, with occasional low pressure systems occurring especially in spring and early summer or late summer in the southern parts.

1.4.4. Western and central Europe (Austria, Belgium, Czech Republic, France, Germany, Hungary, Ireland, Luxembourg, the Netherlands, Poland, Slovakia, Switzerland, United Kingdom)

Western and central Europe was also strongly influenced by the negative AO and NAO, though not as much as northern Europe. Prolonged periods with blocked weather patterns, and an associated absence of westerly airstreams, resulted in a year that was colder, drier and sunnier than average in most of the western areas. The most extreme months were again the winter months, when cold air masses reached all parts of western and central Europe and many low pressure systems with snow moved over central and western Europe, especially in December 2010.

The rest of the year showed quite a large variability, with high pressure situations (particularly in April) alternating with some intense low pressure systems.

1.4.5. Iberia

From January to March, Iberia was frequently affected by southerly frontal zones resulting from the stronger subtropical jet caused by El Niño.

The rest of the year was characterised by a large variability of cold and warm spells due to many meridional situations. Cold air from the north frequently reached Iberia, partly in spring and especially in autumn. In July and August, intense high pressure influence prevailed particularly in Portugal, partly as a result of a strong subtropical high associated with a developing La Niña.

1.4.6. Mediterranean (including Italy, Monaco and Malta)

In the winter 2009/10, the whole Mediterranean region was affected by a strong subtropical jet and more and stronger low pressure systems, triggered by El Niño. Throughout the year, frequently occurring meridional patterns brought cold air as far southwards as the western Mediterranean, especially in winter due to the highly negative Arctic Oscillation. Conversely, the Eastern Mediterranean was mainly affected by warmer air from the south and often under the influence of high pressure.

1.4.7. Balkan Peninsula (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, the Former Yugoslav Republic of Macedonia, Montenegro, Serbia, Slovenia)

The Balkan Peninsula was mostly influenced by warm air from the south. Cold air masses from more northerly parts of Europe reached these parts rarely, except in September and October and on some occasions also in the winter months. However, low pressure systems affected the peninsula frequently throughout the year.

1.4.8. Eastern Europe (Belarus, western Kazakhstan, Moldova, Romania, central and southern European Russia, Ukraine) and South Caucasus region (Armenia, Azerbaijan, Georgia)

In January, eastern Europe was strongly affected by cold continental air, particularly in the north. Meridional air mass exchange began to develop in February and the area was dominated by warmer air masses. However, especially in spring, temporarily colder air masses reached the South Caucasus. In summer, high pressure and warm and mostly dry air dominated the weather in eastern Europe, particularly in Russia where it caused an extremely long hot and dry period. High pressure conditions continued also in early autumn, but cold air masses came to central parts of eastern Europe particularly in October. In November, a southerly airflow advecting warm air from the south dominated, whereas polar air arrived from the north and extended southwards in December.

1.4.9. Middle East (Cyprus, Israel, Jordan, Lebanon, Syria, Turkey)

The Middle East was mainly affected by warm air from the south throughout the year. Intrusion of colder air from the north was very rare, mostly affecting only parts of Turkey. However, intense low pressure systems with abundant rain occurred at times, especially over Turkey in the cold months.

2. Temperature

2.1. Global Overview

According to WMO information, the year 2010 ranked as the warmest year on record, together with 2005 and 1998 since, at least, 1850. Data received by the WMO show no statistically significant difference between global temperatures in 2010, 2005 and 1998 (Fig. 0.4). The global mean temperature has increased by $+0.7^{\circ}\text{C}$ during the period 1881–2010 (linear trend).

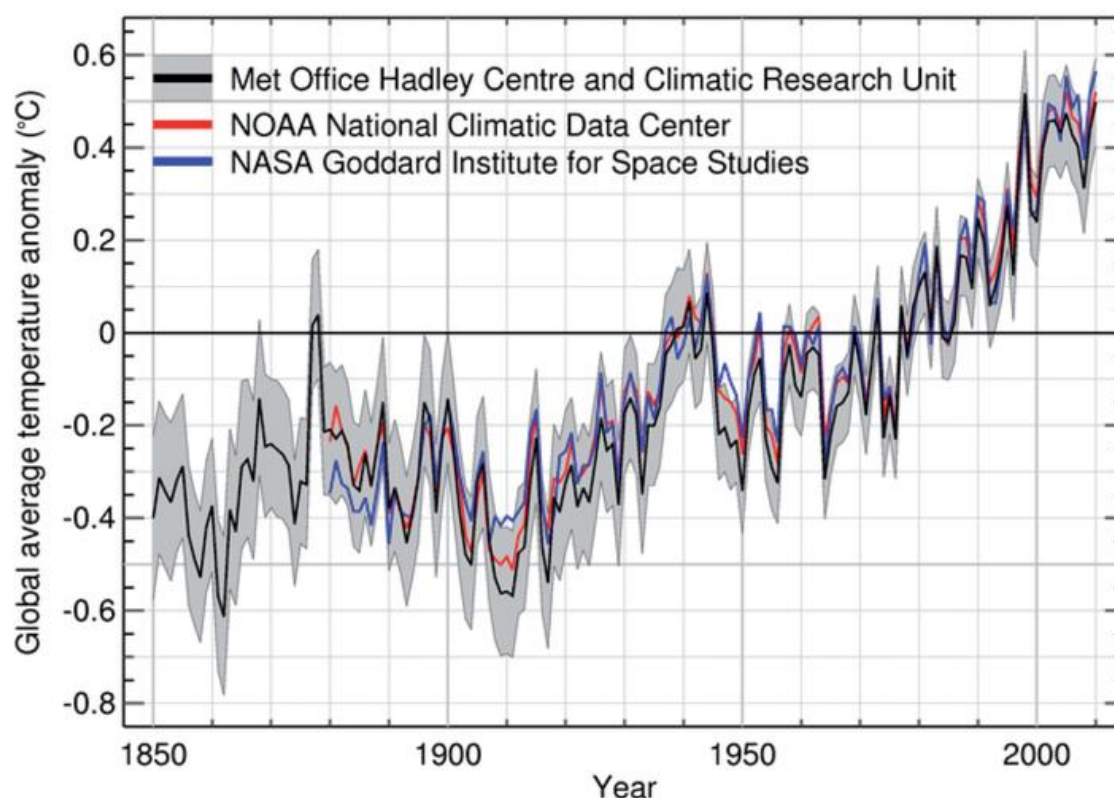


Fig. 0.4: Mean global annual temperature anomalies 1850–2010 (reference period 1961–1990)
Source: WMO,

http://www.wmo.int/pages/mediacentre/press_releases/images/906_2010dataset.PNG

The global annual mean temperature anomaly in 2010 was $+0.53^{\circ}\text{C}$. This value is 0.01°C above the nominal temperature in 2005, and 0.02°C above 1998. The difference between the three years is less than the margin of uncertainty ($\pm 0.09^{\circ}\text{C}$) in comparing the data. These statistics are based on data sets maintained by the UK Meteorological Office Hadley Centre/Climatic Research Unit (HadCRU), the U.S. National Climatic Data Center (NCDC), and the U.S. National Aeronautics and Space Administration (NASA). Highest anomalies were recorded in March (warmest March on record), lowest in December. The global mean temperature itself was 14.53°C in 2010.

In the northern hemisphere, the year 2010 was the warmest year on record; not so in the southern hemisphere, however, where the year nevertheless was still among the five warmest years.

For global land areas, a global anomaly of $+0.92^{\circ}\text{C}$ was computed according to NOAA data (Fig. 0.5). This was the second highest since 1880, behind 2007 ($+0.96^{\circ}\text{C}$). In 2010, the earth's oceans were $+0.37^{\circ}\text{C}$ warmer than normal, making it the third warmest year since 1880 according to NOAA, following slightly behind 2003 ($+0.39^{\circ}\text{C}$) and 1998 ($+0.39^{\circ}\text{C}$).

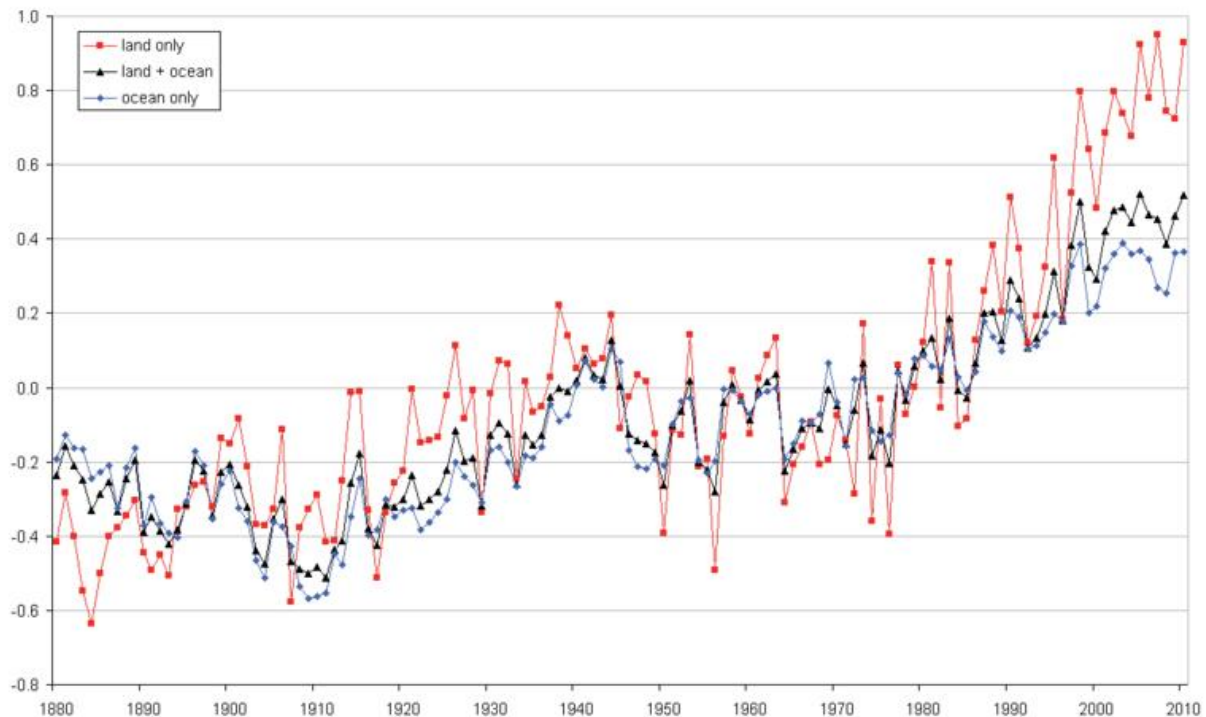


Fig. 0.5: Mean global annual temperature anomalies 1880–2010 (recomputed to the reference period 1961–1990) over land, oceans, and land and oceans combined.

Source: NOAA/NCDC, <http://www.ncdc.noaa.gov/cmb-faq/anomalies.html#anomalies>

2010 was warmer than normal over most of the global land areas (Fig. 0.6). The highest anomalies were reported for eastern Canada (more than $+5^{\circ}\text{C}$ on Baffin Island) and western Greenland. Other far warmer-than-normal areas ($> +2^{\circ}\text{C}$) were northern Africa, the Middle East and north-eastern Russia. In some of these areas, this was the warmest year on record (western Africa, Sahara and Arabic Peninsula, Mediterranean, southern Asia, central and south-western Asia, Greenland and northern Canada). Exceptional heat waves in summer in several parts of Eurasia contributed largely to the high annual temperature level.

It was colder than normal particularly over northern and western Europe, central Russia, central and eastern Australia, parts of the Antarctic and a few smaller areas in north and south America, locally below -1°C .

Especially the spatial distribution of anomalies over the northern hemisphere reflects prevailing meridional circulation patterns associated with a highly negative Arctic Oscillation, particularly in winter. This circulation pattern modulated the general global warming by cooling parts of Europe and Asia due to meridional exchange of air masses whereas parts of North America were additionally warmer than expected from the global warming trend.

The sea surface temperatures were lower than normal in the eastern Pacific (due to La Niña), but above normal in most of the other regions (Fig. 0.6a). The tropical Atlantic was especially warm, with large parts recording their highest sea surface temperature ever, just like the ocean region around Australia.

Over the ten years from 2001 to 2010, global temperatures have averaged 0.46°C above the 1961–1990 average, and were the highest ever recorded for a 10-year period since the beginning of instrumental climate records. Recent warming was especially strong in Africa, parts of Asia, and parts of the Arctic, with many subregions registering decadal mean temperatures 1.2 to 1.4°C above the long-term average.

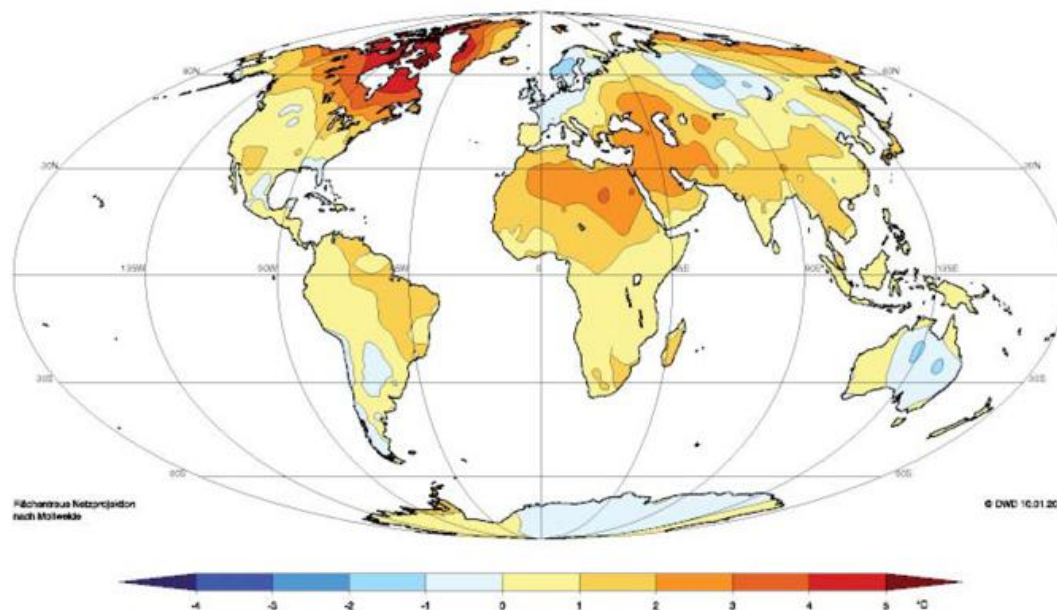


Fig. 0.6: Mean global annual land temperature anomalies in 2010 (reference period 1961–1990; interpolation of CLIMAT data)
Source: Deutscher Wetterdienst, Germany

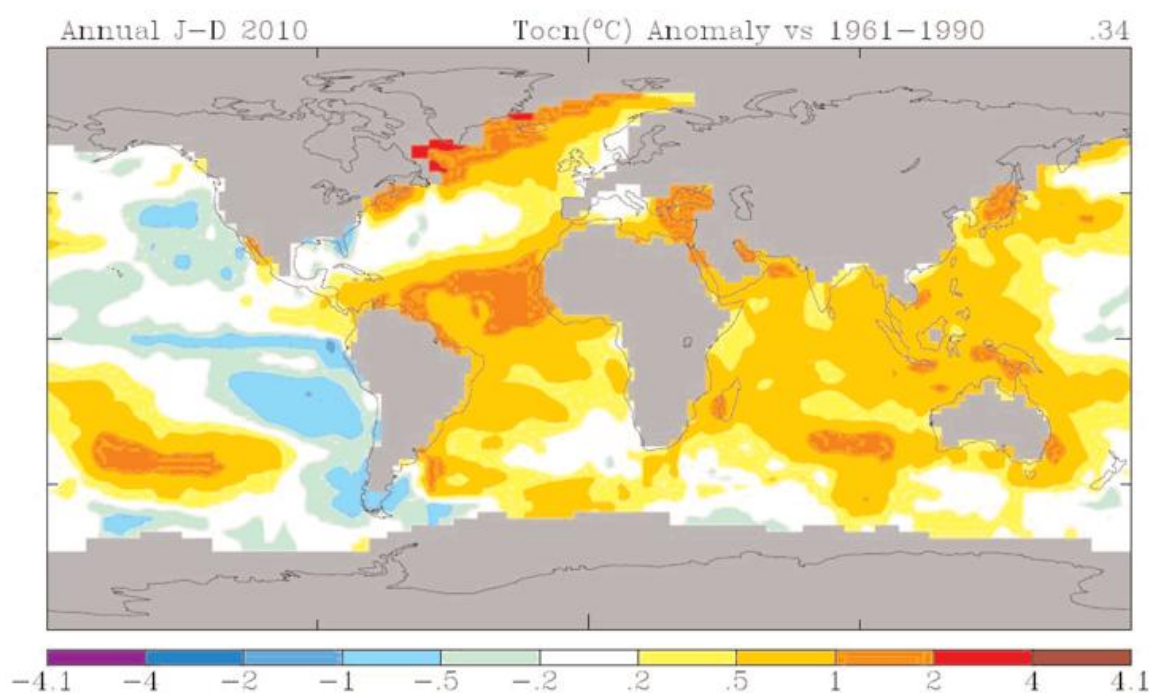


Fig. 0.6a: Mean global annual sea surface temperature anomalies in 2010 (reference period 1961–1990; data of January 1961 – November 1981 based on ship and buoy data, afterwards on satellite data). Gray areas imply no data.
Source: NASA Goddard Institute for Space Studies (GISS),
<http://data.giss.nasa.gov/gistemp/maps>

2.2. RA VI Overview

The anomalies observed in 2010 in the RA VI Region cannot be considered as representative for the whole globe. The areal mean for the European continent as well as the areal mean land surface temperature for the smaller area 35°–75°N, 10°W–30°E, both based on data from the Met Office Hadley Centre, were above normal in 2010 (+0.68°C, Fig. 0.7 and +0.24°C $\pm$ 0.13°C, respectively), but clearly colder than all the other years of the decade 2001–2010. The last year in Europe that, as a whole, was colder than 2010 was 1998. Nevertheless, 2010 was still warmer than what is to be expected from a linear trend since 1900. After all, summer 2010 was the warmest summer on European average since 1900 (+2.1°C anomaly) and July and August 2010 were the warmest months for the same period (+2.9°C and +2.3°C, respectively). On the other hand, the cold months January, February, October and December 2010 were all colder than normal in contrast to the other months including the whole warm half year (April–September) which were warmer than normal.

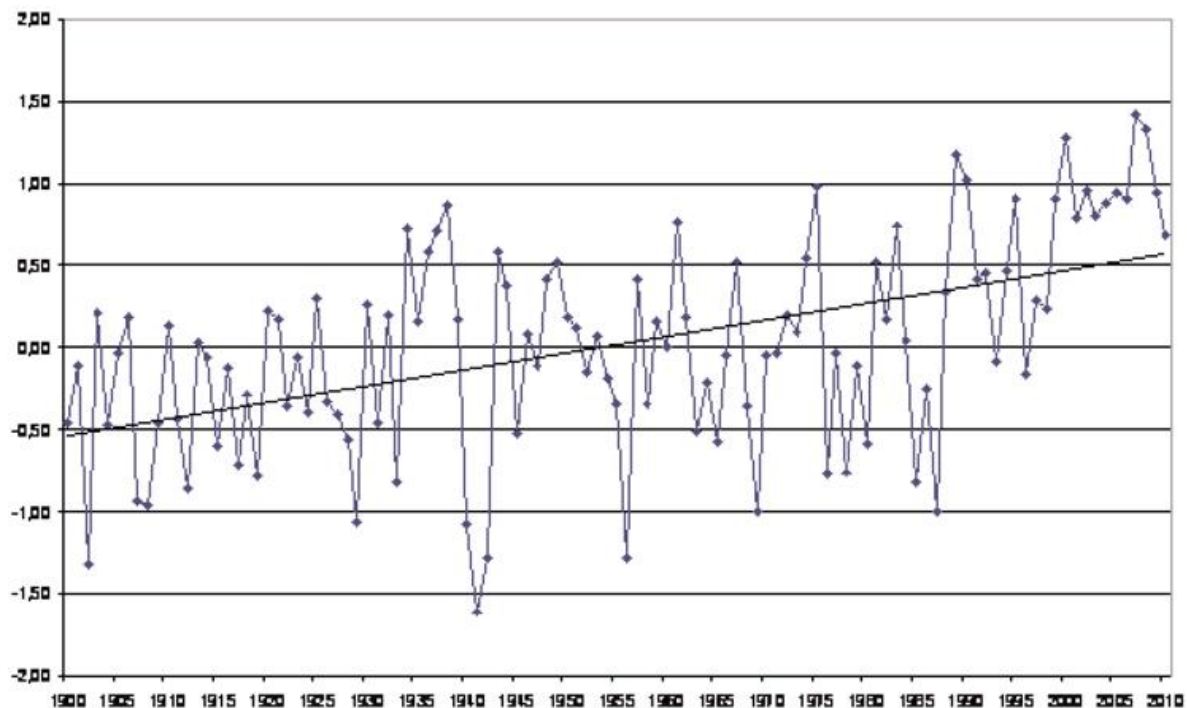


Fig. 0.7: Mean annual temperature anomalies for the European continent (land areas of geographical continental Europe without islands) for 1900–2010 (reference period 1961–1990), based on data from Met Office Hadley Centre (United Kingdom)
Source: Australian Bureau of Meteorology

On average, 2010 was colder than normal almost all over northern, north-western, western and central Europe, but only slightly colder in most areas (Fig. 0.8). Highest negative anomalies were recorded in Norway and Sweden, with values below -1°C . This was in contrast to most years of the recent decade during which nearly the whole Region was warmer than the 1961–1990 average. In most of northern, western and central Europe, 2010 was the coldest year since at least 1996 (Tab. 0.1). In some countries, in Germany for instance, the areal mean was below normal for the first time after 13 consecutive warmer-than-normal years.

During many months of the year, most of these parts of Europe were colder than normal, particularly January, February, May and September to December. March and June were cold in northern Europe.

Country	2010 was the coldest year since	2010 was the coldest year for ... years
Norway	1985	25
Sweden	1987	23
Finland	1987	23
Denmark	1996	14
Faroe Islands	1999	11
Latvia	1996	14
Lithuania	1996	14
Ireland	1986	24
United Kingdom	1986	24
Netherlands	1996	14
Belgium	1996	14
Luxembourg	1996	14
France	1996	14
Germany	1996	14
Switzerland	1996	14
Austria (summit regions)	1996	14
Poland	1996	14
Spain	1997	13

Tab. 0.1: The cold year 2010 in northern, western and central Europe in historical perspective
Source: Reports from National Meteorological and Hydrological Services

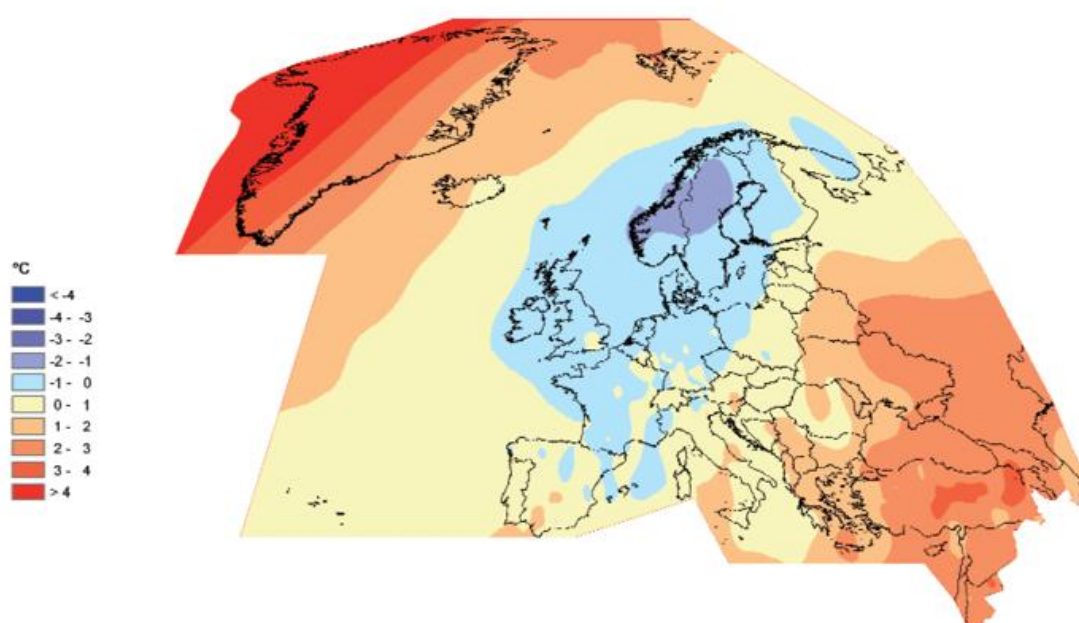


Fig. 0.8: Mean annual temperature anomalies in 2010 (reference period 1961–1990) in WMO Region VI (interpolation of CLIMAT data)
Source: Deutscher Wetterdienst, Germany

The rest of the Region was warmer than normal. Highest anomalies were recorded over western Greenland ($> +4^{\circ}\text{C}$). Most of the other parts of the Arctic and also the south-eastern parts of the Region (southern European Russia, eastern parts of the Ukraine, western Kazakhstan, most of the southern Caucasus, Turkey, Cyprus and the Middle East) were more than $+2^{\circ}\text{C}$ warmer than normal. In most of these areas, the warming persisted more or less throughout almost the whole year, with only short interruptions.

2.3. European Arctic region

On average, the year 2010 was warmer than normal in the whole Arctic region. Annual anomalies ranged from near zero in the east up to +5°C in western Greenland.

While western Greenland was warmer than normal during the whole year, the other parts of the Arctic also saw some colder-than-normal periods, the more to the east, the more frequently. Svalbard, for instance, was colder than normal in March, August and November, though only slightly.

Greenland recorded its warmest decade (2001–2010, anomaly +1.4°C) since the beginning of modern measurements. Most stations in Greenland, except those in the east, recorded their warmest year ever in 2010 (Fig. 0.9).

The average temperature in Reykjavík (Iceland) was 5.9°C (anomaly +1.6°); it has only once been higher and that was in 2003. The temperature has now been above normal for 15 years in a row.

2.4. Northern Europe

Most of northern Europe was colder than normal (Norway, Denmark including the Faroe Islands, Sweden, Finland and western parts of the Baltic countries). Annual anomalies were below -1°C (locally below -2°C) in southern and central Norway and in central Sweden. Especially the cold months were far below normal (January, February, December; Fig. 0.12 for Norway). It was also cold nearly all over northern Europe in June, and partly in March, May and October.

On average, 2010 was warmer than normal in Iceland and in north-eastern Europe (northern European Russia and the Baltic countries). Highest positive anomalies in northern Europe were recorded in Iceland (> +1°C), which was colder than normal only in February, April and November. At +1.6°C, Iceland's capital Reykjavik saw its second warmest year on record. In Lithuania, only February, October and December were below normal.

2010 was the coldest year since at least 1996 in most of the countries in northern Europe, partly even since 1985 or 1987 (Tab. 0.1, Fig. 0.10 and 0.11). This means, it was also the coldest year in the decade 2001–2010. For most of northern Europe (except for the major parts of the Baltic countries), it was also the first year in the 21st century with a negative anomaly compared to the 1961–1990 reference. Even in the north-eastern countries, which were warmer than normal in 2010, it was far colder than in 2009, e.g. almost -1°C anomaly in Lithuania.

However, for whole decade 2001–2010 was the warmest decade on record in many places, for example in Finland since records began in the 1840's, and in Tórshavn on the Faroe Islands since 1890.

2.5. North Atlantic

The northern North Atlantic was +1 to +2°C warmer than normal, whereas the central North Atlantic and the Azores Islands were also warmer, but less than +1°C. Especially the warm half year (April to October) was clearly warmer than normal; the winter months were partly colder, particularly February.

While the minimum temperatures on the Azores were higher than normal, the maxima proved to be lower. In particular, there were more tropical nights than normal in the months July to September.

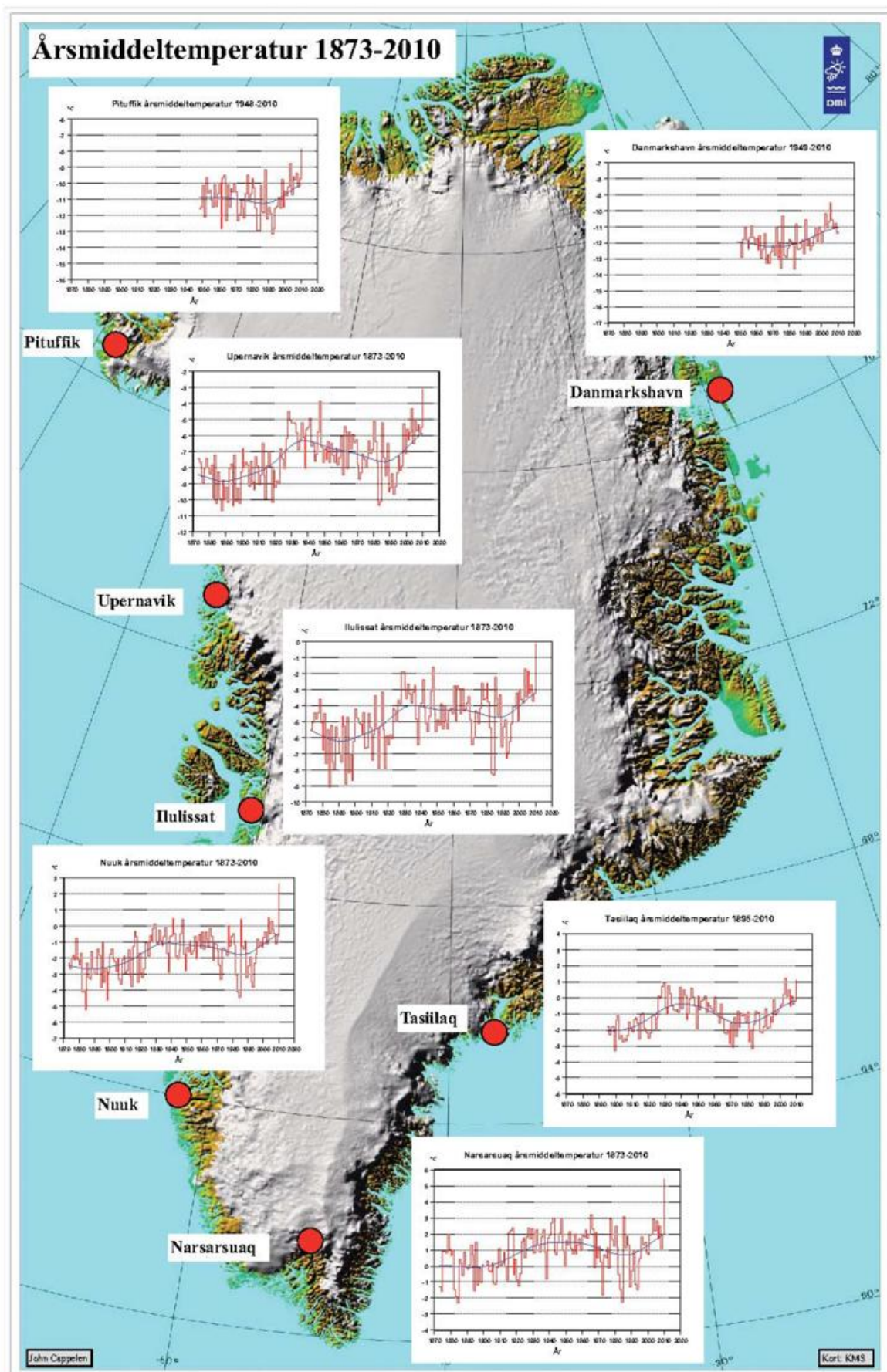


Fig. 0.9: Mean annual temperature 1873–2010 at various stations in Greenland
Source: Danish Meteorological Institute

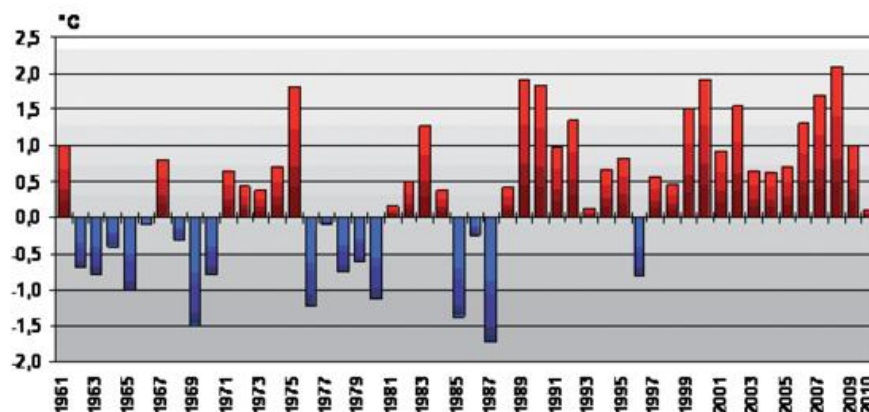


Fig. 0.10: Mean annual temperature anomalies in 1961–2010 (reference period 1961–1990) in Lithuania

Source: Lithuanian Hydrometeorological Service

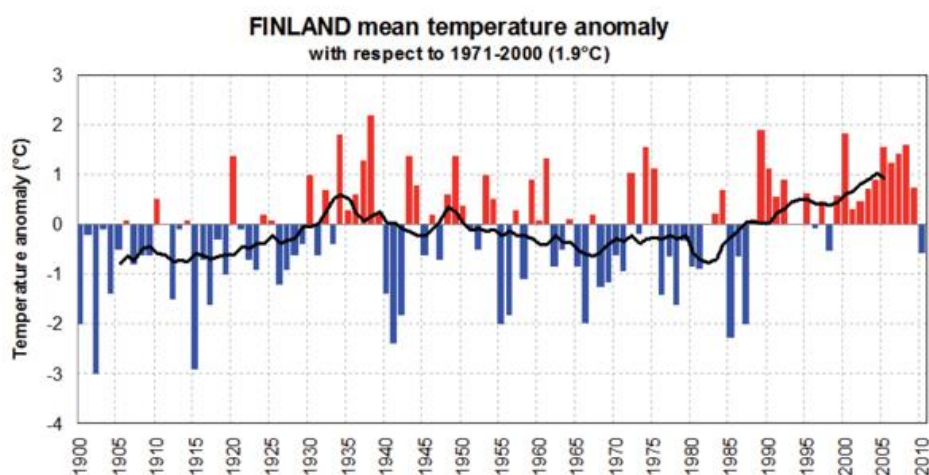


Fig. 0.11: Mean annual temperature anomalies in 1900–2010 (reference period 1971–2000) in Finland

Source: Finnish Meteorological Institute

Deviation from the average temperature for the period 1961-1990

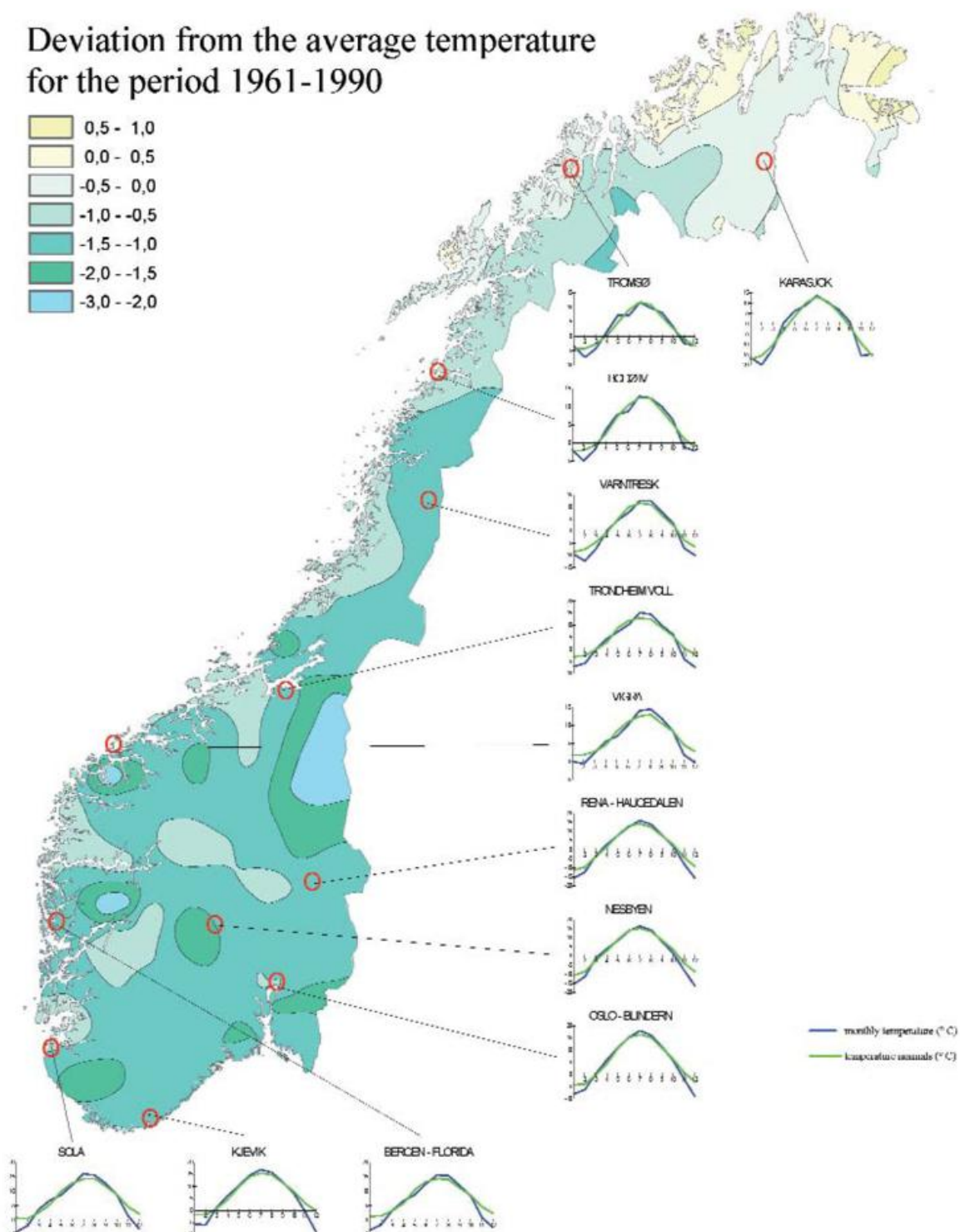


Fig. 0.12: Mean annual temperature anomalies in 2010 (reference period 1961–1990) in Norway
Source: Meteorologisk Institutt met.no, Norway

2.6. Central and Western Europe and the Alpine region

All over western and in most parts of central Europe (except for the east and the Alpine region), it was slightly colder than normal (between 0 and -1°C), mainly due to the cold months January, May and December.

In these areas, the cold year 2010 was characterised by a high number of extremely low mean daily temperatures, frost and ice days. In the United Kingdom, this was revealed, for example, by the daily Central England Temperature (CET) time series, which displayed several extremely low mean daily temperatures particularly at the end of the year (Fig. 0.13). Germany saw an extended frost period from 2009 until March 2010; peaks of minimum temperature were below -24°C locally in eastern and south-eastern Germany. The number of ice days was more than twice as high as usual. De Bilt in the Netherlands had 29 ice days (normal: 8) and 88 frost days (normal: 58), but also a number of warm days (maximum temperature 20°C or more) that was greater than normal (90 compared to 77). Belgium, too, had a very high number of frost days (74 in Uccle, 1981–2010 normal: 46) and ice days (27 compared to 7). In western Europe and most of central Europe, 2010 was also the coldest year since 1996 (Fig. 0.14 to 0.16).

Eastern central Europe and the Alpine region were slightly warmer than normal, with Slovenia having recorded a temperature of up to around $+1.5^{\circ}\text{C}$ above the normal. However, 2010 was nevertheless the coldest year of the decade 2001–2010 and the coldest year since 1996 in Poland, especially in the western half of the country.

Many months were colder than normal over the whole or almost the whole area, namely January, February, May, September, October and December (e.g. in Poland, Fig. 0.17). Late November was also very cold, marking an unusually early start of the winter weather with very low temperatures until just after Christmas. This was only partly compensated by the relatively warm months April, June and July. In the south-eastern parts of central Europe, on the other hand, November was also very mild on average.

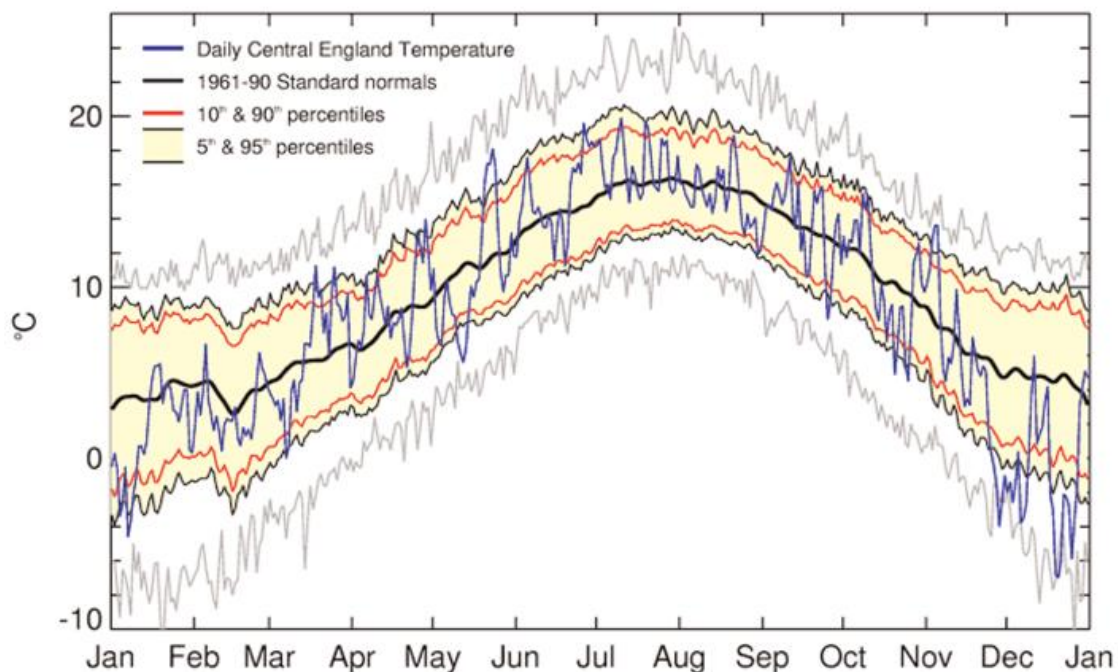


Fig. 0.13: Mean daily Central England temperature (CET) for 2010. 1961–90 normals are smoothed. The light grey lines represent the highest and lowest values of mean CET in the daily record since 1772.

Source: UK Met Office

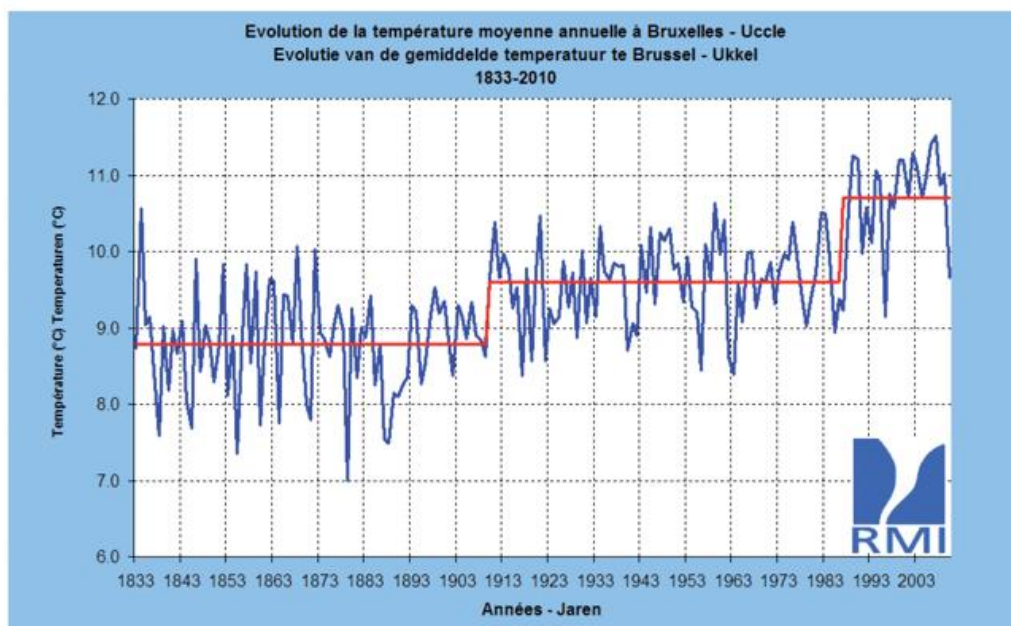


Fig. 0.14: Mean annual temperature 1833–2010 in Brussels-Uccle (Belgium) and averages over subperiods (red line)
 Source: Royal Meteorological Institute (RMI) Belgium

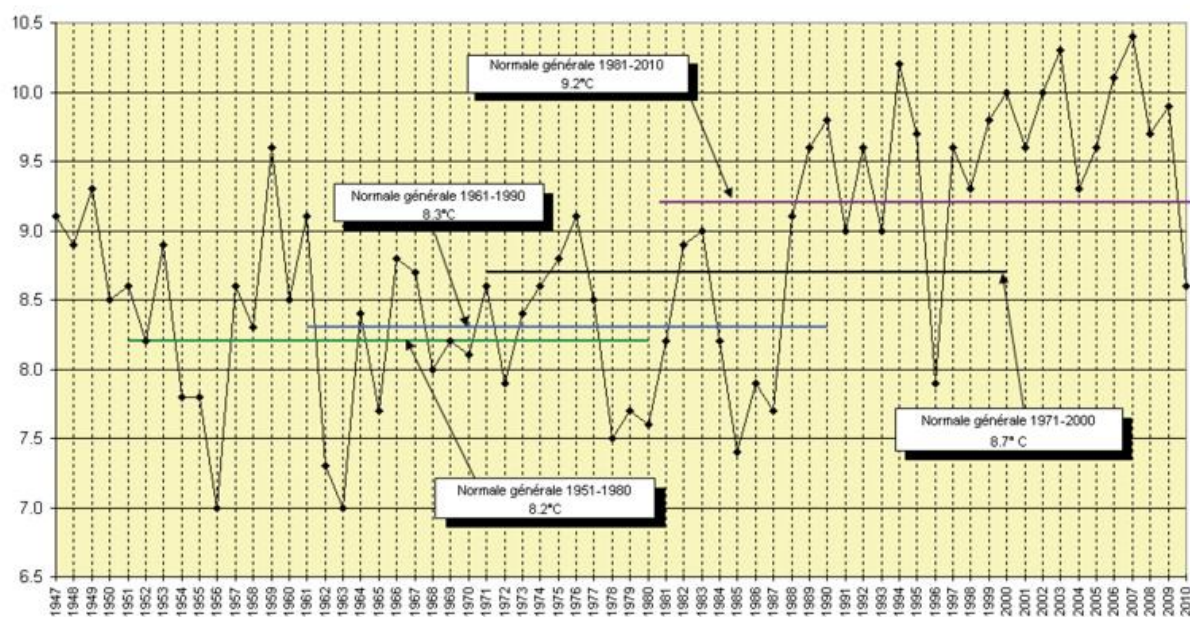


Fig. 0.15: Mean annual temperature 1947–2010 in Luxembourg, compared to several long-term averages
 Source: Service Météorologique de Luxembourg

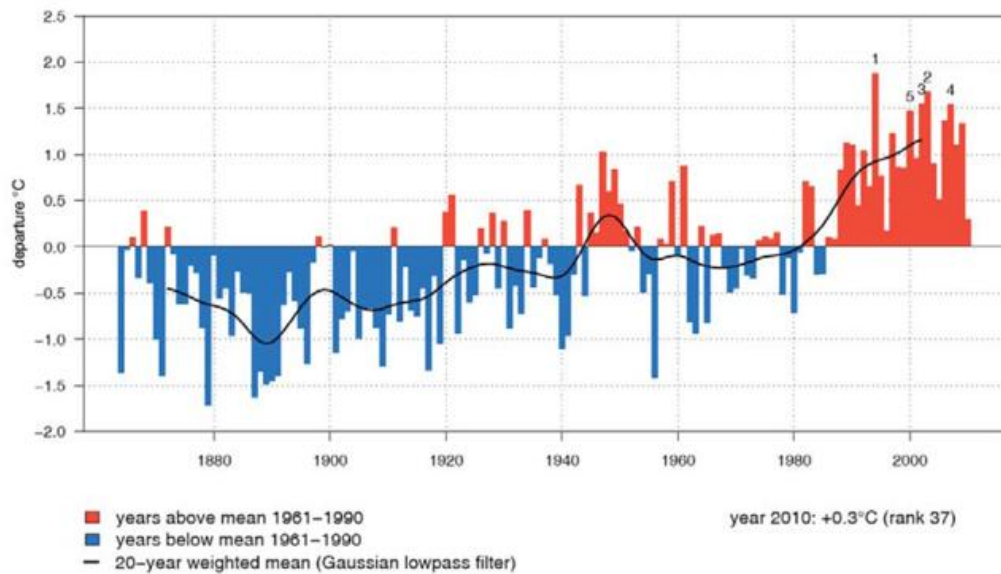


Fig. 0.16: Mean annual temperature anomalies 1864–2010 in Switzerland (1961–1990 reference)
Source: MeteoSwiss, Switzerland

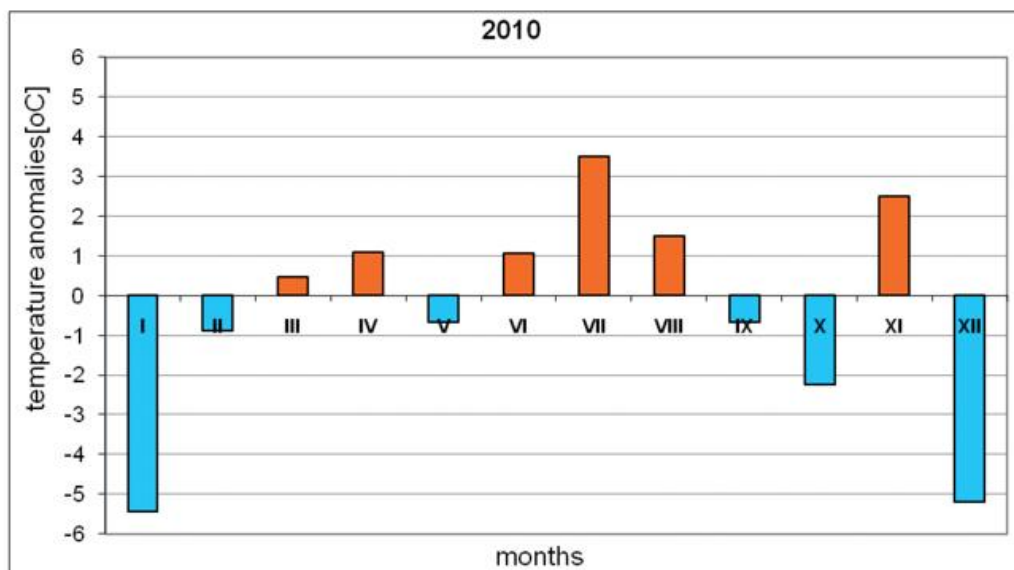


Fig. 0.17: Mean monthly temperature anomalies in 2010 (reference period 1971–2000) in Poland (average for 20 stations)
Source: Centrum Monitoringu Klimatu Polski IMGW, Poland

2.7. Iberia

All over Iberia, 2010 was slightly warmer than normal on average (mostly 0 to +1°C). It was particularly warm in April, July and August. The other months were partly colder than the 1961-90 normal; October and November were colder over almost the whole peninsula.

Four heat waves occurred in Portugal in May, July and August. Nevertheless, 2010 was the coolest year since 1997 in Spain.

2.8. Mediterranean, Italian and Balkan Peninsulas

Almost the whole Mediterranean, Italy and the Balkan Peninsula were warmer than normal, but not as warm as the temperatures recorded for most of the previous years of the last decade. Annual anomalies were close to zero over the western Mediterranean and highest in the eastern Mediterranean (more than $+2^{\circ}\text{C}$). Annual mean temperatures at several stations in Serbia and Bosnia and Herzegovina exceeded the 90th percentile. Athens in Greece had its warmest year since at least 1897, with an annual average of 20°C . Only the Balearic Islands were slightly colder than normal.

In the western Mediterranean region, nearly all months were slightly colder than normal, except April and July. Over the eastern Mediterranean, all months were warmer than normal. The Balkan Peninsula was colder than normal in September and October, in the northern parts also in December; the other months were mostly warmer or around normal; the summer months and November were extremely warm.

The whole decade 2001–2010 was the warmest since the middle of the 19th century in Ljubljana, Slovenia (Fig. 0.18), and Zagreb, Croatia (Fig. 0.19). In Bulgaria, it was the 13th consecutive year with higher temperatures than normal.

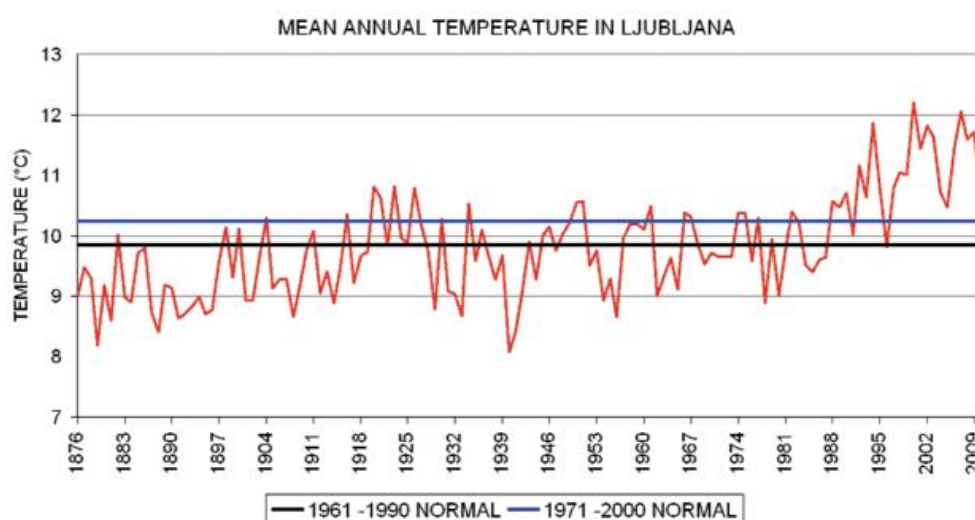


Fig. 0.18: Mean annual temperature 1876–2010 in Ljubljana (Slovenia)
Source: Environmental Agency of Slovenia

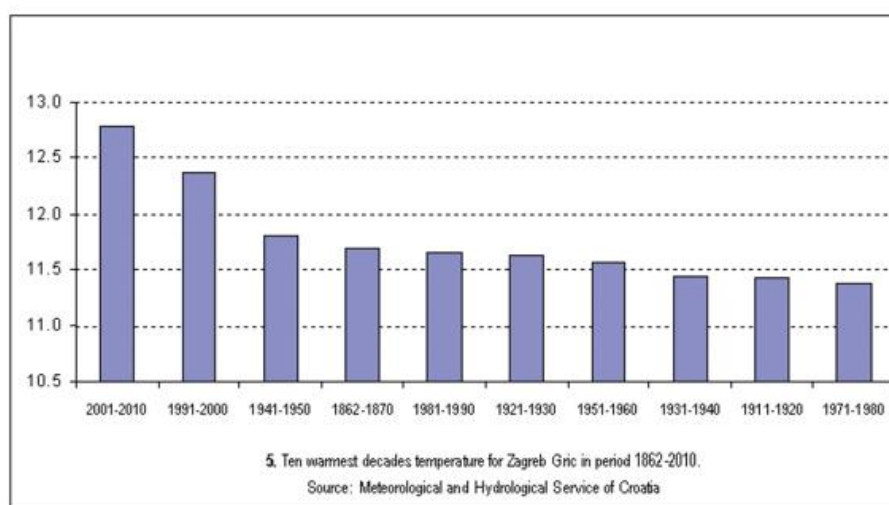


Fig. 0.19: The ten warmest decades in Zagreb Gric (Croatia) in the period 1862–2010 and their mean temperatures in $^{\circ}\text{C}$
Source: Meteorological and Hydrological Service of Croatia

2.9. Eastern Europe and South Caucasus region

All over eastern Europe, the average temperature in 2010 was warmer than normal. The highest annual anomalies were to be found locally in the South Caucasus region and in Turkey (between $+3$ and $+4^{\circ}\text{C}$). Anomalies were lower towards the north and the west of eastern Europe. The mean anomaly over European Russia was $+1.4^{\circ}\text{C}$ (mainly due to a heat wave in summer), which is slightly higher than 2009, but less than in other recent years. 2010 was one of the warmest years in the Ukraine, although the anomalies were smaller than further in the east ($+1$ to $+2.7^{\circ}\text{C}$).

2010 was the warmest year in the South Caucasus since regular records began more than 80 years ago. It was the warmest year in Armenia since 1929 (Fig. 0.20) and west Georgia since 1951 (Fig. 0.21). 2010 also marked the 17th consecutive year with positive annual temperature anomalies in Armenia. The decade 2001–2010 ranks there as the warmest since 1900.

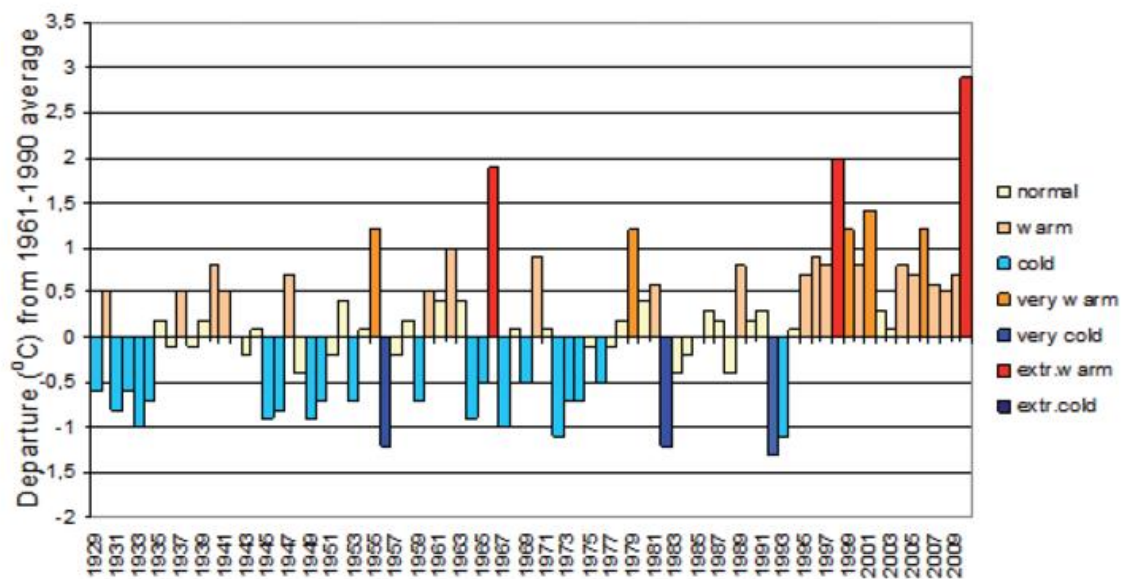


Fig. 0.20: Mean annual temperature anomalies (1961–1990 reference) 1929–2010 in Armenia
Source: Armstatehydromet

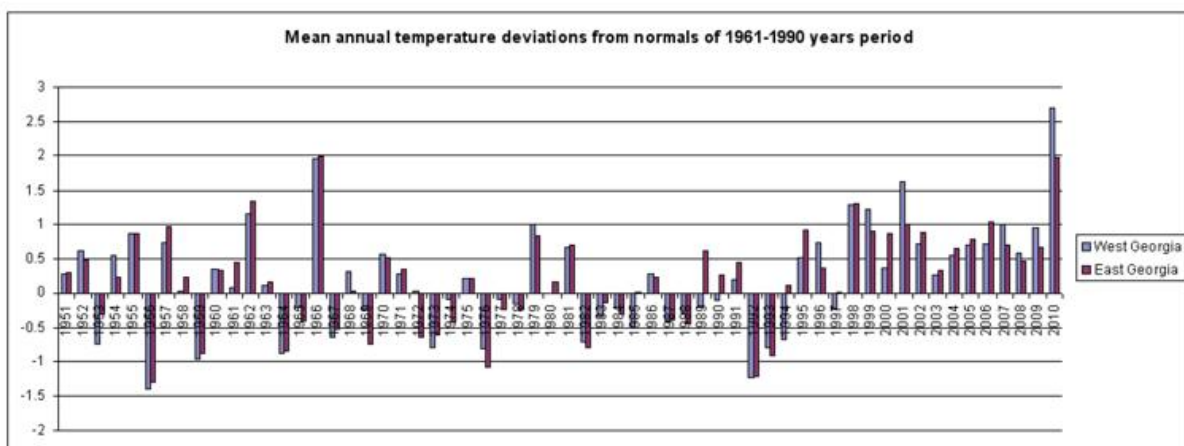


Fig. 0.21: Mean annual temperature anomalies (1961–1990 reference) 1951–2010 in west and east Georgia
Source: Department of Hydrometeorology of Georgia

Some months show extremely high positive anomalies (mostly above $+4^{\circ}\text{C}$) almost all over eastern Europe: for example the summer months June–August as well as November in the Ukraine (Fig. 0.22). Other months were at least very warm in the South Caucasus and southern European Russia (January–March, September, October and December). The northern and western parts of eastern Europe (Belarus, Ukraine, Romania, Moldova, central European Russia and west Kazakhstan) had a few cold months compared to normal, particularly January, October and December.

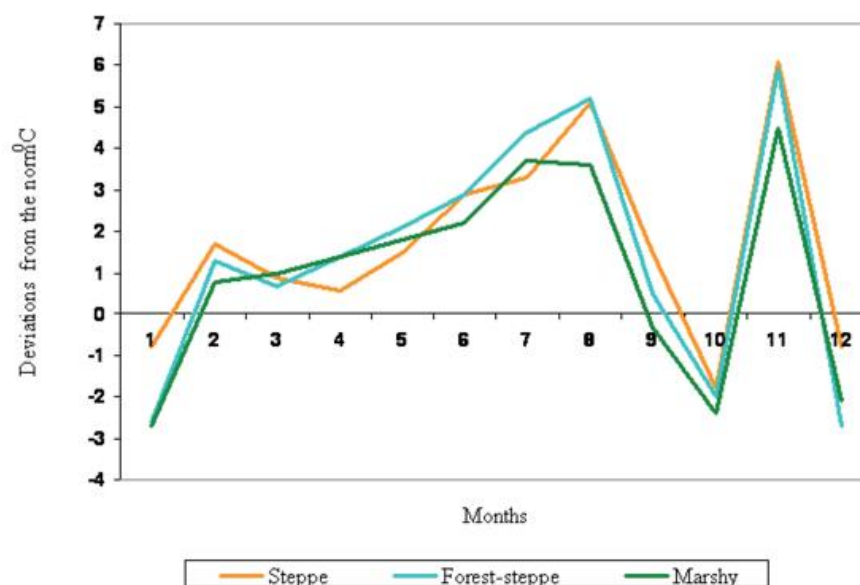


Fig. 0.22: Mean monthly temperature anomalies 2010 (1961–1990 reference) in various vegetation zones in the Ukraine

Source: Hydrometeorological Service, Ukraine

2.10. Middle East

The Middle East was much warmer than normal in 2010. Annual anomalies reached or exceeded $+2^{\circ}\text{C}$ almost everywhere, except in western Turkey, where they were slightly lower than that. Some places that normally are known to be the coldest areas in south-eastern Turkey show anomalies of up to $+5^{\circ}\text{C}$. In Turkey, 2010 was the warmest year on record since 1940, much warmer than the previous years and exceeding an annual mean of 15°C (Fig. 0.23). 209 Turkish stations registered record-breaking monthly maximum temperatures at several occasions (particularly in December), and 14 stations in Turkey set new, absolute all-time daily maxima. The highest temperature in Turkey was 46.7°C in August. Heat wave conditions also prevailed in Cyprus several times, especially in August. Jordan reported seven heat waves in 2010, from May to October, and had its warmest year since 2001. Israel had its warmest January to March and August to November periods on record and recorded the highest annual mean temperature (20.3°C) since 1950 in Jerusalem (Fig. 0.24). These warm periods caused severe damage to agriculture, especially citrus and tomatoes.

The whole area was warmer than normal throughout the year. Only during the period April–June and once more in October, the anomalies were partly lower, or even negative in north-western Turkey.

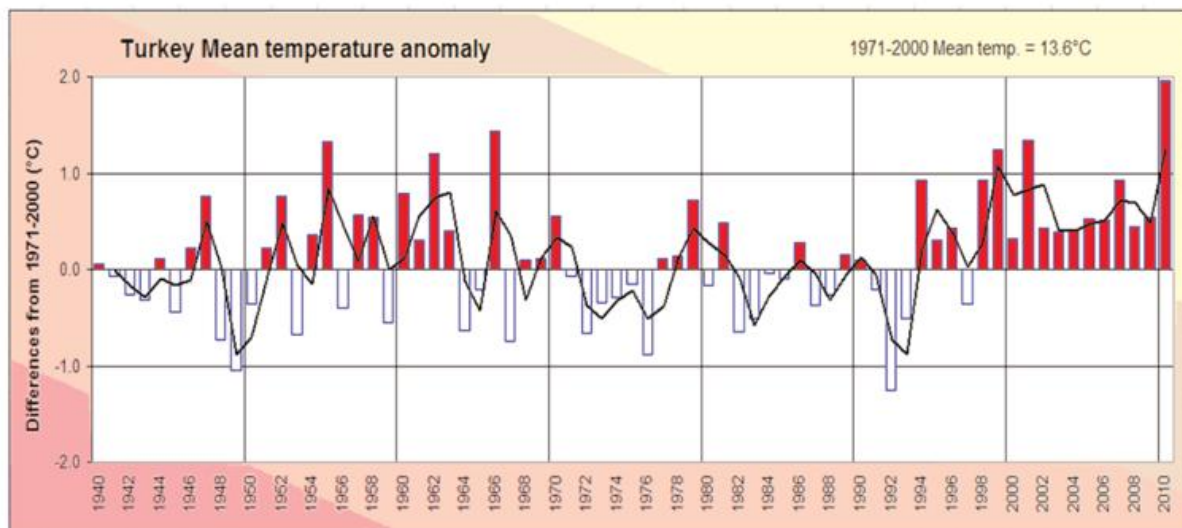
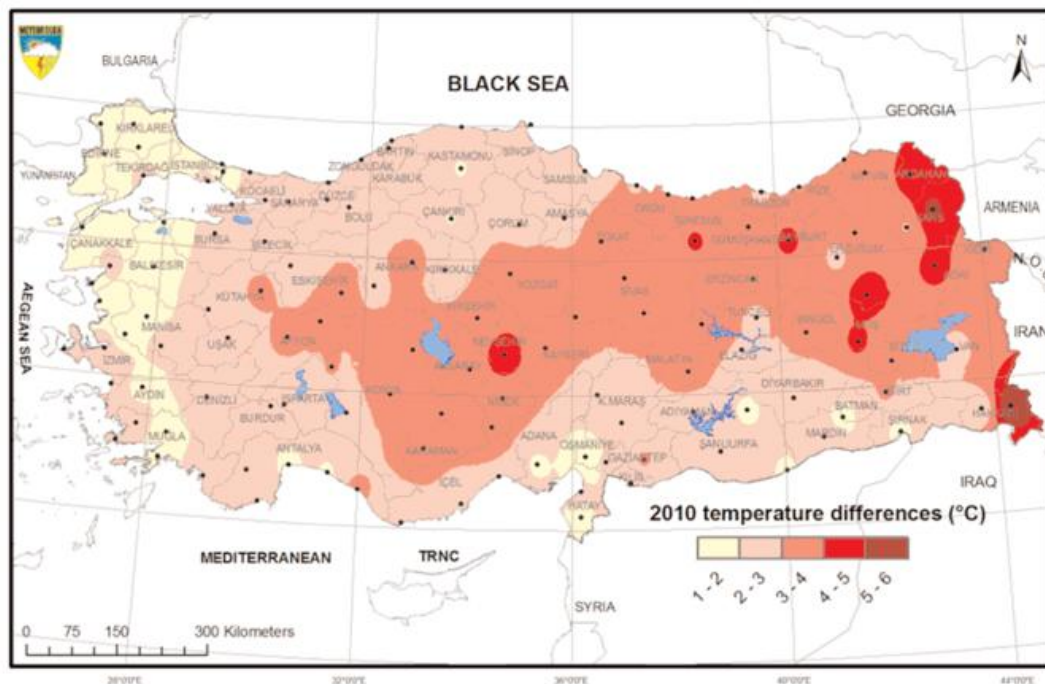


Fig. 0.23: Annual mean temperature anomalies (reference period 1971–2000) in Turkey.
 Left: spatial distribution 2010, right: time series 1940–2010
 Source: Turkish State Meteorological Service

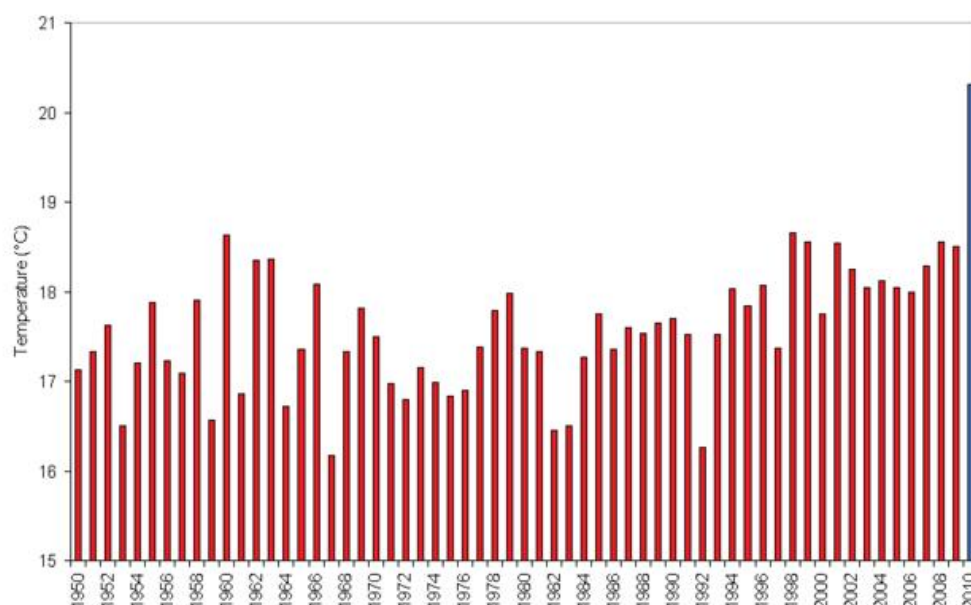


Fig. 0.24: Annual mean temperature 1950–2010 in Jerusalem

Source: Israel Meteorological Service

3. Precipitation

3.1. Global Overview

According to an analysis by the United States National Climatic Data Center, globally averaged land precipitation in 2010 was the highest on record since 1900, 52 mm above the 1961–1990 average annual total of 1,033 mm. The previous wettest years, 1956 and 2000, also coincided with strong La Niña events like in 2010. An analysis by the Global Precipitation Climatology Centre (GPCC) ranked 2010 among the top ten in 110 years.

Across all continents, some land surfaces were wetter than normal in 2010 (Fig. 0.25). Several areas were outstandingly wet compared to the normal in terms of absolute and relative anomalies: especially the far north of South America, some eastern and south-eastern parts of Europe, most of India, Indonesia and eastern Australia. Some anomalies are clearly related to La Niña, which developed over the year and caused high precipitation totals over Australia, India / Pakistan and China / North Korea. Flood events in Pakistan (July/August) and eastern Australia (December) caused the death of thousands of people and made millions of people homeless.

Drier-than-normal areas were to be found, e.g. in southern Greenland, north-western Europe, parts of northern and southern America, southern Africa, the Middle East and western Australia.

3.2. RA VI Overview

Within the RA VI Region, much of the land area was also wetter than normal in 2010, especially on the European continent, although the deviations from normal were small in most parts (about two thirds) of that area (Fig. 0.26).

The relative totals for 2010 were particularly high (>125% of the normal, in some regions locally >150%) over large parts of eastern central Europe, the Balkan Peninsula, western Turkey, Italy, the western Mediterranean and southern Iberia. Some places in Turkey, Serbia and Moldova

reported their wettest year on record. Wet periods occurred throughout the whole year, with some extraordinarily wet spells in February in Italy and over the Balkan Peninsula and in May, August and September in eastern central Europe (flooding events).

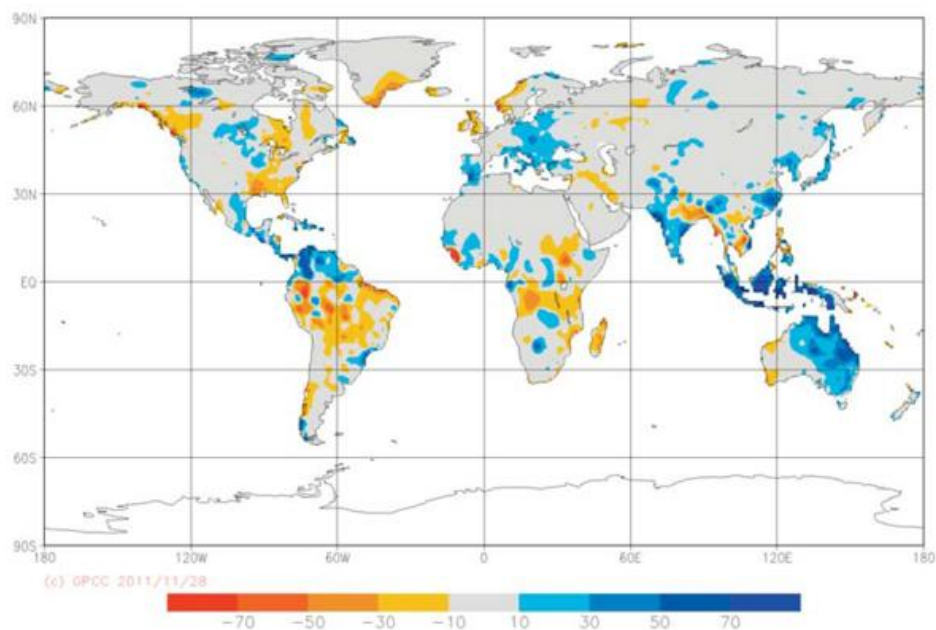


Fig. 0.25: 2010 annual global precipitation anomalies in mm (1951–2000 reference)
Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

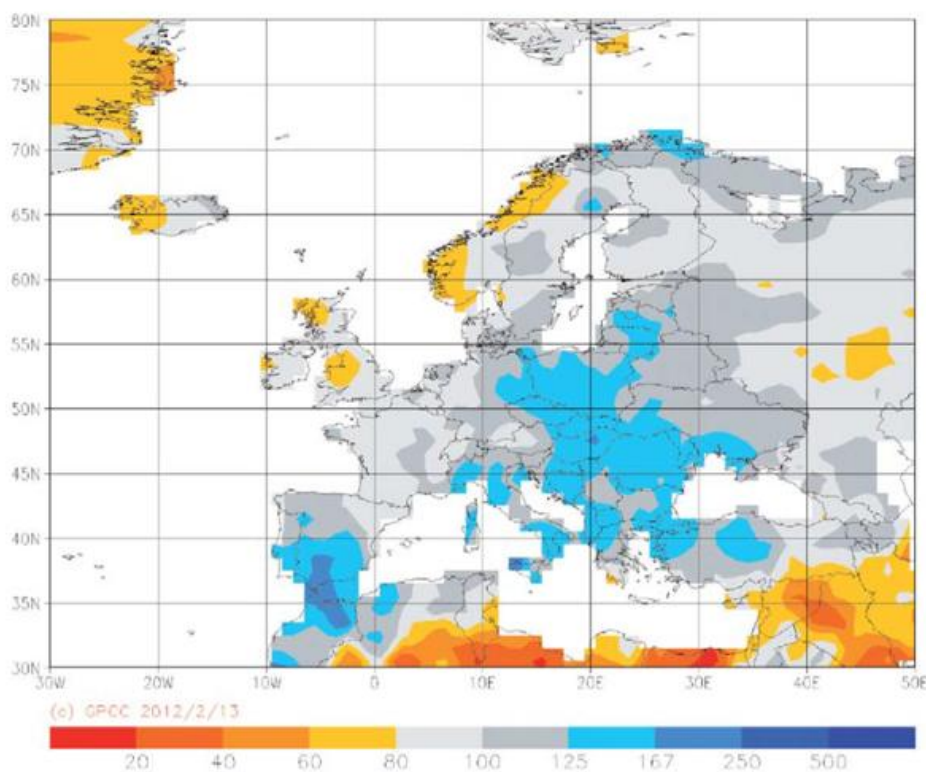


Fig. 0.26: 2010 annual precipitation amounts in WMO Region VI in per cent of the 1951–2000 normal
Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Extraordinarily dry areas, however, were located in places particularly in the Arctic region (Greenland, Iceland, Svalbard), but also over the western parts of the United Kingdom and the Norwegian west coast, mostly with less than 80% of the annual total. This was mainly due to the frequent meridional circulation patterns or, expressed conversely, the absence of westerly patterns. It was also very dry in parts of European Russia, Georgia (especially due to a very dry summer) and near the eastern Mediterranean in Cyprus and in the Middle East, especially in the Lebanon, Israel and Syria.

3.3. Northern Europe and the Arctic

Most of the Arctic region was drier than normal. It was particularly dry at the coast of south-eastern Greenland, locally with less than 60% of the normal annual total. Western Iceland and parts of Svalbard also had quite low totals (<80% of the normal). The annual total in Reykjavík (592 mm) was the second lowest ever registered.

Most of northern Europe saw near-normal precipitation or was drier than normal. It was much drier than normal on the Norwegian west coast (locally <80% of the normal), particularly in the cold months.

Only a few places were much wetter than normal (>125%); these were located in northern Lapland, Sweden and the Baltic countries. Locally in parts of southern and south-eastern Sweden, it was the wettest year on record. 2010 was the 2nd rainiest year in Latvia in 87 years (behind 1928) and by far the wettest in the decade 2001–2010 (Fig. 0.27). Annual rainfall in Latvia exceeded 800 mm on average, which had last occurred 20 years ago. Lithuania was wetter than normal especially during the warm season from May to August, but also in December, whereas January, April and October were drier than normal.

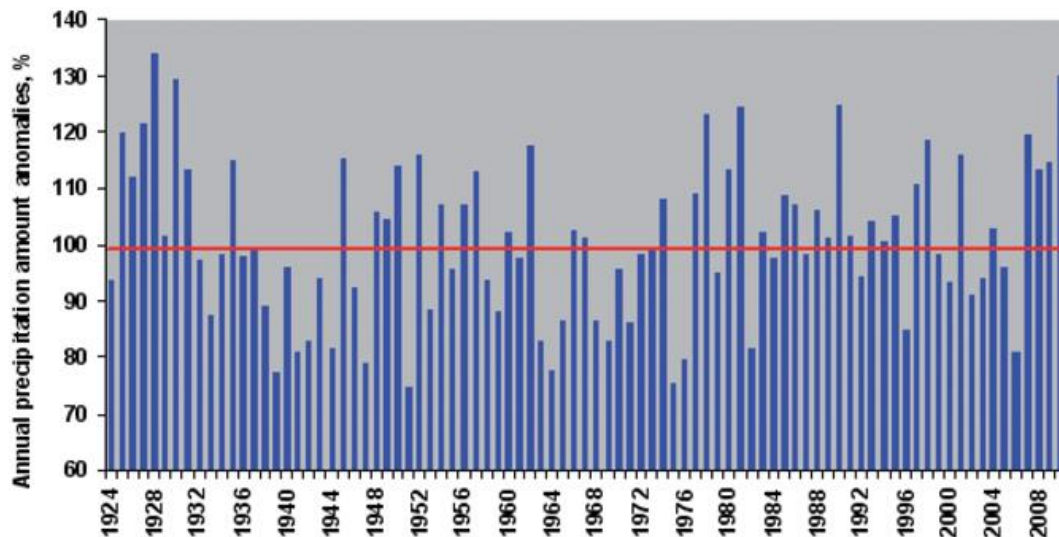


Fig. 0.27: Annual precipitation amounts 1924–2010 in Latvia in per cent of the 1961–1990 normal
Source: Latvian Environment, Geology and Meteorology Centre

3.4. Western and central Europe

Western Europe was drier than normal, especially across Ireland, the United Kingdom and most of France, but also western Switzerland. Less than 80% of the normal total was reached in the western parts of the UK. It was the driest year since 2003 in the UK. The first half of the

year was particularly dry, the driest such period since 1953 in the UK in general and since 1929 in north-west England and north Wales. In eastern England, the dry spell continued into July, causing considerable concern about water resources in these areas.

Most of central Europe was wetter than normal. The western parts of central Europe were close to normal (e.g. Belgium and the Netherlands) due to relatively few thunderstorms throughout the year, but abundant precipitation in August. Based on the annual totals, the eastern parts of central Europe were very wet. More than 125% of normal precipitation was recorded in large parts of eastern Germany, Poland and the Czech Republic, more than 160% in southern Poland, Slovakia and Hungary. Much of this was due to heavy precipitation events with flooding in May and early June and again in August and September. The damage caused by the two flooding events in August and September in Germany was estimated at several hundred million euro. The number of days with heavy precipitation (daily totals >30 mm) was considerably higher than normal; especially in eastern Germany which in places saw more than three times the normal precipitation, partly even the highest number on record. 2010 was by far the wettest year in Slovakia since 1881 (areal annual average of 1255 mm, locally far more, Fig. 0.28) and in Hungary since 1901. A station in the northern medium-high mountains in Hungary (Miskolc-Lilafüred Jávorkút) reached a new annual record with more than 1500 mm (Fig. 0.29).

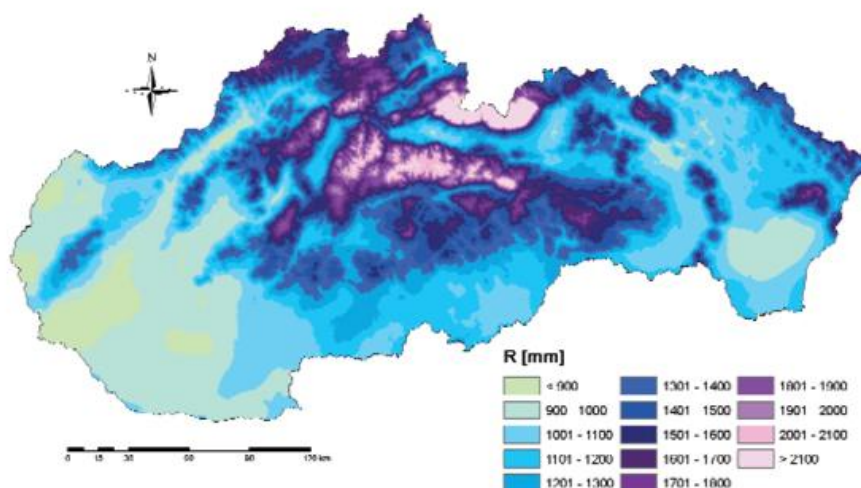


Fig. 0.28: 2010 annual precipitation totals in Slovakia
Source: Slovenský Hydrometeorologický Ústav (SHMÚ), Slovakia

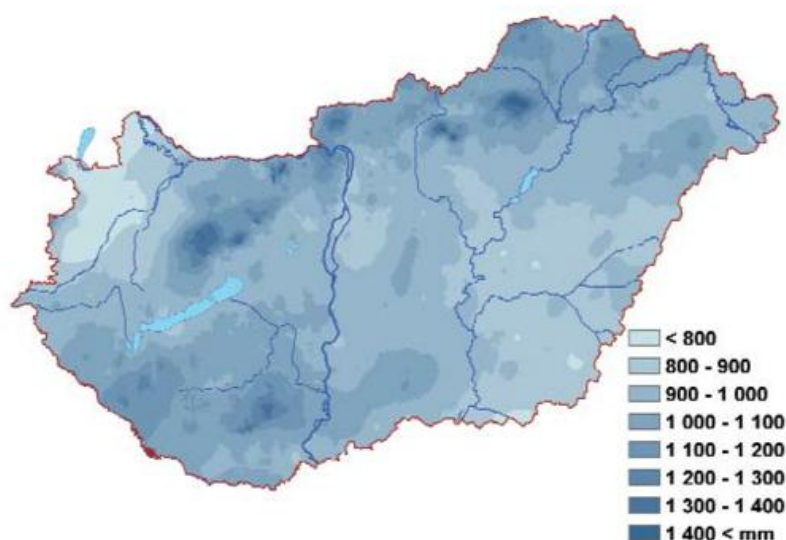


Fig. 0.29: 2010 annual precipitation totals in Hungary
Source: Hungarian Meteorological Service

3.5. Iberia

Most of Iberia was wetter than or near to normal. The south of the peninsula was particularly wet, with locally more than 200% in Andalusia (Spain, Fig. 0.30) and more than 180% of the 1971–2000 average in Lisbon (Portugal, Fig. 0.31), which with an annual total of 1598 mm suffered its wettest year since 1870. Portugal also had its wettest year of the whole decade 2001–2010 (1063 mm = 120% of the normal). It was especially wet over most of Iberia in January–March (with around twice the normal for that period) and December, in Portugal also in October. To the contrary, dry conditions prevailed in the summer half year. It was the driest July and August and the second driest September in more than 20 years in Portugal.

Similarly, the annual precipitation totals were well above normal over the Azores Islands. The rainiest months were January–April and December.

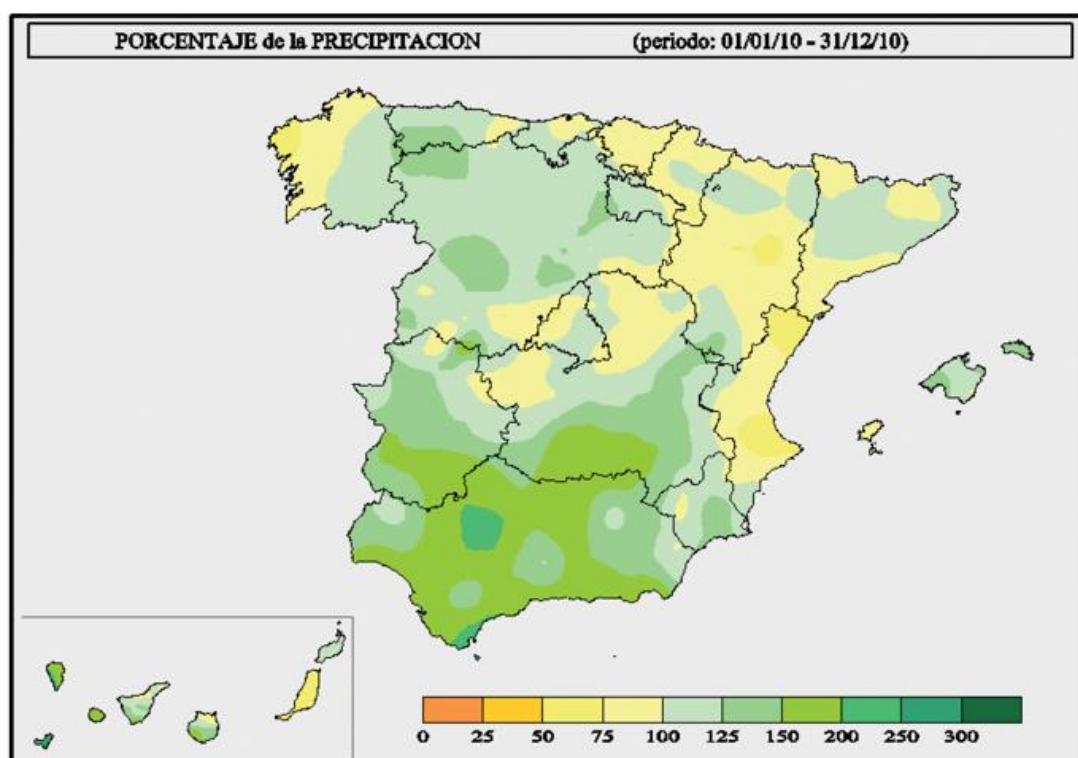


Fig. 0.30: 2010 annual precipitation totals in Spain in per cent (1961–1990 reference)
Source: Agencia Estatal de Meteorología, Spain

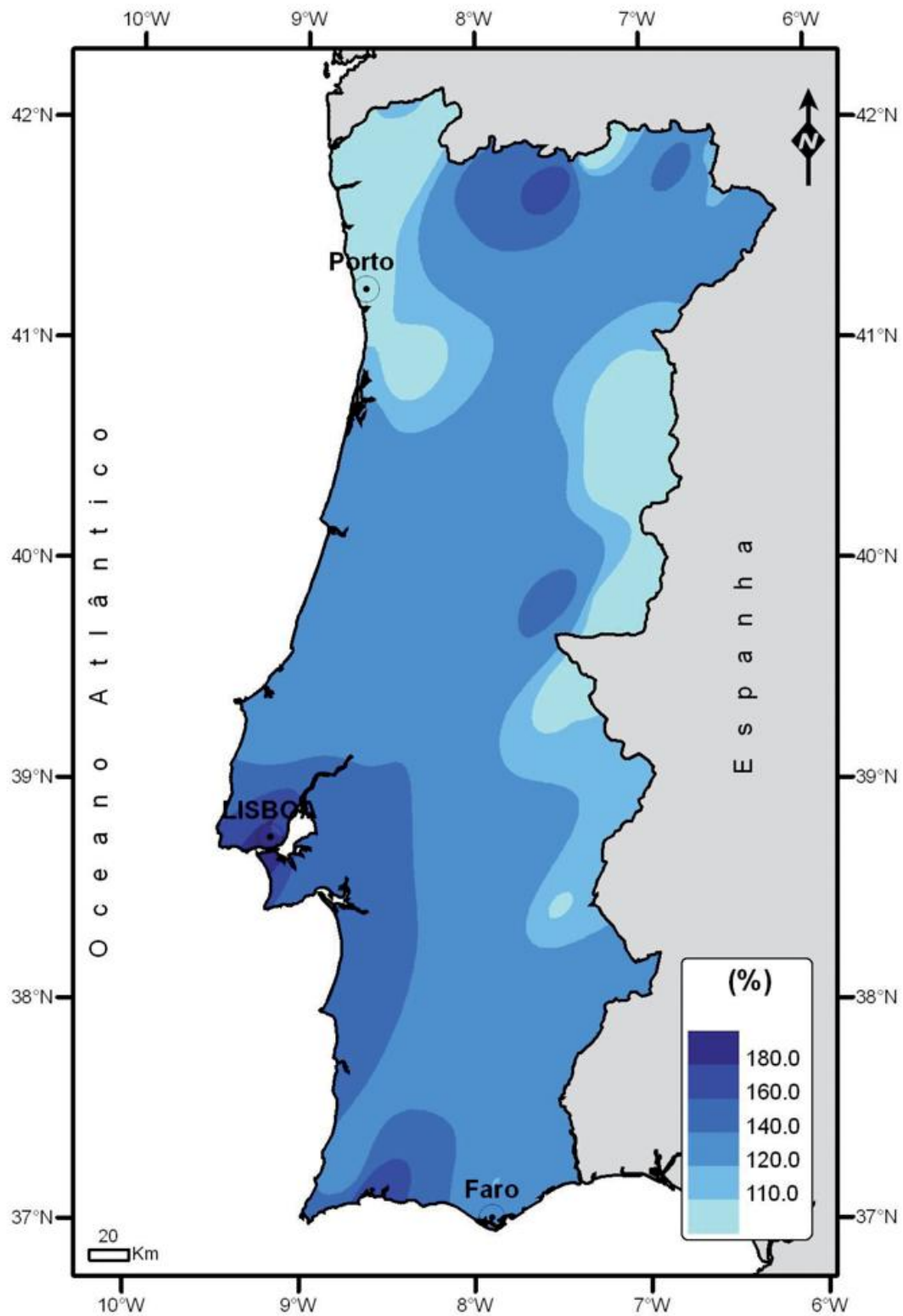


Fig. 0.31: 2010 annual precipitation totals in Portugal in per cent (1971–2000 reference)
 Source: Instituto de Meteorologia, Portugal

3.6. Italian and Balkan Peninsulas, Mediterranean region

Italy, the Balkan Peninsula and most of the other parts near to the Mediterranean were wetter than normal and some periods of heavy rain occurred. Large areas received more than 125% of the normal annual total, locally 175%. This was particularly due to occasional to frequent heavy precipitation (partly causing flooding and landslides) in January, February, and May–November.

Some places on the Balkan Peninsula saw their highest or second highest annual precipitation totals. With 1798 mm, Ljubljana in Slovenia recorded its second highest annual total since the beginning of measurements. Herzegovina had its wettest period in 2010 since the beginning of measurements, with Mostar station reporting an annual precipitation total of around 2500 mm. Extremely heavy precipitation events were frequent in the southern parts of Bosnia and Herzegovina, causing flooding of Neretva and Drina rivers at the end of November and the beginning of December. At least five main meteorological lowland stations in Serbia registered their highest annual total in the past 60 years, partly exceeding 1000 mm. At more than 170% of the 1961–1990 normal, some stations in Montenegro received the highest or second highest precipitation total on record (Fig. 0.32).

It was a dry year in Malta and in southern Greece. Malta had very low precipitation in the colder months (January, February, November, December) and in April, and had hardly any rain in summer.

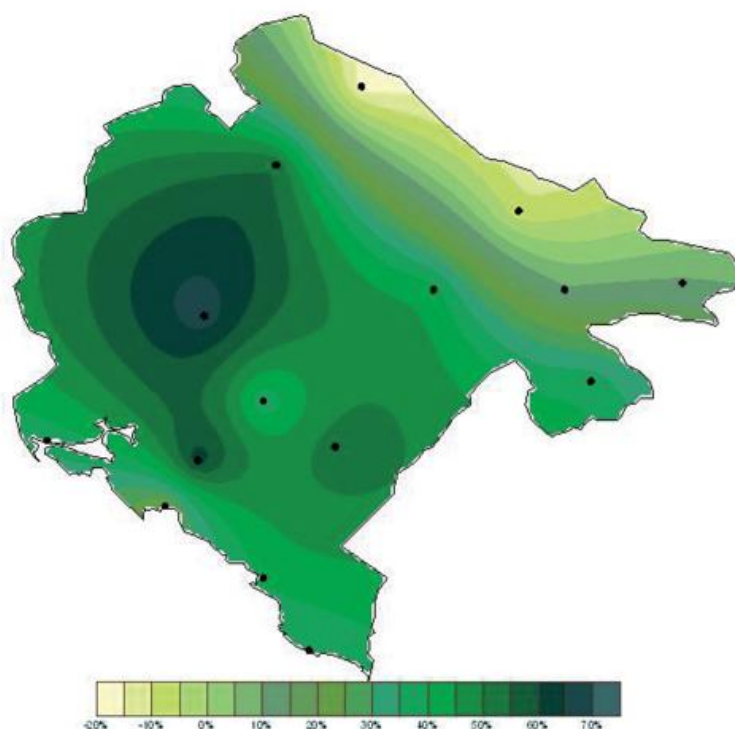


Fig. 0.32: 2010 annual precipitation totals in Montenegro in per cent (1961–1990 reference)
Source: Hydrometeorological Institute of Montenegro

3.7. Eastern Europe and South Caucasus region

Eastern Europe was wetter than normal in its western parts and mostly dry or near normal in the east. It was particularly wet (>125% of the normal) in the western and southern Ukraine, Romania and Moldova. There were many very wet months in that area in all seasons, namely January, February, May, June, August, September, October (in the south only), November and December.

In Romania, the largest precipitation excesses of the year occurred in May and June, which climatologically are anyway among the wettest months in that country (Fig. 0.33). This excess precipitation fell over a soil which was already soaked due to the fact that previous months had also been wetter or around normal, which at times led to severe flooding.

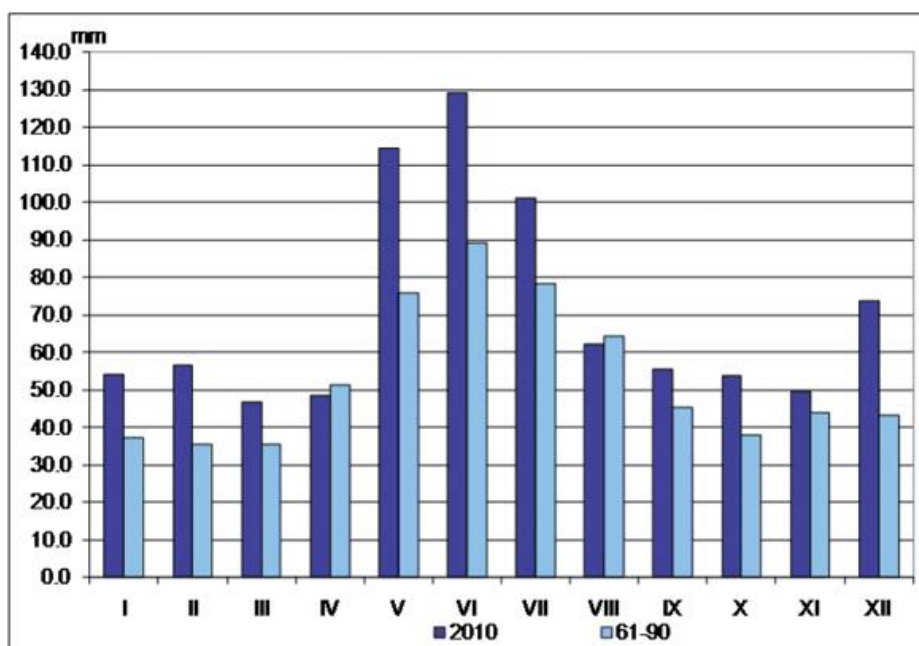


Fig. 0.33: Monthly mean precipitation totals in Romania 2010 compared to the 1961–1990 normal
Source: National Meteorological Administration of Romania

Moldova was also affected by high quantities of precipitation during the period May–July (300–510 mm, i.e. 60–80% of the annual normal fell during these three months), especially in the northern parts, but partly also in the south of the country. Such high amounts were registered for the first time since the beginning of observations in Moldova. The highest total in Moldova for May–July 2010 (510 mm) was recorded at the station Briceni, exceeding twice the normal for these three months (Fig. 0.34). The consequences of the high quantities were flooding of rivers and damage to houses and farmlands as well as power supply disruptions.

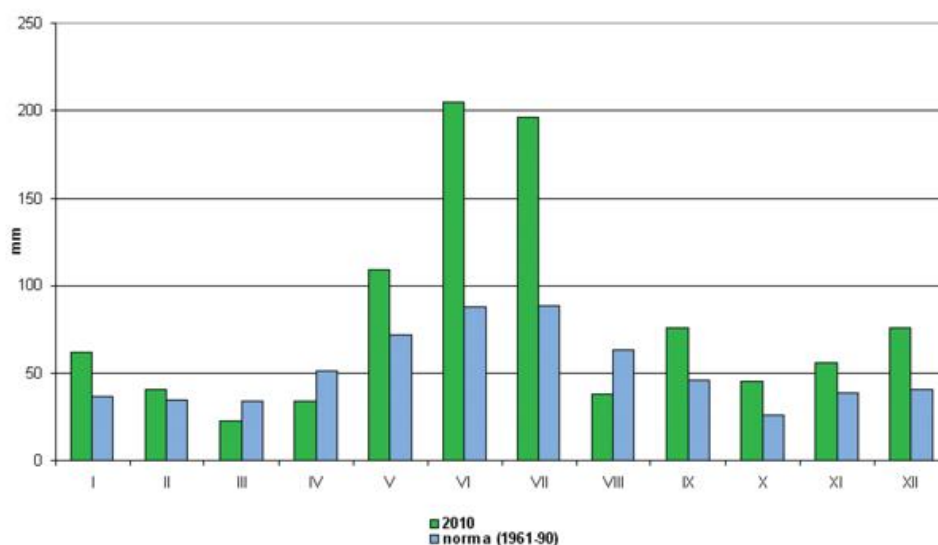


Fig. 0.34: Monthly mean precipitation totals at the station Briceni in Moldova 2010 compared to the 1961–1990 normal
Source: State Hydrometeorological Service of the Republic of Moldova

Some places in Southern European Russia received very much precipitation, 300–500% of the normal in some months.

Dry areas (locally less than 80% of the normal) were to be found in central European Russia, west Kazakhstan and the South Caucasus. Main contributors in Russia were the months April and June–August, in the South Caucasus June, August as well November and December in particular. It is noteworthy that during November and December most parts of the South Caucasus region did not receive any single drop of rain, although climatologically these two months are the second rainy period in that area after April–May. However, several heavy rainfalls and subsequent flooding occurred in Azerbaijan from April to June, the heaviest ones in May. The Kura river in Azerbaijan had high water levels from the end of April until the end of June; several villages were flooded. Thunderstorms with severe hail occurred very often in the South Caucasus from May to July. Overall, 19 days with hail were recorded at different locations in Armenia, with hailstones sometimes reaching 25 mm in diameter. Hail caused significant losses to agriculture due to the damaged crops. Wet conditions also prevailed in January and October in the South Caucasus.

In general, the weather conditions during the vegetation season in 2010 were very unfavourable for agriculture in Armenia. Extensive rainfalls in April damaged most of the blossoming fruit trees in the Ararat Valley; later, frequent hailstorms and heavy rainfall with dry periods in between caused significant losses to agriculture.

3.8. Middle East

Western Turkey saw a wet year (>125% of the annual total), whereas most of the other areas were drier than normal.

Turkey had some relatively very wet months, namely January, February, June, October and partly December, especially in the west. Some locations in Turkey saw hazardous flood events, e.g. Bursa, which had the wettest year on record (at 1328 mm nearly twice the normal). Cyprus also reported heavy rain and flooding, especially in January, February and April, as well as severe hail storms in April, May and December.

On the other hand, especially eastern Syria was very dry, recording local annual totals of less than 40% of the normal. More than a third of the stations in Jordan received less than 75% of the normal total.

It was extremely dry in the Middle East in spring and exceptionally dry in November. Israel had an extremely dry period around Haifa, the driest on record for August to November in at least 70 years. The long drought period caused a large forest fire in northern Israel in early December.

4. Snow

Unusually small amounts of snow fell in south-western Iceland. Reykjavík had its lowest annual number of days with snow cover (only 16 days) since observations started in 1921.

In contrast, 2010 was a year of abundant, widespread and long-lasting snow across large parts of northern, western and central Europe, particularly in the winter months January, February and December.

In the UK, snow depths accumulated to more than 50 cm across the high ground of eastern England and eastern Scotland in both January and December.

Uccle station in Belgium had an exceptionally high number of 53 snow days (compared to the 1981–2010 normal of 19), the highest number since the start of observations in 1901.

Locally record-breaking snow depths were measured in Germany in all three winter months; even in the lowlands such deep snow covers had not been seen for a long time. Since the 1960s, many places in Germany had not seen as many snow days.

In the plains of Switzerland, frequent snowfalls continued to occur even in the first half of March. In summer and autumn, it often snowed in the western Alps and by November it started to snow again in the plains of Switzerland.

Beside the Austrian alpine regions, the amount of fresh snow in Austria exceeded the 1971–2000 averages by around 30–60%.

Poland reported at least 70 days with snow from October 2009 to April 2010 in most of the country; in the west, this was more than twice the 1971–2000 normal. The mean snow depth in Poland was also high that season, 200–500% of the normal. On the other hand, in 2010 most of European Russia had fewer days with snow cover than normal.

5. Sunshine duration

Sunshine duration anomalies in 2010 showed much greater spatial variability than in the previous year (Fig. 0.35). Averaged over the Region, sunshine duration was around normal, but relatively sunny and relatively dull areas were still to be found in all its parts.

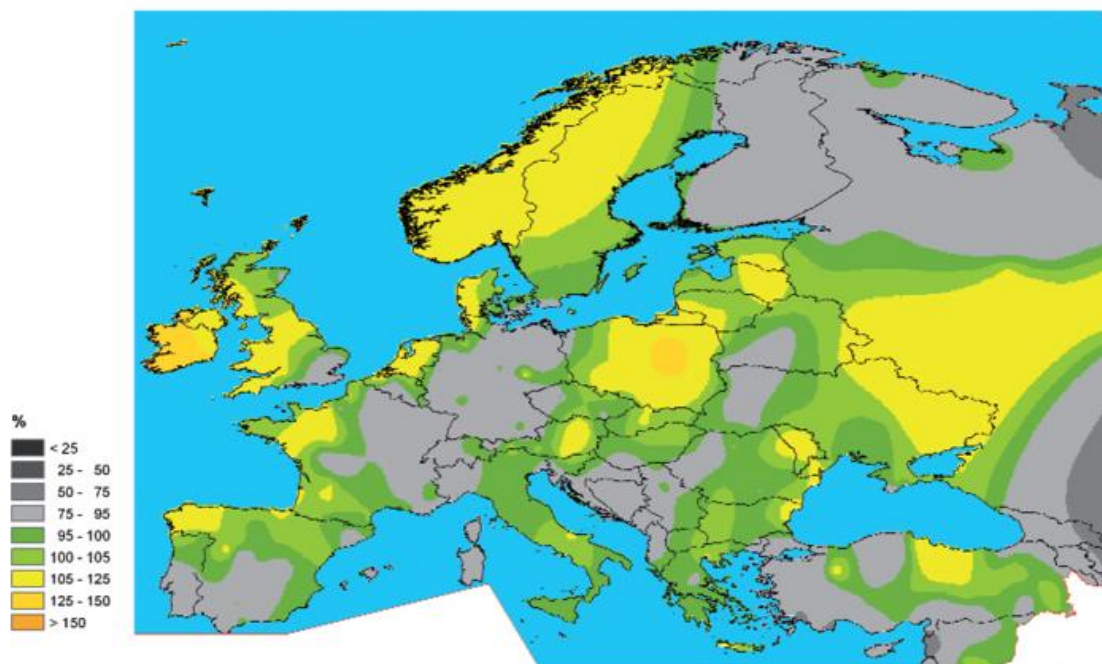


Fig. 0.35: Annual sunshine duration in 2010 in per cent of the 1961–1990 normal in WMO Region VI (interpolation of CLIMAT data)

Source: Deutscher Wetterdienst, Germany

The year was sunnier than normal in the Arctic region (Greenland, Iceland, Svalbard) and over almost the whole of north-western Europe (Ireland, United Kingdom, north-western France, the Netherlands) and the western parts of northern Europe (Norway, western Sweden, Denmark with the Faroe Islands). Although summer was quite dull in most of these areas (except Ireland and the Netherlands), the other seasons had a considerable surplus of sunshine.

The three winter months January, February and December 2010 were record-breaking sunny on the Faroe Islands. Southern Ireland received more than 1,500 hours of sunshine in 2010, which is more than 125% of the normal, and it was the sunniest winter on record in western and southern parts of Ireland. Several months were very sunny in parts of the United Kingdom, notably January, March, April, June and October to December. However, July and August were dull summer months in most areas of the United Kingdom. In Northern Ireland and western Scotland, 2010 was amongst the sunniest years on record.

The Netherlands had 1,772 hours of sunshine on average (normal 1550), locally up to 1,900 hours, but less than the average in 2009. 2010 had the sunniest December on record in Denmark, with a total of 81 hours of sunshine on average for the country.

In contrast, north-eastern Europe (Finland, northern European Russia) had a dull year, particularly towards the east, where less than 75% of the annual total was recorded. Sunshine was lacking especially in autumn.

Large parts of central Europe were also quite dull, namely eastern France, southern Belgium and large parts of Germany. Compared to the normal, there was a lack of sunshine already in all winter months, but also in May, August, September and November. Germany experienced its third dullest January and February since 1951, and winter 2009/10 was the second dullest behind 1969/70. Uccle in Belgium saw its dullest February (29 hours of sunshine duration) since the beginning of heliographic measurements in 1887. May was the dullest month on record (since 1951) in Germany (locally also in Austria), August the second dullest. The other months were mostly very sunny, particularly April (third sunniest April in Germany behind 2007 and 2009), which, however, did not compensate the deficit.

Large parts of eastern central and eastern Europe saw a sunny year, particularly Poland, eastern Austria, eastern Latvia, Moldova and central European Russia. Some locations in Poland received more than 1800 hours of sunshine in 2010, which is more than 250 hours above the 1971–2000 normal. Only February, May and December were dull in almost all these eastern parts. Over the whole year 2010, parts of eastern Austria had more than 125% sunshine than normal, but 2010 was also the year with the lowest sunshine duration in Austria since 1996 due to frequent rainfall in the summer months and an extremely low annual mean air pressure (Fig. 0.36).

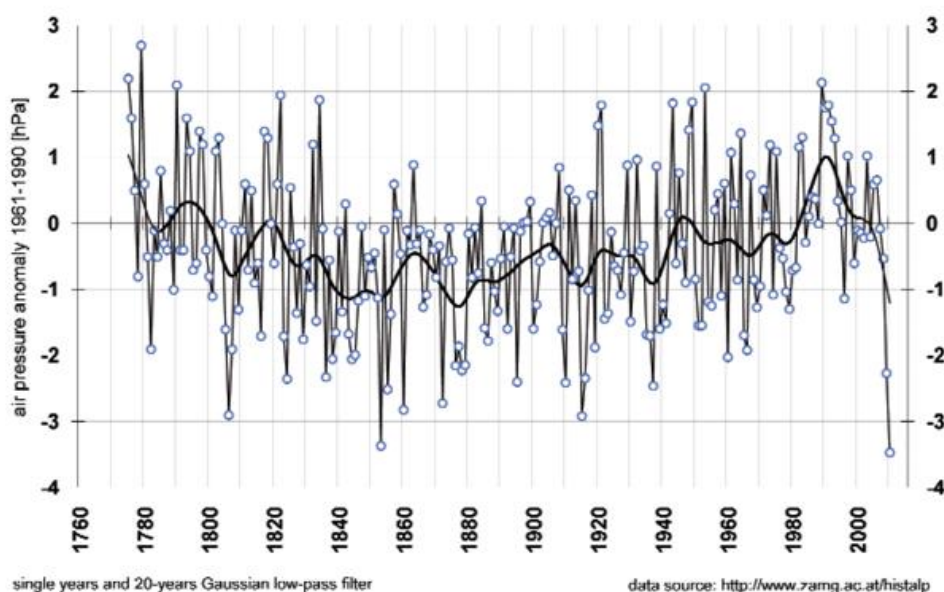


Fig. 0.36: *Anomalies (1961–1990 reference) of the Austrian air pressure stations 1775–2010*
Source: Central Institute for Meteorology and Geodynamics (ZAMG), Austria

Western Kazakhstan and the South Caucasus region had far below-normal sunshine, with less than 75% of the annual total in the east. Just the end of the year (November and December) brought above-normal sunshine to the South Caucasus.

The Mediterranean region and most of Iberia had around normal or below normal sunshine. Spring and summer were mostly sunny, but the winter and autumn months were mostly dull.

6. Wind

Globally, the tropical storm activity in 2010 was lowest since at least 1970, with a total of 67 storms, 38 of which developed to typhoons/hurricanes. Only the North Atlantic had an above-average activity (19 storms / 12 hurricanes vs. a long-term mean of 10 / 6) during the season from end of June to the beginning of November due to high sea surface temperatures in its tropical area. This was triggered by La Niña conditions due to weak vertical wind shear and by the continued warm mode of the Atlantic Multidecadal Oscillation (AMO). However, the strongest storm was typhoon Megi (central pressure 885 hPa) over the Philippines and China in October. Other tropical storms (Giri in Myanmar also in October and Agatha in central America in May) caused at least 150 deaths each. Only one tropical storm reached the RA VI Region as extratropical cyclone: storm Danielle moved from the central Atlantic towards the north-east and dissipated south of eastern Greenland on 03 September without causing any damage in RA VI.

In Europe, due to the frequent meridional circulation patterns, westerlies were rare, and with it also the number of intense cyclones.

Windstorms were markedly fewer than usual in Iceland. The average wind speed at all stations in Iceland was the lowest since 1965.

In winter 2009/10, many stations in Ireland registered record-low mean wind speeds.

Latvia measured the lowest wind speeds for almost 50 years for January, and also in February wind speeds were very low. Gusts up to 119 km/h were recorded in August.

Lithuania reported one strong squall line and one tornado in summer.

In Poland, geostrophical winds up to 81 km/h occurred in January and once more in November.

One extensive storm, Xynthia in February/March, affected large parts of France and Germany.

Several heavy thunderstorms and tornadoes occurred in Germany, particularly between late May and early July.

In Portugal, tornadoes and water spouts were seen in April (Lisbon, Tavira and Sintra), causing damage on buildings, and December (in central parts), when several people were injured and great damage caused at several locations.

Malta recorded its highest wind gusts since 1947 in July.

There were very few Etesian wind patterns in Greece (e.g. N–NW winds prevailing over the Aegean Sea). Cyprus saw some strong wind events in February, October and December, and also tornadoes in January–March, May and December.

Strong winds were recorded quite often in the South Caucasus in January and February, with mean winds up to 140 km/h and gusts up to 170 km/h in Armenia. Azerbaijan reported some severe storm events from January to March, with gusts up to 108 km/h, locally even more. Georgia reported wind gusts up to 115 km/h, highest in February, March and September.

7. Sea ice

7.1. Arctic sea ice

(Text kindly provided by the National Snow and Ice Data Center, University of Colorado, Boulder, USA, <http://nsidc.org/arcticseaicenews/>, 05 January 2011, added by text from NCDC: <http://www.ncdc.noaa.gov/sotc/hazards/2010/9.>)

Despite a late date of the maximum in winter 2009/10 sea ice extent, the minimum sea ice extent for September 2010 (4.6 million km²) was third lowest in the 1979 to 2010 satellite record, above only 2007 (the record low) and 2008 (Fig. 0.37). The average extent for September (4.9 million km²) was 30.4 percent less than the 1979–2000 average. Regarding the total amount of Arctic sea ice, according to the University of Washington's Polar Science Center (using a model that has compared well with observations), sea ice volume for September reached an all-time monthly low in 2010. The reported volume of 4,000 km³ was 70 percent below the 1979–2009 September average of 13,400 km³. Sea ice volume accounts for sea ice extent as well as the thickness of the ice.

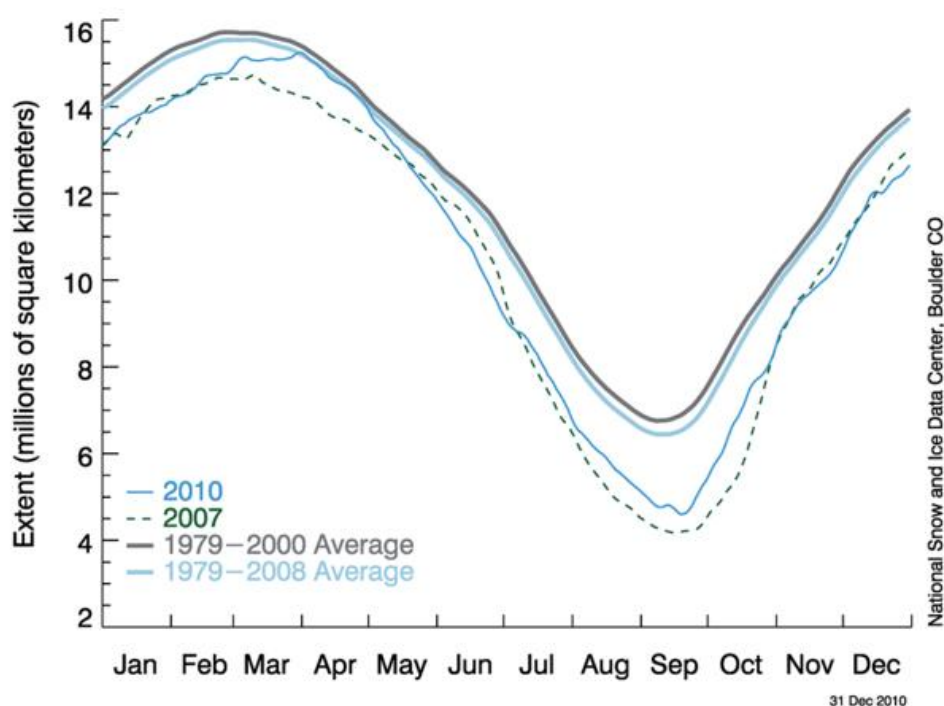


Fig. 0.37: Arctic sea ice extent in 2010, compared to the 1979 to 2000 and 1979 to 2008 climatologies and the year 2007.

Source: National Snow and Ice Data Center, University of Colorado, Boulder, USA

The late summer of 2010 saw an open Northwest Passage: this year, the deep water channel (the northern route) from M'Clure Strait to Lancaster Sound was navigable. The Northern Sea Route along the Siberian coast also became briefly navigable. It was the first time in modern history that both the Northern Sea Route and the Northwest Passage were navigable in a single season.

2010 started out with a highly negative phase of the Arctic Oscillation, an atmospheric pattern that in the past has favoured the survival of old ice through the winter, and more ice at the end of this summer. But this tendency seems to be changing. A recent study led by Julienne Stroeve of NSIDC showed that while wind patterns linked with the strongly negative Arctic Oscillation winter of 2009–2010 transported much old ice into the southern Beaufort and Chukchi Seas, most of this ice later melted. It may be that with a warmer Arctic, old rules regarding links between the atmospheric pressure patterns and sea ice extent no longer hold.

On 5 August, an ice mass of 251 km² broke down from the Petermann Glacier in north-west Greenland.

Freezing in autumn 2010 also was unusually slow due to far above-average temperatures. Arctic sea ice extent averaged over December 2010 was 12.00 million km². This was the lowest December ice extent recorded in satellite observations from 1979 to 2010, 270,000 km² below the previous record low of 12.27 million km² set in 2006 and 1.35 million km² below the 1979 to 2000 average. As in November, ice extent in December 2010 was unusually low in both the Atlantic and Pacific sides of the Arctic, but particularly in Hudson Bay, Hudson Strait (between southern Baffin Island and Labrador), and in Davis Strait (between Baffin Island and Greenland). Normally, these areas are completely frozen over by late November, but in 2010, Hudson Bay was not totally frozen till the end of the year. In the middle of December, the ice extent stopped increasing for about a week, an unusual but not unique event.

The low ice conditions in December occurred again in conjunction with above-average air temperatures in regions where ice would normally expand at this time of year. Air temperatures over eastern Siberia were +6 to +10°C above normal in December. Over the eastern Canadian Arctic Archipelago, Baffin Bay/Davis Strait and Hudson Bay, temperatures were at least +6°C higher than average. Southern Baffin Island had the largest anomalies, with temperatures over +10°C higher than normal. By sharp contrast, temperatures were lower than average (-4 to -7°C) over the Alaska-Yukon border, north-central Eurasia, and Scandinavia.

The warm temperatures in December came from two sources: unfrozen areas of the ocean continued to release heat to the atmosphere, and an unusual circulation pattern brought warm air into the Arctic from the south. Although the air temperatures were still below freezing on average, the additional ocean and atmospheric heat slowed ice growth.

As in winter 2009/10, a strongly negative phase of the Arctic Oscillation dominated the middle and high latitudes of the Northern Hemisphere in December 2010, bringing higher-than-normal pressures to the Arctic region, with lower-than-normal pressures in middle latitudes. However, unlike December 2009, when higher-than-normal pressures centered near the central Arctic, in December 2010 higher pressures centered near Iceland and the eastern tip of the Aleutians in the Pacific, and yielded a different pattern of winds. As a result, different areas experienced warm anomalies in 2010, and a different pattern of ice extent emerged.

7.2. Baltic Sea

(Text kindly provided by J. Vainio et al., taken from Bundesamt für Seeschifffahrt und Hydrographie (BSH, Federal Maritime and Hydrographic Agency of Germany), Baltic Sea Ice Services, http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/iceseaason, 14 October 2010, shortened)

After a slow start in autumn 2009, very cold weather conditions over Scandinavia ensured a rapid development of the ice cover at the beginning of 2010. On January 8, the entire Bay of Bothnia was covered with ice; a week later the amount of ice also increased in the Gulf of Finland and the Gulf of Riga. During this period, ice also started to form along the coast in the Sea of Bothnia and in the Stockholm archipelago.

An intense low pressure system passing over Scandinavia on 27–28 January brought southerly gale force winds which pressed most of the ice in the Skagerrak towards the Norwegian coast. In the Bay of Bothnia, the ice drifted rapidly to the north/north-east, causing severe pressure in the ice field. Conditions were so severe that the area was temporarily closed for all traffic. After the storm, the cold weather came back and ice growth speeded up again, particularly in the Sea of Bothnia, the northern Baltic Sea and the Kattegat. Ice started to form outside the archipelagos in the northern Baltic Sea and along the east coast of Gotland.

In the southern Baltic Sea, ice formation resumed in the eastern waters in early January and spread quickly westward on the sheltered inner coastal waters. Ice formation continued until mid-February. By the end of January, new ice had also formed on the outer coasts, and the Pomeranian Bight was completely covered with ice.

On February 17, the area covered with ice expanded to 244,000km², marking the maximum area for the winter. This took place almost two weeks earlier than normal. At that time, the Gulf of Finland and the Gulf of Bothnia were covered with ice, with the exception of an approximately 6,500 km²-wide area in the eastern Sea of Bothnia off Rauma and Pori. The Gulf of Riga was also thoroughly covered with ice. In the northern Baltic Sea the ice edge ran from near Almagrundet to Glotovi and further on to the south/south-west. The central Baltic Sea off the coastline had a thin ice cover north of Öland and Klaipeda. The southern Baltic Sea off the coast of Germany was covered with thin fast ice in the insular areas. There was also thin ice and new ice in the Kattegat and Skagerrak.

In winter 2009/2010, the temperature remained below zero for an unusually long period of time without a break – a total of 60 days. The frosty winter ended on February 26 and, with the winds blowing from the south, the frozen area began to decrease.

In the Sea of Bothnia, the strong winds ripped large holes into the ice field in the northern part, and caused ridging and rafting in the south. During this time ice pressure in the southern Sea of Bothnia and the Sea of Åland was so severe that it caused substantial problems for traffic. On 3-4 March, conditions were particularly difficult in the Sea of Åland. A brash ice barrier outside of the Stockholm archipelago caught a number of passenger ferries and commercial ships, and icebreaking activities were intense.

The North Sea coast, its tributaries, and the Kiel Canal were completely free of ice by 7 March, the Baltic Sea waters of Schleswig-Holstein by 20 March, and the bodden waters along the coast of Mecklenburg-Vorpommern by 25 March. The numbers of days with ice varied considerably in the different areas: in the river Weser near Brake, ice occurred only on one day, compared to 96 days in the harbour of Neuendorf on the island of Hiddensee. Only a few stations, most of them located in the German Bight, remained free of ice throughout the winter of 2009/10.

In April, the sea ice continued to melt. The melting process proceeded rapidly also in the south and the Baltic Sea coast south of Stockholm was ice free around April 15. Lake Vänern was ice free around the 18th.

The remaining ice of the Sea of Bothnia disappeared at the end of April, while in the Gulf of Finland and the Bay of Vyborg it melted on May 2.

In mid-May, there was an unusually long and widespread heat wave, considering the time of year. The impact of the heat continued and, consequently, made the water warm and the ice to melt. Last ice in the Bay of Bothnia melted at the end of May and the Bay of Bothnia was ice free on May 31.

The time of the final melting, compared to normal, varied greatly. In the coastal waters of the northern Bay of Bothnia the final disappearance of ice took place two to four weeks earlier than average and in the Gulf of Finland about one week to more than a month later than average.

The duration of the ice winter in the northern Bay of Bothnia was over a month shorter than average. In the southern Bay of Bothnia and in the Vaasa archipelago the ice winter was one and a half to two weeks shorter than average, whereas it in the Quark was two weeks longer than average. In the other sea areas surrounding Finland the length of the ice winter was a week (the metropolitan area) to more than a month (western Gulf of Finland) longer than normal.

In the Finnish part of the Bay of Bothnia, the maximum thickness of the fast ice was between 40 and 85 cm, in the Sea of Bothnia between 30 and 60 cm, in the Archipelago Sea between 15 and 50 cm and in the Gulf of Finland between 20 and 60 cm. The thickness of the ice in the pelagic Bay of Bothnia was 30–60 cm, in the Sea of Bothnia 10–40 cm, in the Gulf of Finland 30–45 cm, in the Sea of Åland 10–35 cm and in the northern Baltic Sea 10–35 cm.



Fig. 0.37a: Sea ice off Helsinki on the 7th March 2010 (Courtesy of Dr. Stefan Hendricks, AWI)
Source: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/iceseaon

Seasonal Survey

Temperature

After a cold winter 2009/10 particularly in northern Europe, the other seasons in 2010 became warm, especially in the east of the Region with an outstanding hot summer particularly in Russia. Autumn was colder again in the western half of Europe. Greenland and the Middle East were much warmer than normal in all seasons.

Winter 2009/10 was cold in most of Europe, especially in the north, but mild in the Arctic, in south-eastern Europe and the Middle East (for figures see section “Seasonal Maps”, Fig. S1).

It was mild in the whole Arctic region. Anomalies amounted to +7°C in Svalbard; Greenland was more than +5°C warmer on average, locally exceeding the 90th percentile.

Northern, eastern, central, western and north-western Europe saw an exceptionally cold winter with hard frosts during all three winter months. The number of ice days ($T_{\max} < 0^{\circ}\text{C}$) was higher than normal all over northern and central Europe. The negative temperature deviations from normal were highest in central Scandinavia and north-eastern European Russia ($< -3^{\circ}\text{C}$, Fig. 0.38 e.g. for Sweden) and below the 10th percentile.

It was the coldest winter for at least 14 years in several countries of central Europe, in northern Europe and the Alps even for more than 20 years (Tab. 0.2). It could, however, not compete with the record cold winters of the 1940s or 1960s. Winter was particularly exceptional in north-western Europe (coldest for at least 30 years) and the Alps. High mountain stations in Switzerland registered the coldest winter in around 30 years. At the Jungfrauoch and Grosser St. Bernhard, it was even the coldest winter in 40 years. The long-term warming trend was one reason that winter 2009/10 was still milder than comparable spells in past decades, particularly in central Europe.

Country	Winter 2009/10 was the coldest since	Winter 2009/10 was the coldest for ... years
Sweden	1986/87	23
Finland	1986/87	23
Ireland and Scotland	1962/63	47
England and Wales	1978/79	31
Netherlands	1995/96	14
Belgium	1995/96	14
Germany	1995/96	14
Switzerland	1986/87	23

Tab. 0.2: Last winter which was colder than that of 2009/10 in various countries/areas in northern, north-western and central Europe

Source: Report of National Meteorological and Hydrological Services

Generally, the long duration of cold conditions during that winter was more unusual rather than any local extremes. There was a very long period with below-zero temperatures in central Sweden. Locally, it was the longest such period in more than 120 years of measurements. Helsinki in Finland had its longest cold spell since 1947. In Finland, the lowest temperature of that winter was -41.3°C in Kuhmo in the north. Some areas in Estonia also had the longest period without any above-zero temperatures ever registered, e.g. 76 days in Johvi. In Lithuania, the winter 2009/2010 was almost 4°C colder than the previous winter. Denmark recorded 74 frost days on average (normal is 53 days).

In north-western Europe, temperatures regularly fell well below -10°C in the Scottish glens and, at times, in some places in Ireland. The coldest spell was in early January, when night-time temperatures fell as low as -22.3°C in the Scottish Highlands, the lowest UK temperature since December 1995. Irish inland stations registered a total of 70–80 days with ground frosts; monthly mean temperatures were around 2°C below normal.

Winter in western and central Europe, too, was characterised by several notable cold waves. Belgium suffered three cold waves during all winter months. The winter in France was not exceptional (-1.2°C anomaly), but several cold waves occurred in January and February.

In Iberia, the winter season was slightly colder than normal on most of the peninsula (anomaly of -0.3°C in Spain), although not as cold as in the rest of most of western and northern Europe. It was characterised by frequent cold spells. February was the coldest month in Spain. Only the southern parts were warmer than normal.

Most of south-eastern Europe, the eastern Mediterranean, the Caucasus region and the Middle East had a mild winter. Anomalies ranged between $+1$ and $+2^{\circ}\text{C}$ in south-eastern Europe and exceeded $+2^{\circ}\text{C}$ across almost the entire Middle East, where the 90th percentile was exceeded; they were highest in eastern Turkey and the South Caucasus region (up to $+5^{\circ}\text{C}$). It was the second warmest winter in the South Caucasus since 1935, behind 1965/66, and, in particular, also the second warmest winter on record in Armenia. Western Kazakhstan was only slightly warmer than normal.

All three winter months December 2009, January 2010 and February 2010 had a similar anomaly distribution; they differed only in terms of intensities (the strongest negative anomalies over the whole European continent were observed in January) and location of the lowest values.

This quite unusual temperature distribution resulted from extremely high negative values of both the North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO) in all three winter months, and the subsequent frequent attenuation of westerly airflow. The mean surface air pressure distribution was characterised by an extended low pressure area centered over the North Atlantic east of Newfoundland and a large high pressure area over Asia. This facilitated the intrusion of cold Arctic air into Europe and caused flow of cold continental air from the east to prevail. A compensating flow led warm subtropical air to Turkey and the South Caucasus region. The NAO mean index for the three winter months (-3.1) was the lowest winter NAO since records began in 1821 (data from Climate Research Unit, UK) and ranges even below the values for the winters 1962/63 (very cold winter in western Europe) and 1968/69 (very cold in the east). The NAO index was strongly negative in all winter months, particularly in December 2009 and February 2010.

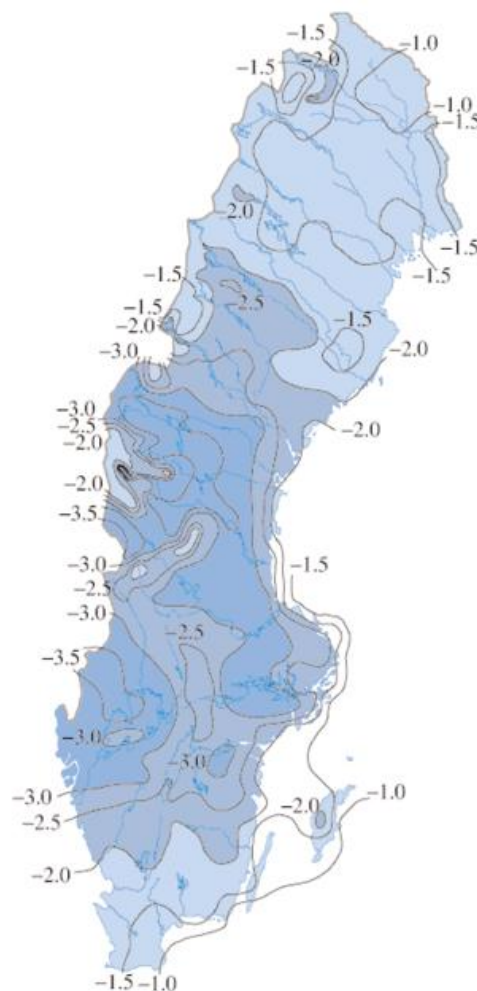


Fig. 0.38: Temperature anomalies (1961–1990 reference) for winter 2009/10 in Sweden
Source: Swedish Meteorological and Hydrological Institute (SMHI)

Spring 2010 was warmer than normal in almost the whole Region, except for a few small areas in various parts of Europe (Seasonal Maps, Fig. S2).

It was warmer than normal in the Arctic region. Western Greenland was still more than +5°C warmer than normal, whereas in other parts of the Arctic, the anomalies remained considerably smaller compared to the previous winter. The 98th percentile was exceeded in southern Greenland.

In most of Europe (except the Arctic and the south-east) and over the North Atlantic, the seasonal warming in spring was generally quite high after the cold winter and the temperature anomalies were positive almost everywhere; only locally they were slightly below zero. Especially April was warm in most of Europe, whereas March and May were cold in some parts.

Spring anomalies were only slightly above or around zero in most of northern, western and central Europe. In Sweden, weather varied between warm and cold spells during March and April, which prevented a rapid snow melt. No summer days (25°C or more) were recorded in Denmark. The Netherlands had a mild start of spring, but an extremely cool May.

The strongest warming occurred over eastern Europe, particularly in Russia in April and May (except the south, which was warm in March). Seasonal anomalies were higher than +2°C in parts of European Russia and exceeded the 90th percentile. In other parts of north-eastern and eastern Europe, seasonal anomalies were higher than +1°C. All spring months were warmer than normal in most of eastern Europe except the north-east, which had a cold March.

Almost all over Iberia and Italy, it was also warmer than normal, partly even more than +1°C and exceeding the 90th percentile. Especially April and partly May were warm, particularly in western and southern Iberia. Even so, spring 2010 was the second coldest spring in Spain since 1996 (behind 2004).

South-eastern Europe, the eastern Mediterranean and the Middle East, too, were warmer than normal, though not as much as in winter. Highest anomalies (>3°C) were to be found in eastern Turkey, where the 90th percentile was surpassed. March was exceptionally warm in the whole Middle East region. Spring in the Caucasus region was only slightly warmer than normal on average due to a warm March, but saw near-normal or slightly below normal temperatures in April and May.

Both the North Atlantic Oscillation and Arctic Oscillation continued to show negative values in all three spring months, which means that meridional circulation patterns were strongly prevailing, causing a stronger-than-normal seasonal warming in most of the Region. However, the spatial variability of surface air pressure was much lower than in the preceding winter. The Icelandic low was stronger than normal, but dislocated far to the south-west. Both the Azores high and the Asia high were weaker than normal.

Summer 2010 was also warmer than normal in almost the whole Region, except over the western Mediterranean, the Norwegian Sea and the Barents Sea, which showed negative anomalies between 0 and -1°C (Fig. S3). Averaged over the European continent, summer 2010 was the hottest on record. The most extreme conditions occurred in western Russia.

Greenland was mostly more than +2°C and large parts of the North Atlantic more than +1°C warmer than normal. The summer was the warmest ever registered in Reykjavík (Iceland). The 98th percentile was reached over all these areas.

Most of the western half of the continent was around +1°C warmer than normal, exceeding the 90th percentile. Several countries saw some longer warm periods, but not the whole summer was warm. June was colder than normal across Fennoscandia, but July and August were hot. In the United Kingdom, the monthly mean temperature deviation decreased from +1.5°C in

June to -0.1°C in August. Generally, western and central Europe recorded a warm first half of the summer, but August was around or slightly cooler than normal. Switzerland experienced a hot summer period from mid-June to mid July.

The highest anomalies occurred again in eastern Europe and the Middle East, but they were much higher than in spring and higher than the 98th percentile. New daily maximum temperature records were set in many locations in eastern Europe and Finland. Summer in Estonia started with cooler-than-normal temperatures, but became very warm in July and August, resulting in an anomaly of $+2.6^{\circ}\text{C}$. The mean summer temperature in Tartu was 18.7°C , the highest value since 1866. Latvia saw its warmest summer for 87 years ($+2.7^{\circ}\text{C}$ anomaly), with 23 hot days (maximum $\geq 30^{\circ}\text{C}$) peaking in an absolute daily maximum of 34.8°C on 13 July. Lithuania, too, was especially warm in July and August (summer anomaly $+2.8^{\circ}\text{C}$); highest maxima exceeded 35°C on 18 July and 15 August.

Highest deviations were above $+4^{\circ}\text{C}$ during all summer months in European Russia (Fig. 0.39) and adjacent areas in Belarus, the Ukraine and western Kazakhstan; highest seasonal anomalies in European Russia reached $+5^{\circ}\text{C}$, daily anomalies even reached more than $+10^{\circ}\text{C}$, temperature maxima exceeded 40°C at several stations south-east of Moscow. It was the warmest summer in European Russia for the whole 130-year period of instrumental observations; possibly it was even one of the hottest in eastern Europe for about 500 years. This was mainly due to an exceptionally long and strong heat wave in July and August centered in Russia, partly also already in June. New daily maximum temperature records were set in all summer months until 19 August. Over most of European Russia, daily maxima above 30°C lasted for more than one month during July/August and both months were the hottest since at least 1939 averaged over the whole area. The high temperatures triggered massive forest and peat fires in European Russia, with smoke and smog adversely affecting tens of millions of people. Thousands of people (an estimated number of around 50,000) lost their lives, half of them around Moscow alone. A land area of more than 1700 km^2 burned down. The Russian crop production decreased by about one third compared to 2009 and the world market price for wheat rose to twice as high as before. Economic losses amounted to 15 billion US dollars. The Ukraine, Belarus and Finland, too, had new record maximum temperatures. Maxima of air temperature reached $38\text{--}42^{\circ}\text{C}$ in the Ukraine, soil temperatures in 10 cm depth $25\text{--}33^{\circ}\text{C}$, causing poor conditions both for late summer harvest and sowing winter crops.

Parts of the Balkan Peninsula were also extremely warm. The number of hot days was above normal throughout Slovenia. Several places in Bosnia and Herzegovina exceeded the 98th percentile. In all three summer months, several heat waves were recorded in the mainland of Greece with highest monthly anomalies in August. Extreme heat was also recorded in Turkey, with maxima of 46.7°C e.g. in Mut. Mean temperatures were above normal in all three summer months in the eastern Mediterranean and the Middle East (up to $> +2^{\circ}\text{C}$), but particularly high in August. Israel also reported several heat waves, especially in August.

In the South Caucasus region, too, summer was much warmer than normal, with seasonal anomalies locally between around $+4$ and $+6^{\circ}\text{C}$. It was the hottest summer in Georgia since at least 1957 and the second warmest on record in Armenia behind 2006. The South Caucasus was especially affected by a large number of hot days since it was influenced by very warm air masses coming from the south over a long time. Baku in the coastal area of Azerbaijan counted more than 40 days with more than 35°C , normally there are only a few.

Iberia also had a hot July and August, with this two-month period being the second warmest since 1960. Portugal had its second highest mean summer maximum temperature since 1931. July and August were exceptionally warm, particularly in Portugal and eastern Spain. Anomalies in the whole Mediterranean region were mostly positive, rising up to $+2^{\circ}\text{C}$. Outbreaks of cold air occurred only occasionally.

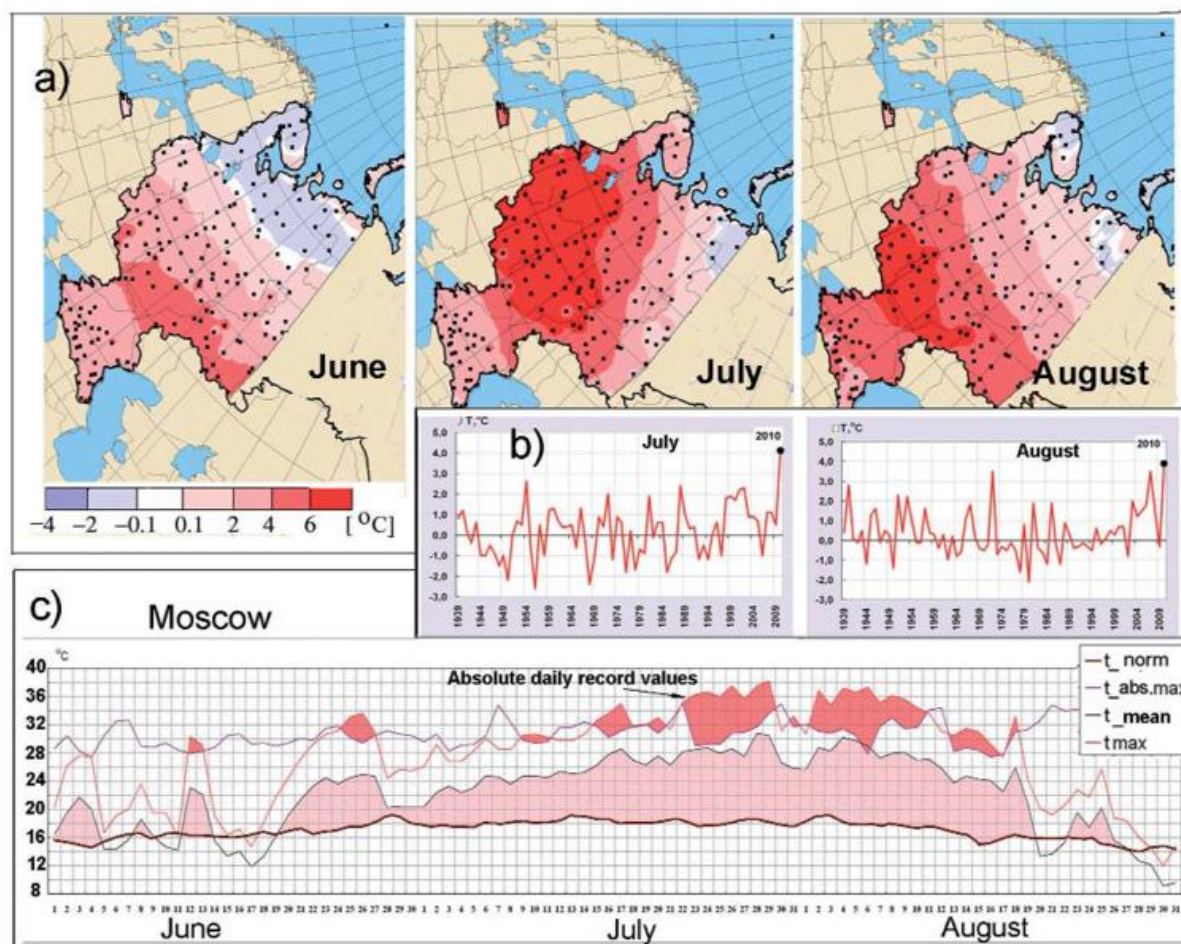


Fig. 0.39: a) Monthly mean temperature anomalies (1961–1990 reference) in the summer months 2010 in European Russia
 b) Time series of monthly mean temperature anomalies averaged over European Russia in July and August 1939–2010
 c) Daily mean (t_{mean}) and maximum (t_{max}) air temperature in Moscow June–August 2010, daily normal 1961–1990 (t_{norm}) and absolute daily maxima ever recorded ($t_{\text{abs.max}}$)
 Source: Roshydromet, Russia

The mean minimum temperature was also much higher ($> +3^{\circ}\text{C}$) than normal, especially over large parts of south-western, southern and eastern Europe. Some stations in Serbia saw new records for the number of nights warmer than 20°C .

The main reasons for the extraordinary hot summer were strong high pressure influence, particularly in eastern parts of the Region, but also dominating high pressure over the northern North Atlantic, especially in June and August (strongly negative North Atlantic Oscillation index in both months). During the summer, the Icelandic low was quite weak on average.

The high pressure area over Russia implied a blocking event in the northern hemisphere jet stream, which kept weather patterns almost stationary for more than one month. Russia is disposed toward blocking events during summer, and many of its prior heat waves also were associated with such blocking patterns. According to NOAA, the blocking pattern of summer 2010 was the most extreme and longest lasting one since 1920.

Autumn 2010 was cold in the western parts of Europe, but still warm in the east and in the Arctic ("Seasonal Maps", Fig. S4).

Once again, it was more than +1°C warmer than normal in the Arctic region and over most of the North Atlantic. Again, highest anomalies were to be found over western Greenland with more than +4°C, exceeding the 98th percentile.

Northern, western, central and south-western Europe were slightly colder than normal and locally below the 10th percentile. Anomalies were below -1°C over large parts of southern and eastern Norway and central Sweden, with the largest contribution from a very cold November. Denmark had its coldest autumn since 1998. Especially in the western parts of Europe (United Kingdom, Ireland, Spain), September was mild, but lower-than-normal temperatures occurred towards the end of autumn. In central Europe, it was the reverse: most of central Europe saw negative anomalies in September and October, whereas November was warmer than usual. The Baltic countries, too, were only slightly colder than normal and had a mild November. The whole season, however, was colder than autumn 2009 (difference at least about -1°C).

In the south-eastern parts of central Europe (especially Austria, Czech Republic, south-eastern Poland, Slovakia, Hungary), in Italy and on the northern Balkan Peninsula, November was extremely mild, whereas September and October were cold, resulting in a seasonal anomaly around zero.

Most of eastern and south-eastern Europe and especially the Middle East and the southern Caucasus saw a warm autumn, first in September (except for the Balkan Peninsula) and particularly in November. Only October was colder in most of eastern and south-eastern Europe. Large areas in the south-east of the Region were more than +2°C warmer than normal, surpassing the 90th percentile. Highest anomalies were to be found near the eastern Mediterranean with more than +3°C, e.g. in southern Turkey and partly in the Middle East. In these areas, all three autumn months were far warmer than normal, and likewise in the South Caucasus. It was the hottest autumn ever recorded in Armenia.

This season was again characterised by a highly negative North Atlantic Oscillation index and thus dominated by meridional circulation patterns, causing a cold airflow to prevail over western Europe and a warm airflow over the North Atlantic and eastern Europe. The Azores high was weak, the Icelandic low dislocated to the south.

Precipitation

Winter was especially wet in the south; the other seasons were particularly wet in eastern central Europe. Winter and autumn were dry in the north, spring in the west and summer in the east.

Winter 2009/10 was mostly drier than normal in northern, north-eastern, western and central Europe (except for parts of the Arctic and the Baltic countries), but wet in the southern parts of the Region. In most of western and central Europe, average winter precipitation was near normal, except for the south-eastern parts of central Europe (Fig. S5).

Especially Norway and Scotland, with their exposed locations for precipitation, saw a relatively dry winter, partly with less than 20% of the normal. Western Norway had its driest winter on record. Norway as a whole had around half of its normal seasonal precipitation totals and its second driest winter on record, surpassed only by winter 1899/1900. The Norwegian coast, large parts of Ireland and western parts of the United Kingdom were drier than normal in all three winter months. Dublin Airport had its driest winter since 1963/64. At most stations in Ireland, however, it was not as dry as in the winter of 2005/06.

Most of the southern half of the Region received a lot of precipitation, especially Iberia, the Mediterranean region, the Balkan Peninsula, Hungary and Slovakia as well as the areas around the Black Sea. Spain had seasonal totals exceeding 250% of the normal, particularly in the south, due to a persisting period of rainy weather originating from wet Atlantic air masses and many heavy rain events. It was the third wettest winter in Spain since 1947. At 1379 mm, Gibraltar set a new winter precipitation record. The station Lisbon in Portugal also hit a new record of winter precipitation (775 mm) for the time series since 1870 and a new all-time record for the period December 2009 to March 2010 (958 mm). As a consequence of the unusually rainy winter season, large areas of southern and south-western Iberia were affected by floods, particularly along the Guadalquivir river, with important socioeconomic impacts on agriculture, road/rail traffic, buildings and infrastructure. Floods were directly responsible for nine fatalities and for displacing about 1000 people.

On the Balkan Peninsula, Bosnia and Herzegovina reported seasonal totals locally exceeding 300% of the normal while places in Slovenia and northern Serbia reached more than 200% due to some heavy rainfall, particularly in February. Winter precipitation was also far above average throughout Romania and Moldova in all three winter months. The eastern Mediterranean, Turkey, most of the South Caucasus and western Kazakhstan were wetter than normal, with above 125% of the normal over large parts.

This distribution of precipitation resulted from a dominating high pressure influence in the north and low pressure influence in the south, reflecting the strongly negative Arctic Oscillation.

That winter was also characterised by a thick and persistent snow cover in large parts of northern, north-western and central Europe (Fig. 0.40). Over these areas, most of the winter precipitation, though mostly below normal in quantity, fell as snow, and there were new local snow depth records. The number of snow days was higher than normal, especially in south Scandinavia and central Europe, and it was one of the snowiest winters also in western Europe. Even Spain reported snowfall several times.

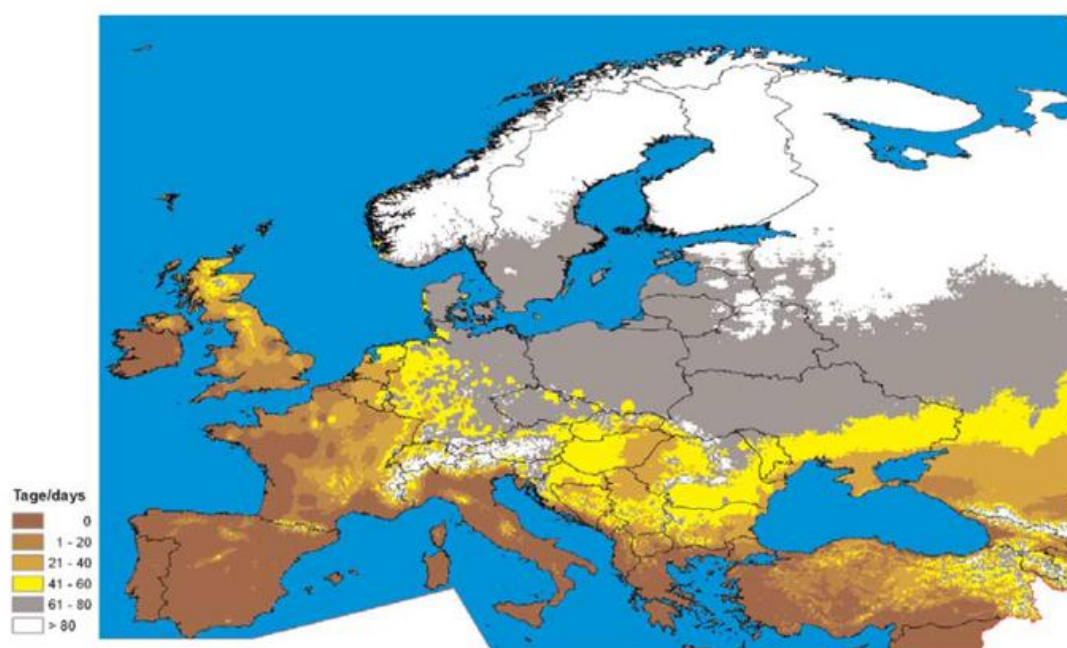


Fig. 0.40: Number of snow days (number of days with a snow cover of at least 1 cm on the ground) in Europe in winter 2009/10

Source: Deutscher Wetterdienst, Germany

In contrast, snow was relatively rare in Iceland. Reykjavík recorded 47 consecutive snow-free days from January to February, the longest snow-free period ever observed during this time of the year.

Significant snowfalls occurred in the United Kingdom from mid-December until the end of February and partly into spring. Snow depths in the UK reached up to 70 cm in Aberdeenshire. These were the most widespread snowfalls since the mid-1980s, affecting all forms of traffic as well as electricity and water supply. Ireland saw 20–30 days with snow in many places, mainly in form of showers, but snowfall accumulations were generally slight except on high ground.

In central Europe, very large numbers of snow days were to be noted. The Netherlands had 42 days with snow cover on average, more than three times the long-term average of 13. Such a large number of days with snow had not been seen for more than 30 years since the winter 1978/79. Uccle in Belgium had 31 snow days, the third highest number since 1901. It was one of the snowiest winters in the last 30 years in France, although the snow depths remained below historical records. Snow was also abundant in Germany; locally the highest depths on record and up to 73 snow days were recorded in the northern and eastern parts of the country, around twice as much as normal.

There was also more snow than usual in southern Finland because of the long lasting cold spell. Helsinki had not had so much snow since 1970, recording its maximum snow depth of that winter at 73 cm in late February, which, however, remained far below its highest record of 109 cm in 1941.

In Latvia and Lithuania, a steady snow cover began to form in the second decade of December and lasted almost the entire winter, except at the seaside. The snow cover in Latvia was two to three times deeper than normal most of that time. In the Ukraine, too, it was one of the snowiest winters in the past decade, with the highest maximum depth over the entire observation series.

In contrast, the snow cover duration was significantly lower than normal in most of European Russia. Even in the mountain regions of northern Caucasia, the snow cover persisted not as long as it usually does. The maximum snow depths, however, were higher than normal due to a rather large amount of precipitation as well as an absolute absence of thaws in central European Russia as had not been recorded for several decades.

Spring 2010 was dry in western Europe as well as over most of Russia and the eastern Mediterranean region, but wet in most of northern and eastern central Europe and over the western Mediterranean (Fig. S6).

It was a mostly dry spring in the Arctic region, namely in Svalbard and parts of Greenland.

Most of Scandinavia saw a wet spring (except for the southern parts), partly with more than 125% of the normal, with some heavy precipitation events causing locally severe mud slides, especially in late spring. Places in northern Norway received more than 200% of the normal, while stations in the southernmost parts of the country recorded only 50% of the normal. Southern Iceland and southern Sweden, too, were drier than normal, and Denmark also had a small precipitation deficit.

Likewise, many of the western countries of Europe (Ireland, the United Kingdom, the Low Countries, France, western Germany, Switzerland, northern Spain) were drier than normal, partly with totals of less than 80% of the normal, locally even less than 60%. It was the driest spring in the UK since 1984, due to the particularly dry April and May months with about 50% of the 1961–1990 normal in England and Wales. Uccle in Belgium had only 33 precipitation days in spring (normal: 49 days), the lowest number since 1990.

Most of Iberia and the western Mediterranean had a wetter-than-normal spring, except the north of Spain. Local areas in northern Iberia received less than 80% of the climatological average, whereas the southern parts received up to 125%. Lisbon in Portugal saw its rainiest spring of the last 51 years.

In most of eastern central Europe, spring was wet, too, although April was very dry. Especially Poland, the eastern Czech Republic, Slovakia and Hungary partly had around twice the normal amount. A large contribution to this anomaly came from a flooding event in May. In many areas, the number of days with a daily total > 20 mm was higher than normal. Large parts of the Balkan Peninsula were also wetter than normal due to some heavy thunderstorms in April and May, except for the south.

Precipitation was also above normal in the Baltic countries. In addition, melting of snow and ice blockages caused local floods in parts of Estonia and Latvia.

Central European Russia and parts of the eastern Ukraine were dry, locally with less than 60% of the normal, whereas the northern and southern parts of European Russia and the southern Caucasus region were wet.

The eastern Mediterranean region and the Middle East were extremely dry during the whole spring, mostly with less than 40% of the normal. March and April were unusually dry months in Greece. In contrast, the southern Caucasus region and west Kazakhstan were wetter than normal.

The reason for this large-scale precipitation distribution was a prevailing strong meridional circulation pattern, with frequent low pressure activity over eastern central Europe and high pressure influence west and east of it.

Summer 2010 was wetter than normal in most parts of Europe, but very dry in the east (Seasonal Maps, Fig. S7). The large number of days with daily totals >20 mm in many parts of Europe implies a large number of convective events.

The Arctic region was very dry, namely Greenland and Svalbard, but summer precipitation totals were between 125% and 150% of the normal in large parts of the Nordic and Baltic countries, except Iceland and southern Finland. Northern Norway experienced its second wettest summer on record, together with 1995 and behind 1921. Latvia experienced its third wettest summer for 87 years. Lithuania, too, had extraordinarily rainy weather that summer, which included 10 heavy rainfall and 3 large hail events.

Summer rainfall was close to average in western Europe, though with high spatial and temporal variability due to various wet and dry spells over the three summer months.

In most areas of Europe, the seasonal totals were only slightly higher than normal. However, over large parts of eastern central Europe (eastern Germany, Poland, the Czech Republic, Slovakia, Hungary), some parts of eastern Europe (western Ukraine, Romania), northern Europe and also west and south of the Black Sea, the totals exceeded 125% of the normal, in Latvia and Lithuania 150%, in parts of Slovakia even 200%.

There were a number of heavy rainfall events in various parts of Europe. Central Europe was particularly affected, especially the eastern areas. Two exceptional flooding events concerned especially eastern Germany, Poland and the Czech Republic. Germany recorded several periods of heavy rain with daily totals of more than 100 mm (such daily totals had not been measured in Germany in the previous years 2008 and 2009). Slovakia recorded its wettest summer in its history of precipitation measurements since 1881.

The Balkan Peninsula, too, received much heavy rain. In Slovenia, precipitation was abundant in the north-west. Many other parts had below-normal precipitation but also very intense thunderstorms during summer. Heavy precipitation in Romania between 20 June and 14 July caused severe flooding in many parts of the country. The rest of the eastern parts of the Balkan Peninsula were also wetter than normal as opposed to drier parts in the west.

Southern Spain, which already had received much precipitation in spring, also saw a lot of precipitation in summer, in places close to twice the normal, whereas other parts of Spain, Portugal, southern and western France were very dry. June was relatively wet in Spain, but July and partly also August were drier than normal. Average July precipitation over Spain (generally low in summer) was only around 50% of average. In southern Europe, it was generally very wet in June 2010, but became very dry in August.

In the Mediterranean, it was wet over Corsica and Sardinia, but dry over Sicily and Malta, in particular, which received only 1.4 mm during the whole summer and all of June (summer normal is 10.6 mm).

It was dry over most of European Russia and some adjacent areas (including southern Finland and most of the South Caucasus), particularly during the heat wave in this area in July and August. Some parts of eastern European Russia received less than 20% of the seasonal normal. Numerous forest and peat fires with subsequent air pollution occurred in many places; several settlements burnt down completely. It was the worst drought since 1972.

The main reason was the strong high pressure influence particularly over Russia, whereas low pressure systems were blocked over eastern central Europe.

The DWD drought index (Fig. 0.41) shows extreme drought conditions for the very dry areas in Russia and the Middle East and severe drought conditions over southern Portugal for that summer. Anomalies of this drought index imply that only the drought area in Russia showed an extreme deviation from normal.

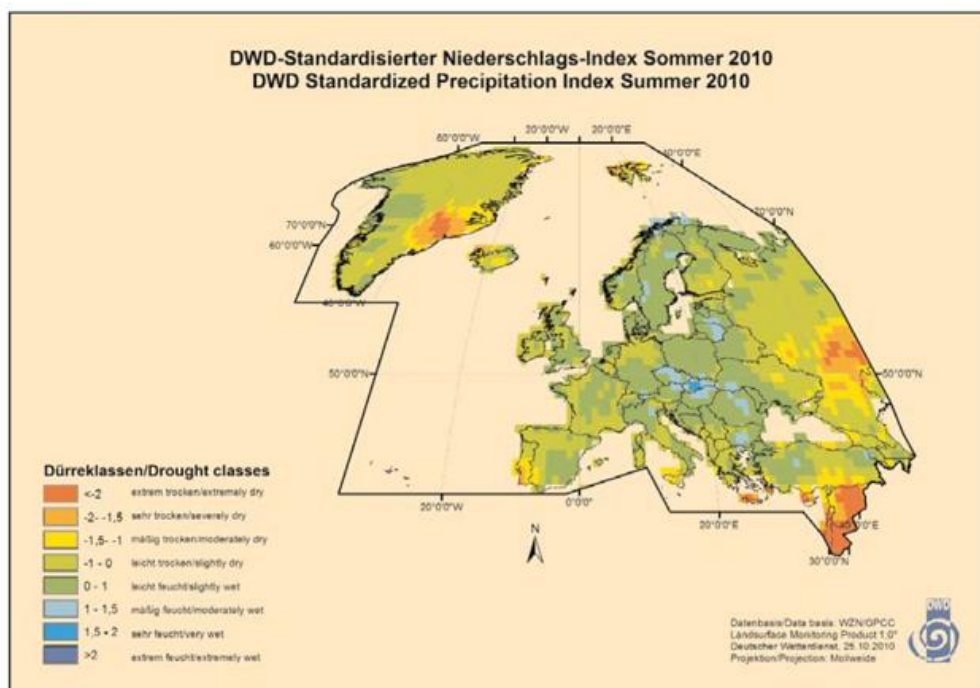


Fig. 0.41: Standardized precipitation index (DWD version) for summer 2010
 Source: Deutscher Wetterdienst, Germany

Autumn 2010 was wet or around normal in most of Europe, but very dry in Scandinavia (except for the southern parts), the Arctic, the northern Alps and particularly the Middle East (Seasonal Maps, Fig. S8).

Especially Norway and most of Sweden were very dry, mostly with less than 80% of the normal precipitation, locally less than 40%.

Precipitation was close to normal in most of western Europe as a result of a dry October, but a wet November. However, several heavy rain events caused high above-normal anomalies in some places in France.

Some larger parts of central, eastern and southern Europe (eastern Germany, Poland, eastern Ukraine, most of Italy and the Balkan Peninsula) were particularly wet; partly they received around twice the normal seasonal precipitation. Especially September and November totals were mostly above normal across central Europe, but these wet spells were interrupted by a mostly dry October, with some local exceptions.

Autumn was wet in northern Spain, whereas the Spanish Mediterranean regions were drier than normal. However, the number of days with totals >20 mm was much larger than normal over the Mediterranean and northern Italy.

It was very dry in the Middle East and in Cyprus. That area received less than 40% of its normal precipitation, which means a prolongation of the dry summer period.

The distribution of precipitation reflects a centre of intense low pressure activity over eastern central Europe, the Balkan Peninsula and the central Mediterranean.

Seasonal Maps

Surface temperature anomalies
December 2009 - February 2010

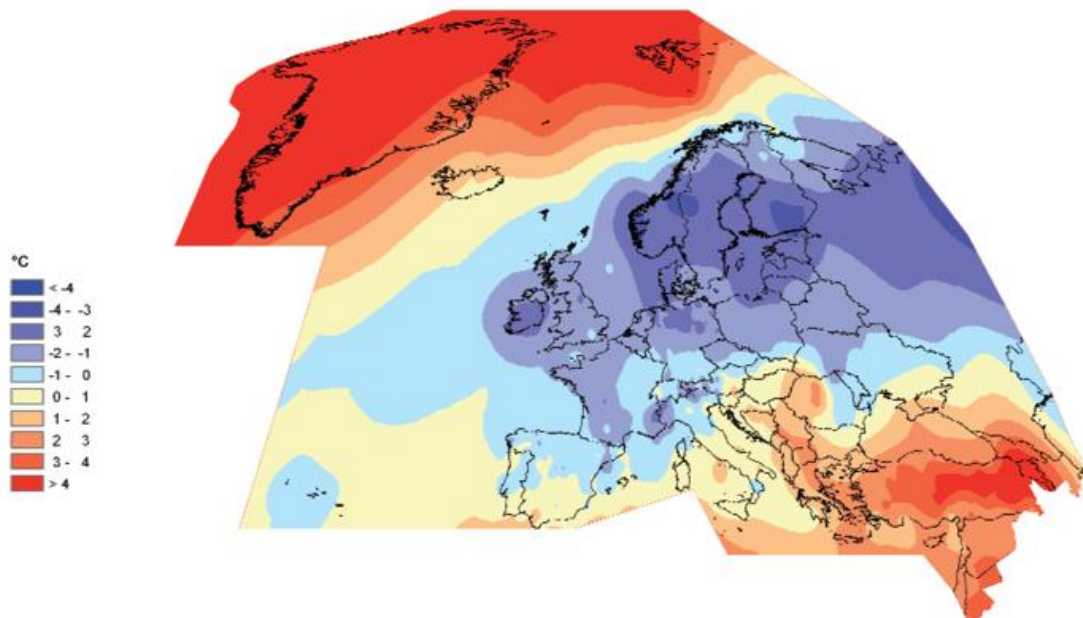


Fig. S1: Surface temperature anomalies (reference period 1961–1990) for winter 2009/10
Source: Deutscher Wetterdienst, Germany

March 2010 - May 2010

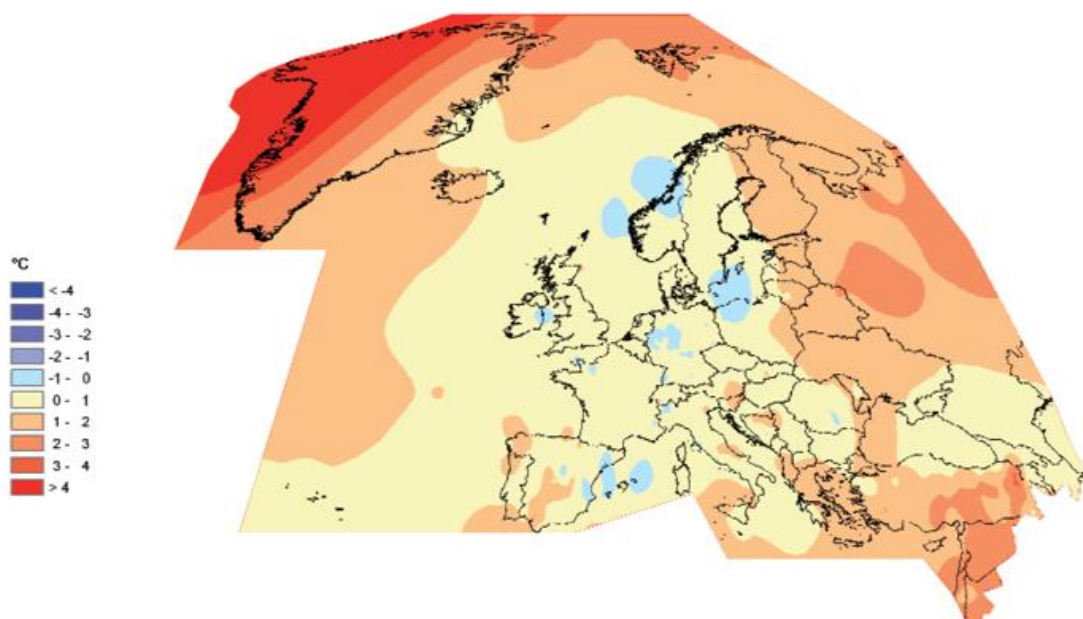


Fig. S2: Surface temperature anomalies (reference period 1961–1990) for spring 2010
Source: Deutscher Wetterdienst, Germany

**Surface temperature anomalies
June 2010 - August 2010**

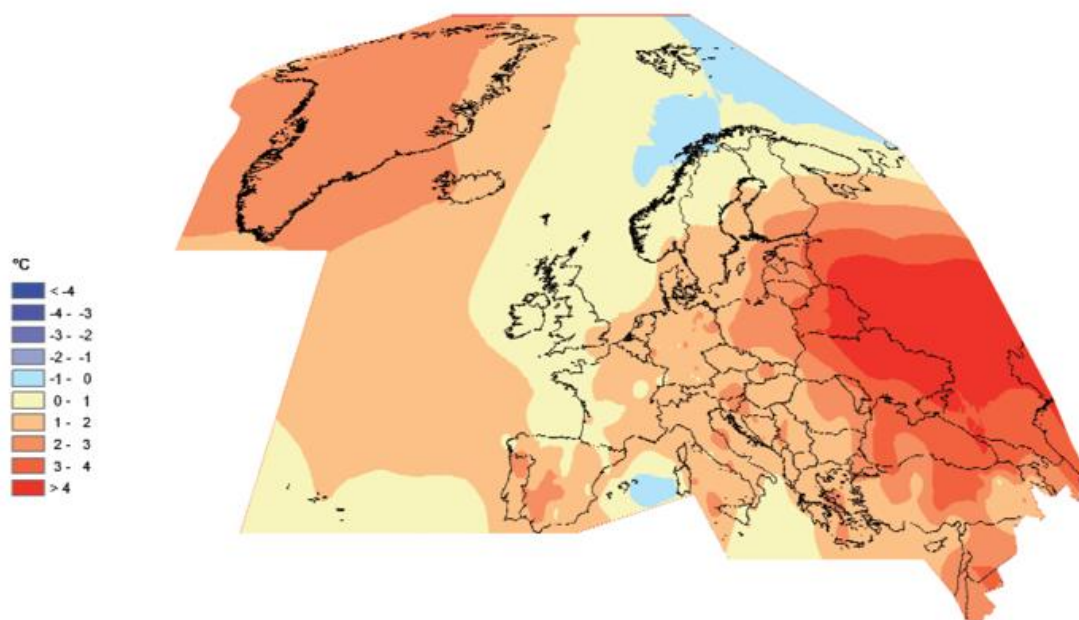


Fig. S3: Surface temperature anomalies (reference period 1961–1990) for summer 2010
Source: Deutscher Wetterdienst, Germany

September 2010 - November 2010

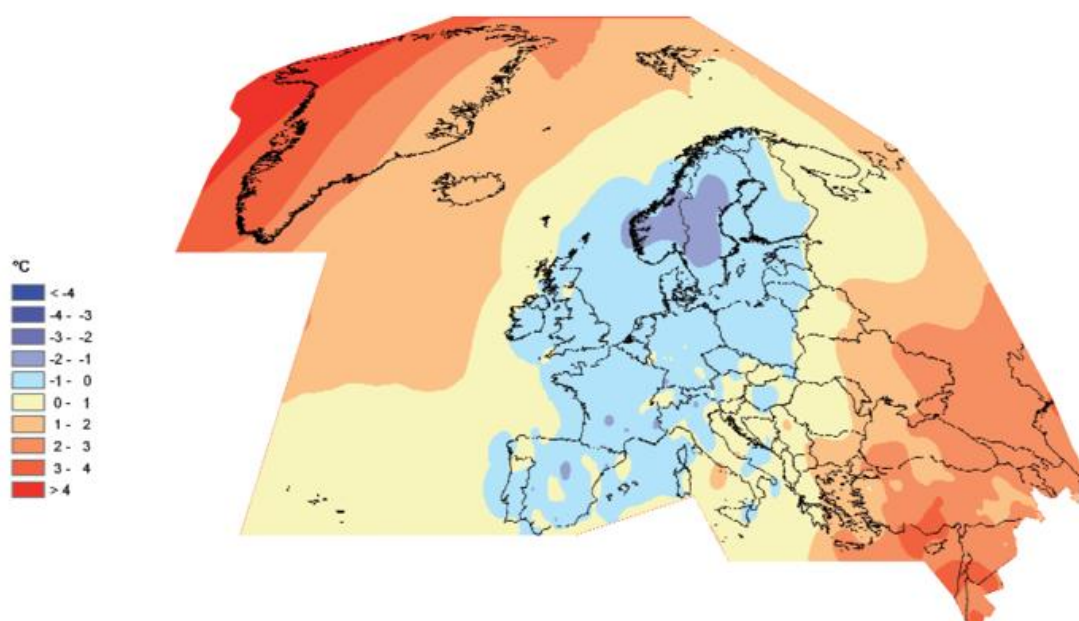


Fig. S4: Surface temperature anomalies (reference period 1961–1990) for autumn 2010
Source: Deutscher Wetterdienst, Germany

Precipitation in per cent of normal

December 2009 - February 2010

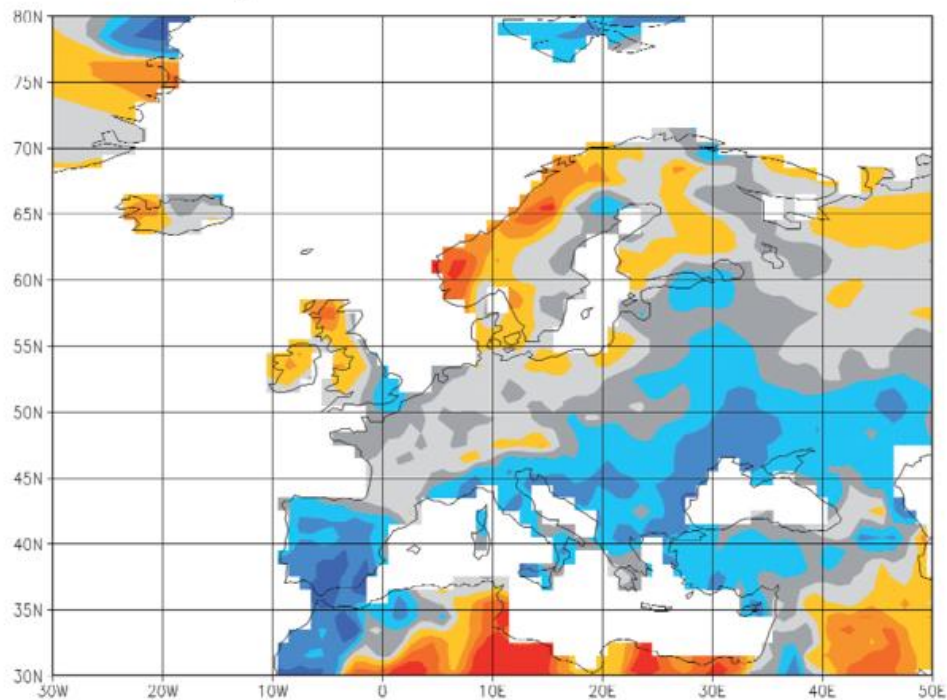


Fig. S5: Precipitation in per cent of normal (reference period 1951-2000) for winter 2009/10.
Gauge-based analysis 1.0 degree
Source: GPCC / Deutscher Wetterdienst, Germany

March 2010 - May 2010

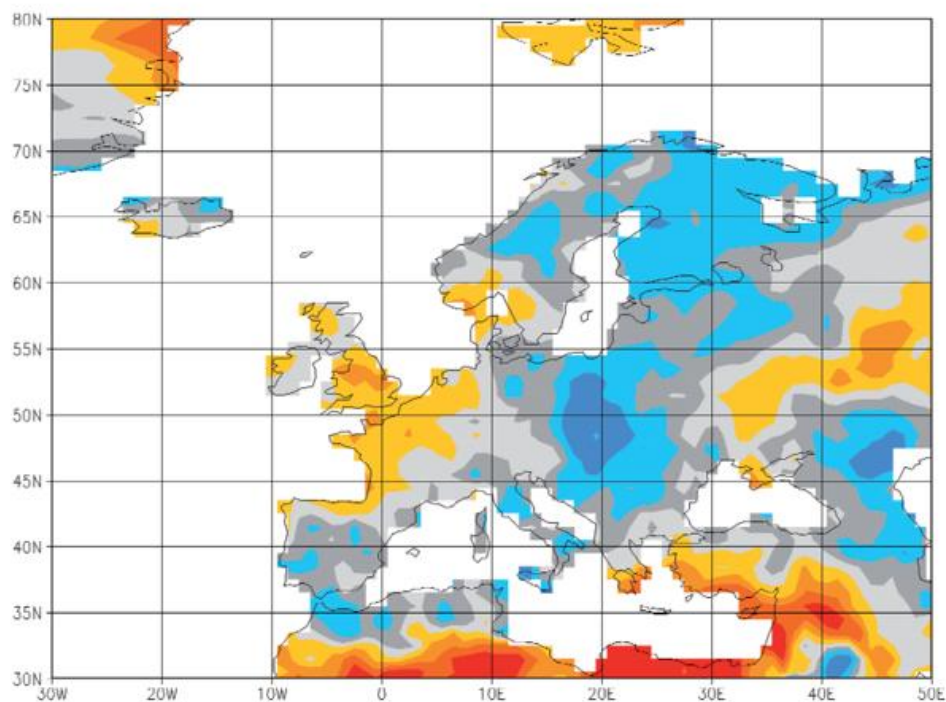


Fig. S6: Precipitation in per cent of normal (reference period 1951-2000) for spring 2010.
Gauge-based analysis 1.0 degree
Source: GPCC / Deutscher Wetterdienst, Germany



Precipitation in per cent of normal

June 2010 - August 2010

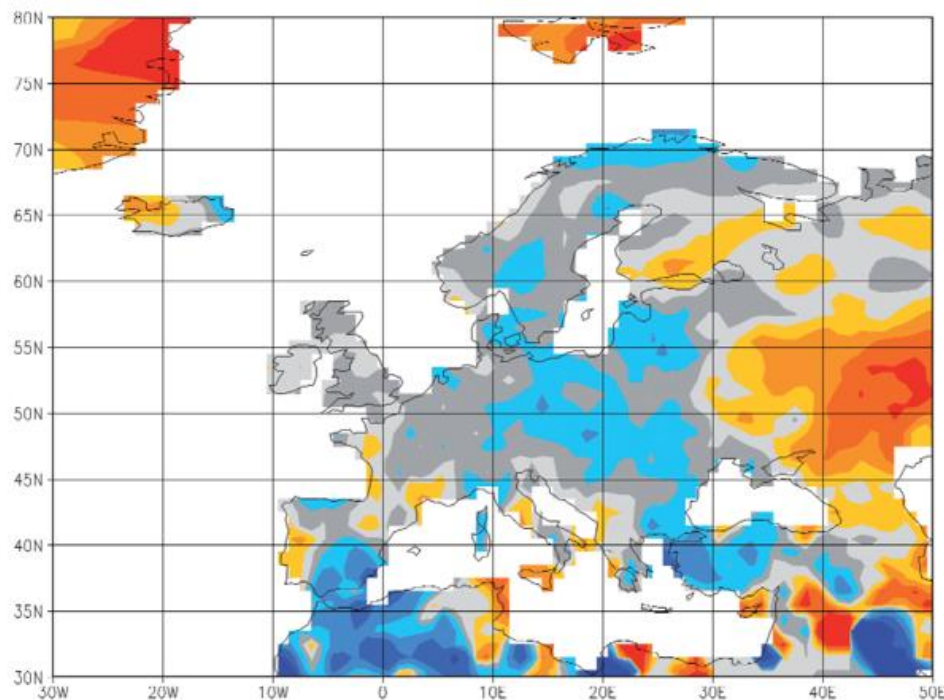


Fig. S7: Precipitation in per cent of normal (reference period 1951-2000) for summer 2010.
Gauge-based analysis 1.0 degree
Source: GPCC / Deutscher Wetterdienst, Germany

September 2010 - November 2010

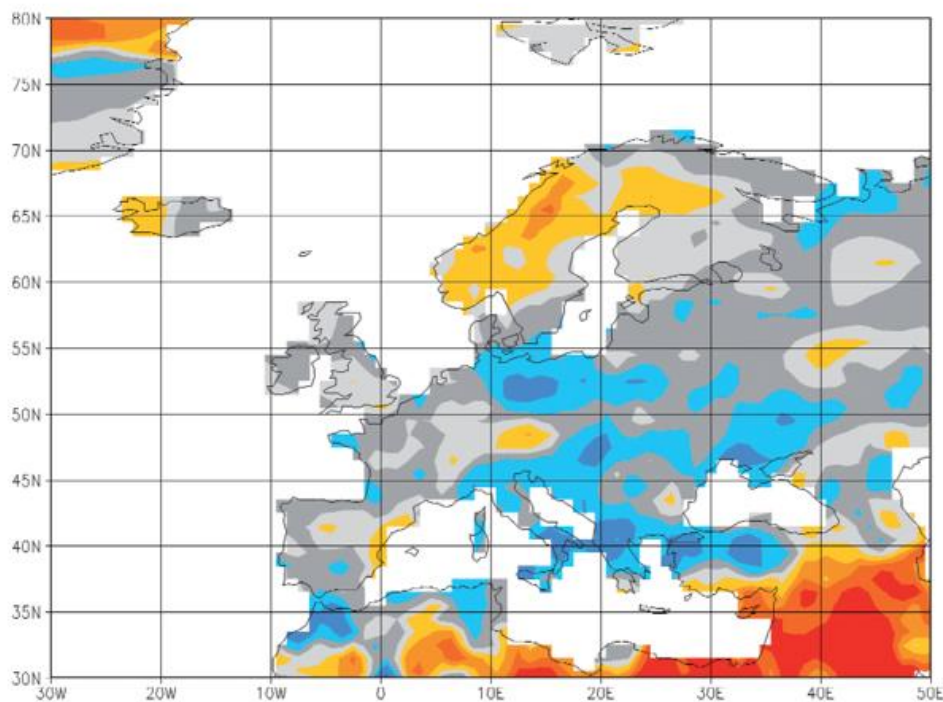


Fig. S8: Precipitation in per cent of normal (reference period 1951-2000) for autumn 2010.
Gauge-based analysis 1.0 degree
Source: GPCC / Deutscher Wetterdienst, Germany



Monthly and Annual Tables

Temperature and precipitation values with deviations from the 1961-1990 normal
(some stations have shorter reference periods)

WMO No.	Station	January 2010				February 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	dev.	Temp. mean	(°C) dev.	Prec. (mm) total	dev.
01008	Svalbard Airport	-7.2	8.2	69	55	-10.3	5.4	1	-18
01025	Tromsø	-2.9	1.1	77	-4	-7.4	-3.7	58	-28
01492	Oslo	-8.1	-3.8	14	-35	-6.3	-2.3	37	1
02196	Haparanda	-13.8	-1.7	17	-27	-14.9	-3.6	50	18
02485	Stockholm	-7.0	-4.2	26	-13	-5.2	-2.2	29	2
02836	Sodankylä	-14.6	0.5	12	-19	-17.5	-3.9	29	4
02974	Helsinki	-12.4	-5.5	22	-19	-9.1	-2.3	50	19
03091	Aberdeen	2.1	-0.6	73	-8	1.8	-1.1	86	35
03772	London	2.3	-1.9	52	0	4.4	-0.1	100	65
03967	Dublin Casement Aerodrome	1.4	-3.0	44	-22	2.3	-2.1	37	-14
04030	Reykjavik	2.4	2.9	91	15	0.0	-0.4	26	-46
04339	Scoresbysund	-12.4	1.9	32	3	-17.5	-2.5	25	-4
06186	Copenhagen	-2.4	-2.9	7	-44	-1.1	-1.6	21	-10
06260	De Bilt	-0.5	-2.7	41	-25	1.6	-0.9	77	28
06447	Brussels	0.1	-2.5	44	-23	2.5	-1.0	76	23
06590	Luxembourg	-2.1	-2.1	35	-36	1.0	-0.1	89	27
06660	Zurich	-1.9	-1.4	39	-28	0.9	0.0	35	-35
06700	Geneva	0.4	-0.4	47	-33	2.0	-0.3	97	16
07510	Bordeaux	3.5	-2.3	78	-22	5.8	-1.3	54	-32
07650	Marseilles	4.8	-1.9	89	42	6.9	-1.0	59	5
08222	Madrid	5.4	-0.7	61	15	6.4	-1.1	112	68
08314	Mahón/Minorca	10.0	-0.5	74	8	10.5	-0.2	75	18
08495	Gibraltar	13.9	0.5	386	265	14.8	1.0	485	385
08515	Santa Maria/Azores	15.0	0.6	181	81	14.3	0.3	176	90
08535	Lisbon	11.5	0.1	194	84	11.1	-1.2	298	187
10384	Berlin-Tempelhof	-4.5	-4.3	21	-22	0.3	-0.5	23	-11
11035	Vienna	-1.9	-0.9	56	18	0.8	-0.2	20	-22
11518	Prague	-4.5	-2.1	25	2	-1.7	-0.9	9	-14
11903	Sliač	-3.3	0.6	66	22	-1.1	0.0	48	4
12160	Elbląg	-7.4	-5.0	19	-28	-2.0	0.2	21	-4
12375	Warsaw	-8.0	-4.7	25	3	-1.8	0.2	37	16
12843	Budapest	-2.0	-0.4	52	20	0.7	-0.4	50	18
13274	Belgrade	0.7	0.3	92	43	3.7	1.0	113	69
14015	Ljubljana	-1.5	-0.4	125	43	1.3	-0.1	145	65
14445	Split	6.8	-0.6	140	57	8.5	0.4	164	96
14654	Sarajevo	0.4	1.3	161	90	1.5	0.0	96	29
15420	Bucharest	-3.6	-1.2	64	24	-0.5	-0.4	94	58
15614	Sofia	0.1	1.7	28	1	1.6	1.1	56	23
16206	Grosseto	6.9	-0.1	109	45	8.5	0.5	64	7
16597	Luqa	13.4	1.2	57	-32	13.8	1.4	16	-45
16716	Athens	11.1	0.9	31	-13	12.8	2.2	38	-5
16754	Heraklion/Crete	13.4	1.4	141	51	14.9	2.8	11	-66
17040	Rize	9.0	2.7	312	89	9.3	2.7	159	-12
17062	Istanbul	7.2	1.6	186	87	8.6	2.7	141	74
17170	Van	0.1	4.5	52	18	1.4	5.2	39	6
17300	Antalya	10.9	1.0	340	101	12.3	2.0	289	93
17609	Larnaca	14.0	2.5	131	66	13.8	2.1	120	63
22113	Murmansk	-12.2	-0.5	17	-16	-12.5	-1.3	30	8
26038	Tallinn	-11.0	-5.5	27	-18	-7.7	-2.0	50	21
26629	Kaunas	-10.2	-5.2	20	-17	-3.9	0.4	39	12
26730	Vilnius	-10.4	-4.3	23	-18	-4.1	0.7	44	6
26850	Minsk	-11.1	-4.2	40	0	-4.8	1.0	55	21
27612	Moscow	-14.5	-5.2	18	-27	-8.4	-0.7	64	27
33345	Kiev	-8.8	-3.2	54	7	-3.3	0.9	62	16
33815	Kishinev	-5.2	-1.9	86	46	-0.9	0.8	62	24
34300	Kharkiv	-9.7	-2.8	45	1	-4.2	1.5	59	27
34880	Astrakhan	-6.6	-1.2	25	12	-5.5	-0.6	9	-1
35188	Astana	-19.4	-3.6	20	3	-20.0	-4.1	10	-4
37789	Yerevan	2.8	6.0	52	23	4.5	5.5	56	18
40007	Aleppo	8.9	3.2	49	-15	9.3	2.0	81	29
40080	Damascus	9.4	3.5	36	7	10.7	2.8	16	-8
40180	Tel Aviv	15.6	3.3	67	-82	16.7	3.8	157	59
40199	Eilat	18.4	3.2	20	15	20.1	3.2	4	-1
40265	Mafrq	10.5	3.3	40	6	11.5	2.8	43	12
60030	Las Palmas/Grand Canary	19.3	1.8	60	43	20.3	2.7	30	8

WMO No.	Station	March 2010				April 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	(mm) dev.	Temp. mean	(°C) dev.	Prec. (mm) total	(mm) dev.
01008	Svalbard Airport	-15.8	-1.1	13	-8	-7.7	4.0	5	-7
01025	Tromsø	-4.3	-2.1	89	25	1.5	0.8	51	-9
01492	Oslo	0.3	0.5	66	20	6.0	1.4	32	-10
02196	Haparanda	-7.5	-0.7	58	23	1.8	2.3	23	-6
02485	Stockholm	-0.2	-0.3	21	-5	6.4	1.8	23	-7
02836	Sodankylä	-10.3	-1.8	55	30	1.2	3.3	20	-4
02974	Helsinki	-2.7	0.2	56	22	4.7	1.8	54	17
03091	Aberdeen	5.5	1.0	47	-11	8.0	1.7	34	-19
03772	London	7.5	1.0	40	-7	10.7	1.8	23	-22
03967	Dublin Casement Aerodrome	5.4	-0.6	59	10	8.3	0.5	33	-14
04030	Reykjavik	3.1	2.6	55	-27	2.8	-0.1	36	-22
04339	Scoresbysund	-17.3	-1.9	32	9	-8.5	1.8	27	6
06186	Copenhagen	3.4	0.8	40	-2	8.0	1.4	25	-17
06260	De Bilt	6.4	1.4	55	-8	9.7	1.7	31	-21
06447	Brussels	6.7	1.2	50	-4	10.3	1.5	16	-41
06590	Luxembourg	5.0	1.0	65	-5	10.0	2.5	18	-43
06660	Zurich	4.6	0.4	54	-15	10.1	2.3	34	-53
06700	Geneva	5.6	0.5	61	-18	11.0	2.2	22	-43
07510	Bordeaux	8.8	0.0	68	-8	13.8	2.5	27	-45
07650	Marseilles	9.7	-0.5	59	15	14.3	1.1	25	-23
08222	Madrid	9.3	-0.7	60	27	14.3	2.1	48	-6
08314	Mahón/Minorca	11.0	-0.6	19	-36	13.1	-0.2	58	8
08495	Gibraltar	15.3	0.3	187	112	16.8	0.6	82	22
08515	Santa Maria/Azores	14.6	0.0	252	173	15.5	0.3	103	48
08535	Lisbon	13.4	-0.3	193	124	17.1	2.0	89	25
10384	Berlin-Tempelhof	5.1	0.9	39	2	9.8	1.2	16	-25
11035	Vienna	6.0	1.0	18	-23	10.8	0.9	91	40
11518	Prague	3.8	0.8	15	-13	8.9	1.2	37	-1
11903	Sliač	4.0	1.0	21	-21	9.8	1.3	62	15
12160	Elbląg	3.0	0.9	37	2	7.8	1.0	10	-32
12375	Warsaw	3.9	1.9	24	-4	9.5	1.7	39	7
12843	Budapest	6.6	1.0	19	-10	12.0	0.9	43	5
13274	Belgrade	8.2	1.0	47	-3	13.4	1.0	44	-15
14015	Ljubljana	6.2	0.8	35	-63	11.5	1.6	82	-27
14445	Split	10.6	0.2	69	-6	15.4	1.5	88	22
14654	Sarajevo	5.2	0.1	63	-7	10.2	0.8	59	-15
15420	Bucharest	4.7	-0.1	47	9	11.5	0.2	45	-1
15614	Sofia	5.5	0.9	74	36	10.5	0.6	54	4
16206	Grosseto	9.6	-0.6	49	-23	13.4	0.7	65	-4
16597	Luqa	14.1	0.7	71	30	17.0	1.5	1	-22
16716	Athens	13.9	1.3	8	-33	17.7	1.6	11	-14
16754	Heraklion/Crete	15.3	1.9	37	-19	17.6	1.3	6	-24
17040	Rize	8.6	0.7	219	73	11.5	-0.1	109	7
17062	Istanbul	9.1	1.6	70	8	13.7	1.7	48	-1
17170	Van	5.8	4.9	38	-4	8.4	1.1	46	-8
17300	Antalya	16.1	3.4	9	-94	17.6	1.5	14	-32
17609	Larnaca	15.7	2.4	1	-48	18.7	1.3	2	-9
22113	Murmansk	-7.9	-1.1	47	27	1.7	3.6	26	5
26038	Tallinn	-1.8	0.4	51	22	4.9	1.5	36	0
26629	Kaunas	0.1	0.3	30	-2	7.4	1.4	59	16
26730	Vilnius	0.2	0.8	47	8	7.6	1.9	36	-10
26850	Minsk	0.1	1.5	28	-14	8.5	2.5	27	-15
27612	Moscow	-1.1	1.1	22	-12	8.3	2.5	31	-9
33345	Kiev	1.4	0.7	20	-19	10.3	1.6	42	-7
33815	Kishinev	4.0	1.1	29	-6	11.0	0.8	45	3
34300	Kharkiv	0.2	0.5	20	-7	10.3	1.4	24	-12
34880	Astrakhan	2.7	1.4	20	6	10.7	-0.4	42	24
35188	Astana	-6.7	1.4	39	25	5.8	0.9	20	-2
37789	Yerevan	9.2	-0.4	17	24	11.2	-0.4	128	77
40007	Aleppo	13.8	2.8	16	-29	17.6	1.8	16	-20
40080	Damascus	14.5	3.5	2	-15	18.1	2.6	0	-11
40180	Tel Aviv	18.6	3.7	22	-40	20.1	1.9	3	-20
40199	Eilat	22.8	2.8	<1	-4	26.4	2.2	<1	-4
40265	Mafraq	14.9	3.4	2	-27	17.9	2.1	0	-10
60030	Las Palmas/Grand Canary	20.3	1.9	0	-10	21.0	2.3	<1	-6

WMO No.	Station	May 2010				June 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	(mm) dev.	Temp. mean	(°C) dev.	Prec. (mm) total	(mm) dev.
01008	Svalbard Airport	0.0	3.7	7	1	3.5	1.3	4	-6
01025	Tromsø	7.2	2.3	44	-4	7.2	-2.1	116	63
01492	Oslo	11.0	0.2	25	-27	15.3	0.1	91	26
02196	Haparanda	10.2	4.1	56	25	11.9	-0.9	25	-16
02485	Stockholm	11.3	0.6	31	1	15.7	0.1	33	-12
02836	Sodankylä	8.1	3.1	63	28	10.9	-0.7	29	-27
02974	Helsinki	11.9	2.0	80	45	15.1	0.2	32	-12
03091	Aberdeen	9.3	0.3	58	-1	13.2	1.1	23	-30
03772	London	12.5	0.0	21	-30	17.8	2.1	12	-39
03967	Dublin Casement Aerodrome	10.3	-0.2	45	-13	14.8	1.5	45	-3
04030	Reykjavik	8.2	1.9	30	-14	11.4	2.4	30	-20
04339	Scoresbysund	-1.9	1.0	16	4	2.0	-0.4	8	-18
06186	Copenhagen	10.6	-1.4	49	6	15.4	-0.7	67	13
06260	De Bilt	10.5	-1.8	66	5	16.4	1.2	18	-50
06447	Brussels	11.2	-1.7	67	-4	17.4	1.7	30	-49
06590	Luxembourg	10.9	-0.9	111	30	17.5	2.6	72	-10
06660	Zurich	11.5	-0.6	140	37	16.9	1.7	126	2
06700	Geneva	13.0	0.0	108	31	17.6	1.1	77	-12
07510	Bordeaux	14.9	0.3	41	-36	19.2	1.4	102	46
07650	Marseilles	16.9	-0.2	43	1	21.6	0.7	56	28
08222	Madrid	16.2	0.2	23	-18	21.1	0.4	59	33
08314	Mahón/Minorca	15.8	-1.0	48	11	19.8	-1.0	11	-3
08495	Gibraltar	19.0	0.5	27	-8	21.8	0.7	14	3
08515	Santa Maria/Azores	17.0	0.3	39	9	19.4	0.7	10	-12
08535	Lisbon	18.1	0.7	38	-1	20.4	0.2	32	11
10384	Berlin-Tempelhof	11.6	-2.3	72	16	18.4	1.0	2	-73
11035	Vienna	14.6	0.0	169	108	19.2	1.3	120	46
11518	Prague	11.8	-0.9	78	1	16.8	0.9	56	-17
11903	Sliač	14.8	1.1	152	88	19.0	2.4	165	80
12160	Elbląg	11.3	-1.6	86	45	16.0	0.6	23	-71
12375	Warsaw	13.6	0.2	116	57	17.8	1.2	87	15
12843	Budapest	15.9	-0.1	163	108	20.0	0.9	133	70
13274	Belgrade	17.9	0.7	86	15	21.1	1.0	182	92
14015	Ljubljana	15.3	0.7	102	-20	20.3	2.5	124	-31
14445	Split	18.5	0.1	98	42	23.5	1.3	64	13
14654	Sarajevo	14.4	0.3	93	11	17.9	1.0	182	91
15420	Bucharest	16.4	-0.3	78	8	21.1	0.9	120	43
15614	Sofia	15.7	1.4	66	-7	18.6	0.9	77	5
16206	Grosseto	16.6	-0.3	69	25	21.4	0.8	18	-10
16597	Luqa	19.4	0.3	12	5	22.9	-0.1	1	-2
16716	Athens	21.8	1.2	21	5	26.1	1.0	11	4
16754	Heraklion/Crete	21.5	1.7	5	-11	24.8	1.3	6	3
17040	Rize	17.7	1.9	107	6	23.2	3.3	250	125
17062	Istanbul	19.3	2.8	13	-18	22.7	1.6	104	83
17170	Van	13.3	0.5	73	23	19.8	2.2	41	20
17300	Antalya	21.5	1.2	19	-9	25.0	0.0	21	13
17609	Larnaca	22.1	1.2	<1	-7	25.4	1.1	6	5
22113	Murmansk	6.2	2.4	40	8	9.0	-0.4	52	-1
26038	Tallinn	11.0	1.3	64	27	13.8	-0.7	43	-10
26629	Kaunas	13.7	1.0	95	39	16.5	0.5	127	52
26730	Vilnius	14.0	1.5	113	51	16.7	0.9	142	65
26850	Minsk	14.6	1.7	136	74	18.4	2.3	146	63
27612	Moscow	16.7	3.8	59	1	18.8	2.2	62	-14
33345	Kiev	17.3	2.2	55	2	22.0	3.8	25	-48
33815	Kishinev	16.8	0.7	69	18	21.0	1.6	85	10
34300	Kharkiv	18.0	2.4	47	0	23.2	4.3	19	-39
34880	Astrakhan	20.0	1.7	29	5	26.2	3.3	5	-17
35188	Astana	14.1	1.0	32	-1	21.6	2.6	8	-27
37789	Yerevan	15.9	3.8	96	36	24.4	2.5	33	4
40007	Aleppo	23.1	1.9	4	-15	26.7	0.9	0	-2
40080	Damascus	22.8	2.6	0	-4	26.4	2.0	0	0
40180	Tel Aviv	22.9	1.8	2	-1	26.4	2.4	1	1
40199	Eilat	30.0	1.6	0	-1	33.3	1.6	0	0
40265	Mafrq	21.5	1.7	<1	-3	24.4	1.7	0	0
60030	Las Palmas/Grand Canary	21.4	1.5	4	2	22.7	1.3	0	0

WMO No.	Station	July 2010				August 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	dev.	Temp. mean	(°C) dev.	Prec. (mm) total	dev.
01008	Svalbard Airport	6.6	0.6	13	0	4.8	0.0	13	-12
01025	Tromsø	11.5	-0.2	102	30	9.8	-1.1	65	-17
01492	Oslo	18.0	1.6	109	25	16.1	0.9	152	62
02196	Haparanda	16.5	1.0	34	-16	12.8	-0.5	71	8
02485	Stockholm	21.2	4.0	74	2	17.2	1.0	103	37
02836	Sodankylä	15.8	1.7	132	67	11.4	0.2	55	-8
02974	Helsinki	22.4	5.8	15	-58	17.7	2.7	71	-9
03091	Aberdeen	14.5	0.7	110	50	13.8	0.2	48	-27
03772	London	20.0	2.2	18	-28	17.4	0.0	89	38
03967	Dublin Casement Aerodrome	15.9	1.0	82	28	13.9	-0.7	44	-34
04030	Reykjavik	13.0	2.4	43	-9	12.1	1.8	55	-7
04339	Scoresbysund	6.0	0.7	5	-33	5.9	1.3	31	-2
06186	Copenhagen	20.6	3.4	26	-43	17.5	0.5	168	105
06260	De Bilt	19.9	3.1	77	2	16.8	0.1	155	84
06447	Brussels	20.5	3.0	63	-12	17.0	-0.3	187	124
06590	Luxembourg	20.5	3.6	47	-21	16.6	0.2	178	106
06660	Zurich	20.0	2.4	132	15	17.2	0.5	121	-12
06700	Geneva	22.1	3.0	14	-53	18.7	0.5	122	43
07510	Bordeaux	22.1	1.9	15	-32	20.4	0.5	17	-37
07650	Marseilles	26.1	2.3	2	-12	24.0	0.8	43	14
08222	Madrid	27.4	3.0	15	2	26.0	2.1	3	-6
08314	Mahón/Minorca	24.3	0.1	<1	-4	23.5	-1.0	17	-9
08495	Gibraltar	24.4	0.7	2	1	25.7	1.5	6	0
08515	Santa Maria/Azores	21.8	1.0	7	-18	22.6	0.4	38	-2
08535	Lisbon	24.2	1.8	0	-5	25.0	2.2	2	-4
10384	Berlin-Tempelhof	23.3	4.5	56	4	18.9	0.5	142	81
11035	Vienna	22.3	2.6	88	25	19.4	0.5	123	65
11518	Prague	20.7	3.2	128	62	17.8	0.8	121	51
11903	Sliač	22.0	3.8	93	34	18.8	1.5	118	49
12160	Elbląg	21.3	4.5	65	-29	19.4	2.7	115	34
12375	Warsaw	21.9	4.0	92	25	19.7	2.4	143	80
12843	Budapest	23.6	2.7	41	-11	21.0	0.7	82	31
13274	Belgrade	24.1	2.4	41	-25	24.0	2.7	54	2
14015	Ljubljana	22.8	2.9	112	-10	20.3	1.2	176	32
14445	Split	27.2	1.8	23	-5	26.3	1.1	10	-40
14654	Sarajevo	20.7	1.8	29	-50	21.4	2.9	44	-27
15420	Bucharest	22.8	0.8	69	5	23.5	2.3	32	-26
15614	Sofia	21.2	1.2	53	-3	22.5	3.1	41	-11
16206	Grosseto	26.1	2.5	5	-15	23.8	0.3	52	15
16597	Luqa	26.7	0.8	0	0	27.2	0.9	0	-7
16716	Athens	29.5	1.7	0	-5	30.8	3.2	0	-5
16754	Heraklion/Crete	27.4	1.7	0	-1	28.3	2.7	0	-1
17040	Rize	25.9	3.7	189	55	27.0	4.8	342	156
17062	Istanbul	25.7	2.5	43	24	27.7	4.7	2	-24
17170	Van	24.0	2.1	0	-4	23.2	2.0	1	-3
17300	Antalya	27.6	-0.5	0	-3	30.2	2.5	4	3
17609	Larnaca	27.8	0.9	0	0	30.0	2.9	0	0
22113	Murmansk	14.0	1.2	103	43	10.3	-0.7	97	32
26038	Tallinn	21.5	5.2	147	68	17.7	2.4	54	-30
26629	Kaunas	21.9	4.8	101	33	19.7	3.4	113	50
26730	Vilnius	21.8	4.9	208	130	19.8	3.5	116	44
26850	Minsk	22.6	5.3	95	7	20.9	4.4	86	14
27612	Moscow	26.0	7.9	12	-80	21.8	5.4	68	-6
33345	Kiev	24.4	5.1	104	16	24.6	6.0	25	-44
33815	Kishinev	23.3	2.4	71	2	24.9	4.4	53	8
34300	Kharkiv	25.7	5.4	61	1	26.1	6.6	16	-34
34880	Astrakhan	29.1	3.8	<1	-23	27.3	4.0	<1	-19
35188	Astana	19.5	-1.8	32	-18	21.5	3.8	9	-31
37789	Yerevan	27.1	2.7	25	11	26.6	3.9	<1	-6
40007	Aleppo	29.7	1.4	0	0	32.2	4.1	0	-1
40080	Damascus	28.8	2.5	0	0	30.6	4.6	0	0
40180	Tel Aviv	27.6	1.9	0	0	29.5	3.4	0	0
40199	Eilat	34.1	1.2	0	0	36.2	3.4	0	0
40265	Mafrq	26.2	2.1	0	0	28.8	4.6	0	0
60030	Las Palmas/Grand Canary	24.0	0.7	<1	<1	25.4	1.3	0	0

WMO No.	Station	September 2010				October 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	dev.	Temp. mean	(°C) dev.	Prec. (mm) total	dev.
01008	Svalbard Airport	2.0	1.5	8	-15	-2.9	2.6	36	21
01025	Tromsø	8.1	1.3	51	-43	3.5	0.6	230	105
01492	Oslo	11.3	0.5	89	-1	5.7	-0.7	84	0
02196	Haparanda	8.9	1.0	57	-6	3.8	1.3	45	-19
02485	Stockholm	12.1	0.9	73	18	6.4	-1.1	34	-16
02836	Sodankylä	6.9	1.0	51	-4	2.0	2.3	53	2
02974	Helsinki	11.5	1.5	54	-19	5.1	-0.3	29	-44
03091	Aberdeen	12.1	0.4	39	-29	9.1	-0.8	62	-15
03772	London	15.3	0.3	38	-13	11.9	0.2	75	17
03967	Dublin Casement Aerodrome	13.4	0.4	103	34	10.1	-0.2	38	-30
04030	Reykjavik	10.2	2.8	92	25	6.3	1.9	41	-45
04339	Scoresbysund	2.6	2.0	101	48	-3.1	2.5	20	-36
06186	Copenhagen	13.4	-0.2	42	-20	8.8	-1.1	41	-18
06260	De Bilt	13.6	-0.4	90	23	10.4	-0.1	88	16
06447	Brussels	14.2	-0.3	110	51	10.6	-0.3	71	1
06590	Luxembourg	13.0	-0.4	81	11	8.8	-0.3	53	-22
06660	Zurich	13.2	-0.6	89	-3	8.7	-0.6	46	-23
06700	Geneva	14.4	-0.5	36	-45	10.1	0.0	31	-46
07510	Bordeaux	17.9	0.0	24	-50	13.5	-0.5	93	5
07650	Marseilles	19.4	-0.9	30	-17	15.5	-0.6	78	0
08222	Madrid	21.3	0.8	12	-18	14.1	-0.7	58	13
08314	Mahón/Minorca	21.2	-1.0	90	36	18.2	-0.3	171	87
08495	Gibraltar	23.0	0.2	11	-4	19.5	0.0	72	8
08515	Santa Maria/Azores	22.1	0.7	52	-5	19.6	0.3	56	-28
08535	Lisbon	21.5	-0.2	5	-21	17.5	-1.0	262	182
10384	Berlin-Tempelhof	13.7	-0.9	87	41	8.6	-1.4	20	-16
11035	Vienna	14.2	-0.9	65	20	7.8	-2.1	23	-18
11518	Prague	12.2	-1.1	73	33	6.8	-1.5	12	-18
11903	Sliač	13.0	-0.4	115	59	6.7	-1.6	36	-14
12160	Elbląg	13.0	0.3	53	-17	6.3	-2.6	17	-36
12375	Warsaw	12.4	-0.8	89	46	6.1	-2.2	3	-35
12843	Budapest	14.7	-1.7	144	104	8.4	-2.5	30	-4
13274	Belgrade	17.8	0.1	52	1	10.5	-1.9	49	9
14015	Ljubljana	14.7	-0.8	425	295	9.5	-0.9	105	-10
14445	Split	21.1	-0.3	79	18	16.0	-0.9	58	-21
14654	Sarajevo	14.9	-0.2	126	56	8.6	-1.8	81	-7
15420	Bucharest	16.8	-0.1	24	-18	8.0	-2.8	54	22
15614	Sofia	16.3	0.5	47	8	8.6	-1.8	90	53
16206	Grosseto	20.2	-0.2	19	-46	15.6	-0.5	29	-58
16597	Luqa	24.0	-0.1	75	35	20.6	-0.1	230	140
16716	Athens	25.2	1.0	31	21	19.2	-0.1	108	56
16754	Heraklion/Crete	25.1	2.0	<1	-18	21.7	2.0	70	-6
17040	Rize	22.9	3.5	187	-36	16.7	1.3	461	188
17062	Istanbul	22.1	2.4	16	-25	15.4	0.1	278	207
17170	Van	19.5	2.7	4	-6	12.6	2.5	46	-2
17300	Antalya	26.9	2.4	10	-1	21.7	2.1	67	-3
17609	Larnaca	27.4	2.3	0	0	23.4	2.1	3	-16
22113	Murmansk	8.0	1.3	56	4	2.9	1.9	79	37
26038	Tallinn	11.6	0.8	56	-26	4.5	-1.8	39	-31
26629	Kaunas	12.0	-0.1	63	4	4.7	-2.2	31	-20
26730	Vilnius	11.4	-0.2	80	15	4.4	-2.2	42	-11
26850	Minsk	11.9	0.2	79	19	4.4	-1.9	21	-28
27612	Moscow	11.7	0.8	70	6	3.8	-1.2	42	-16
33345	Kiev	14.9	1.0	51	4	6.3	-1.8	35	0
33815	Kishinev	16.1	-0.1	46	-2	7.5	-2.6	69	42
34300	Kharkiv	15.8	1.7	117	76	6.0	-1.3	80	45
34880	Astrakhan	19.9	2.6	3	-23	9.6	0.5	75	58
35188	Astana	13.6	1.6	14	-10	5.5	2.7	6	-24
37789	Yerevan	23.7	2.4	3	-6	15.2	2.4	83	51
40007	Aleppo	27.4	2.2	2	0	21.2	1.6	11	-11
40080	Damascus	26.5	3.3	0	-1	22.0	3.9	4	-8
40180	Tel Aviv	27.9	3.1	<1	<1	25.6	3.6	6	-20
40199	Eilat	32.6	2.2	0	0	29.7	3.0	0	-4
40265	Mafrq	25.4	2.7	0	-1	22.3	3.2	0	-7
60030	Las Palmas/Grand Canary	24.9	1.1	6	-2	23.5	1.0	25	15

WMO No.	Station	November 2010				December 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	dev.	Temp. mean	(°C) dev.	Prec. (mm) total	dev.
01008	Svalbard Airport	-11.0	-0.5	10	-3	-11.6	1.7	9	-3
01025	Tromsø	-2.2	-1.4	61	-43	-2.9	0.1	127	23
01492	Oslo	-2.0	-2.7	24	-51	-9.2	-6.4	15	-41
02196	Haparanda	-8.1	-4.0	25	-33	-12.6	-3.1	24	-18
02485	Stockholm	0.3	-2.3	56	3	-6.5	-5.5	37	-9
02836	Sodankylä	-11.4	-4.0	8	-31	-15.2	-2.1	9	-22
02974	Helsinki	-1.7	-1.8	78	6	-8.9	-4.8	56	-2
03091	Aberdeen	4.3	-0.7	92	17	0.0	-3.5	61	-12
03772	London	6.7	-0.5	32	-23	1.4	-3.7	20	-37
03967	Dublin Casement Aerodrome	4.9	-1.8	120	50	-0.4	-5.7	66	-11
04030	Reykjavik	0.6	-0.5	38	-35	0.7	0.9	57	-22
04339	Scoresbysund	-12.3	-1.5	0	-44	-9.2	5.2	70	6
06186	Copenhagen	3.9	-1.6	53	-9	-3.1	-5.3	27	-31
06260	De Bilt	5.8	-0.1	83	2	-1.1	-4.3	43	-37
06447	Brussels	6.1	0.0	125	49	-0.7	-4.2	76	0
06590	Luxembourg	5.0	1.2	85	2	-2.5	-3.5	85	5
06660	Zurich	5.3	1.4	81	-1	-0.8	-1.4	105	32
06700	Geneva	6.3	1.3	102	10	0.3	-1.5	95	8
07510	Bordeaux	9.2	0.1	215	121	4.5	-1.9	80	-19
07650	Marseilles	10.5	-0.2	93	35	6.5	-0.8	34	-22
08222	Madrid	8.6	-0.8	28	-36	6.2	-0.2	78	27
08314	Mahón/Minorca	14.0	-0.4	185	108	11.2	-0.6	32	-42
08495	Gibraltar	15.2	-0.9	294	153	15.1	1.0	333	187
08515	Santa Maria/Azores	17.4	0.0	73	-29	15.0	-0.4	378	283
08535	Lisbon	13.9	-0.6	87	-27	11.8	0.0	162	54
10384	Berlin-Tempelhof	5.4	0.5	102	53	-4.0	-5.4	48	-5
11035	Vienna	7.5	2.9	36	-14	-2.3	-3.2	42	-1
11518	Prague	4.9	2.1	51	19	-5.3	-4.7	36	10
11903	Sliač	7.0	4.0	130	61	-4.6	-2.9	60	3
12160	Elbląg	4.5	1.2	112	56	-6.2	-6.5	70	18
12375	Warsaw	5.8	2.6	109	67	-5.4	-4.5	34	2
12843	Budapest	8.0	3.2	76	24	-1.7	-2.1	41	1
13274	Belgrade	12.3	5.3	45	-9	2.5	0.2	61	3
14015	Ljubljana	8.1	3.5	186	51	-0.4	-0.4	182	81
14445	Split	13.9	1.7	198	90	8.2	-0.5	134	34
14654	Sarajevo	9.7	4.9	139	48	1.4	1.6	113	49
15420	Bucharest	9.5	4.3	18	-31	-0.7	-0.9	92	49
15614	Sofia	10.2	5.2	28	-19	0.6	0.1	105	66
16206	Grosseto	12.0	0.8	117	23	8.0	0.1	72	7
16597	Luqa	18.2	1.2	19	-61	14.5	0.7	31	-81
16716	Athens	18.2	2.7	36	-14	13.7	1.5	22	-49
16754	Heraklion/Crete	18.8	2.2	50	-9	15.9	2.1	105	31
17040	Rize	14.1	2.5	8	-242	12.3	4.0	111	-127
17062	Istanbul	15.8	4.2	15	-74	10.6	2.5	162	40
17170	Van	4.3	0.3	0	-44	2.1	3.2	10	-24
17300	Antalya	19.5	4.7	27	-107	14.5	3.1	141	-86
17609	Larnaca	19.8	3.4	0	-44	16.2	3.0	79	3
22113	Murmansk	-6.3	-1.2	45	5	-9.9	-0.6	35	-3
26038	Tallinn	0.5	-0.7	106	38	-6.2	-3.3	75	20
26629	Kaunas	4.0	1.9	57	4	-7.8	-5.4	64	20
26730	Vilnius	3.7	2.5	54	-3	-7.5	-4.6	56	1
26850	Minsk	4.2	3.4	54	2	-7.4	-3.6	63	10
27612	Moscow	2.7	3.8	75	17	-7.6	-1.5	79	27
33345	Kiev	7.9	5.8	72	21	-4.2	-1.9	58	6
33815	Kishinev	10.3	5.9	40	1	-2.1	-1.8	83	45
34300	Kharkiv	7.9	6.6	42	-2	-1.6	1.8	66	21
34880	Astrakhan	8.8	5.5	2	-17	3.3	5.2	8	-7
35188	Astana	0.2	6.1	39	17	-12.6	0.0	22	5
37789	Yerevan	9.0	4.5	0	-30	5.0	4.5	2	-24
40007	Aleppo	14.7	2.5	0	-35	9.3	2.1	48	-11
40080	Damascus	14.6	2.8	0	-22	8.7	1.5	41	15
40180	Tel Aviv	21.6	3.6	0	-68	16.9	3.1	99	-39
40199	Eilat	25.1	3.6	<1	-3	18.6	2.0	4	-2
40265	Mafrq	17.0	3.5	0	-17	10.6	1.8	19	-9
60030	Las Palmas/Grand Canary	21.9	1.5	38	17	20.8	2.5	11	-10

WMO No.	Station	Year 2010			
		Temp. mean	(°C) dev.	Prec. (mm) total	dev.
01008	Svalbard Airport	-4.1	2.3	188	5
01025	Tromsø	2.4	-0.4	1071	98
01492	Oslo	4.8	-0.9	738	-31
02196	Haparanda	0.7	-0.4	485	-67
02485	Stockholm	6.0	-0.6	540	1
02836	Sodankylä	-1.1	-0.1	516	16
02974	Helsinki	4.5	0.0	597	-54
03091	Aberdeen	7.8	-0.1	733	-50
03772	London	10.7	0.2	520	-79
03967	Dublin Casement Aerodrome	8.4	-0.9	716	-19
04030	Reykjavik	5.9	1.5	594	-204
04339	Scoresbysund	-5.5	0.8	367	-61
06186	Copenhagen	7.9	-0.7	566	-70
06260	De Bilt	9.1	-0.3	824	19
06447	Brussels	9.7	-0.2	915	115
06590	Luxembourg	8.6	0.3	919	44
06660	Zurich	8.8	0.3	1002	-84
06700	Geneva	10.1	0.5	812	-142
07510	Bordeaux	12.8	0.1	814	-108
07650	Marseilles	14.7	-0.1	611	66
08222	Madrid	14.7	0.4	557	101
08314	Mahón/Minorca	16.1	-0.6	781	183
08495	Gibraltar	18.7	0.5	1899	1124
08515	Santa Maria/Azores	17.9	0.4	1365	590
08535	Lisbon	17.1	0.3	1362	609
10384	Berlin-Tempelhof	8.9	-0.5	628	44
11035	Vienna	9.9	0.2	851	244
11518	Prague	7.7	-0.2	641	115
11903	Sliač	8.8	0.9	1066	380
12160	Elblag	7.2	-0.4	628	-62
12375	Warsaw	8.0	0.2	798	279
12843	Budapest	10.6	0.2	874	356
13274	Belgrade	13.0	1.1	866	182
14015	Ljubljana	10.7	0.9	1799	406
14445	Split	16.3	0.4	1125	300
14654	Sarajevo	10.5	1.0	1186	268
15420	Bucharest	10.8	0.2	737	142
15614	Sofia	11.0	1.3	719	156
16206	Grosseto	15.2	0.3	668	-34
16597	Luqa	19.3	0.7	513	-40
16716	Athens	20.0	1.5	317	-52
16754	Heraklion/Crete	20.4	1.9	432	-69
17040	Rize	16.5	2.6	2454	282
17062	Istanbul	16.5	2.4	1078	381
17170	Van	11.2	2.6	350	-28
17300	Antalya	20.3	1.9	941	-125
17609	Larnaca	21.2	2.1	343	14
22113	Murmansk	0.3	0.4	627	149
26038	Tallinn	4.9	-0.2	748	81
26629	Kaunas	6.5	0.1	799	191
26730	Vilnius	6.5	0.5	961	278
26850	Minsk	6.9	1.1	830	153
27612	Moscow	6.5	1.6	602	-86
33345	Kiev	9.4	1.7	603	-46
33815	Kishinev	10.6	0.9	738	191
34300	Kharkiv	9.8	2.3	596	77
34880	Astrakhan	12.1	2.2	219	-1
35188	Astana	3.6	0.9	251	-67
37789	Yerevan	14.6	3.1	496	128
40007	Aleppo	19.5	2.2	227	-110
40080	Damascus	19.4	2.9	99	-47
40180	Tel Aviv	22.5	3.0	358	-209
40199	Eilat	27.3	2.5	30	-2
40265	Mafrq	19.2	2.7	105	-54
60030	Las Palmas/Grand Canary	22.1	1.6	175	58

Monthly Surveys

January

- **Very cold in most of Europe, warm in the Arctic and in the south-east**
- **Dry in northern and western Europe, mostly wet in the south**
- **Heavy snowfalls in many parts of Europe**

Atmospheric circulation characteristics

As a continuation of the weather conditions in December 2009, the year 2010 started with a strong negative North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) with only rare westerly flows over the North Atlantic and Europe. Instead, an extremely strong high pressure area extended from Siberia far into the west, reaching north-western Europe and even Greenland and causing a flow of cold and mostly dry continental air from the east to the west, which spread out more or less over the whole of Europe. The cold conditions were intensified by a persistent widespread snow cover. At the beginning of the month, a relatively stable, large cold trough extended from Scandinavia and north-western Russia to Iberia, causing low pressure conditions and frequent snowfall over large parts of Europe.

Over the North Atlantic, the Icelandic Low was shifted far to the south-west to a position south of Greenland and east of Newfoundland, causing a prevailing meridional airflow from the south which led mild air to the Arctic region.

The south-east of the Region was mostly affected by warm subtropical air masses from the south. Within these warm air masses, but also in a strong frontal zone between warm and cold air in more northern latitudes, cyclonic activity was increased, leading to frequent precipitation. At the end of the month, a polar low pressure pattern moved far to the south into the South Caucasus region, causing a cold and wet spell with snow and heavy rains.

Temperature

The Arctic region was very mild. Anomalies were highest over Spitsbergen, with more than +8°C. In southern Greenland, anomalies were between +4 and +6°C, and the 90th percentile¹ was exceeded. The minimum temperature in Reykjavík (Iceland) was above freezing for 21 consecutive days. This was the longest known such period at that location.

In contrast, large parts of the European continent were very cold (Fig. 1.1), as a continuation of December 2009. Deviations from normal were below -4°C over parts of eastern Europe (Baltic countries, eastern Germany, most of Poland, Belarus, European Russia) and southern Scandinavia and partly below the 10th percentile. Monthly anomalies were even below -6°C in southern Finland and large parts of the Baltic countries, particularly in Estonia (Fig. 1.2) and Latvia; they were below -8°C in central European Russia (central Chernozem region).

¹ Monthly percentiles for temperature and precipitation have been taken from surface observation data of the Climate Prediction Center (CPC) of the US National Centers for Environmental Prediction (NCEP): http://iridl.ldeo.columbia.edu/maproom/.Global/.Atm_Temp/Percentiles.html . Reference period is 1961-1990.

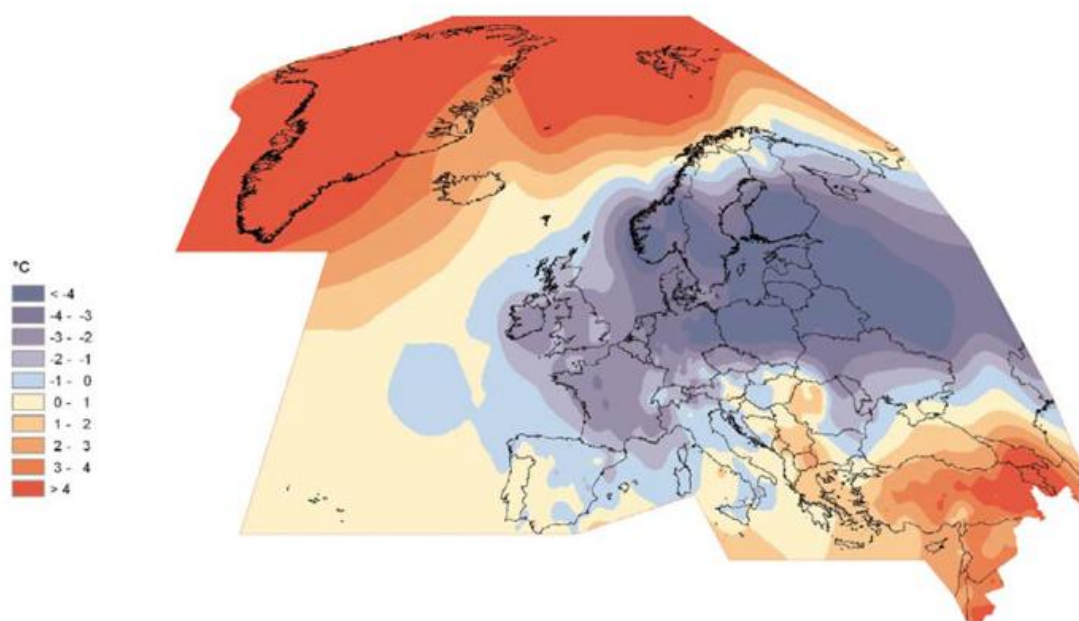


Fig. 1.1: Monthly mean temperature anomalies in January 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

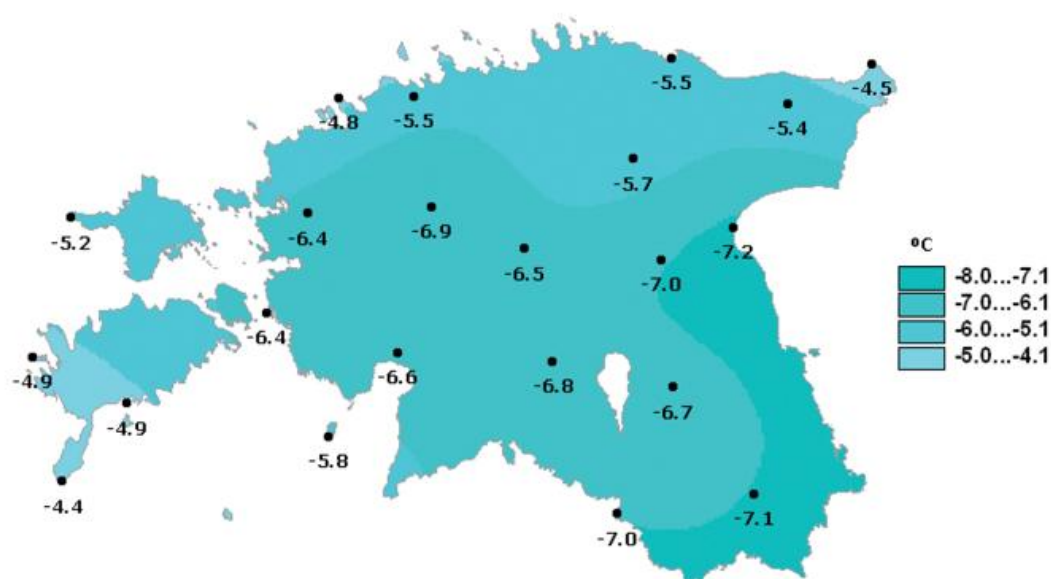


Fig. 1.2: Monthly mean temperature anomalies in January 2010 (reference period 1961–1990) in Estonia
Source: Estonian Meteorological and Hydrological Institute

Most of Scandinavia started the year with colder-than-normal temperatures; especially the southern parts were much colder than usual. The lowest minimum temperature in Norway was -42.4°C on 8 January. In Sweden, temperatures remained below 0°C during the whole January in Stockholm, which last happened in 1829. Minima in southern parts of Sweden were down at -30°C (e.g. in Gävle), the lowest since the 1960s.

Western parts of Europe also saw a frosty January. It was the coldest January over the United Kingdom since 1987, with anomalies around -2°C and sharp frosts; minima regularly fell well below -10°C in the Scottish Highlands and reached -22.3°C on 8th, the lowest UK temperature since 1995. Ireland also had a cold spell during the first 10 days of January (continued from December 2009); it was the most extreme cold spell over Ireland since early 1963. Taken as a whole, it was the coldest January since 1985 in Ireland and the coldest since 1963 in the Dublin area. Most places in Ireland recorded 22–27 days with ground frosts, compared to 12–18 days normally. For the first time since 1997, the monthly average temperature in De Bilt (Netherlands) was below 0°C . In France, too, it was the coldest January for the last 20 years and minima fell down to around -20°C south of Ile-de-France.

Central Europe also had an extremely cold month, especially in its eastern parts. It was the coldest January in Germany since 1987. Temperatures in Germany remained below zero most of the month; in eastern Germany, minima dropped below -20°C in late January. The lowest minimum was -24.3°C on 27 January. In Switzerland, it was the coldest January in 23 years; daily temperatures were not extremely low there, but they remained below average for almost the entire month. Poland had an anomaly of -5.4°C below the 1971–2000 normal, the daily minimum of that month (and year) was -30.3°C .

The cold weather in January was much more extreme in north-eastern parts of Europe, especially in the Baltic countries and central European Russia. It was the coldest January in Latvia since 1987. Starting on 6 January, temperatures in the whole of Latvia remained continuously below zero during the rest of the month; such a long frost period had last occurred 54 years ago. Likewise, there was almost a complete absence of thaws in Lithuania and central European Russia, as was last the case several decades ago; instead, severe frosts occurred in large areas, particularly in the second half of the month. The end of the month was especially cold in Estonia (with a minimum of -32.4°C at Jogeve) and Lithuania (with minimum temperatures between -25 and -30°C in many places and locally breaking all-time records for these days of the year). The Ukraine, further in the south, recorded less negative anomalies than the northern east European countries, but minimum temperatures were nevertheless quite low, down to -34°C in the Ivano-Frankovsk region.

The cold weather even reached some northern parts of the Balkan Peninsula, although only temporarily. In Slovenia, the monthly mean temperature was close to normal; anomalies were significantly negative only in the mountains, particularly during the last third of the month. Romania was only slightly colder than normal due to a very mild period from 6–12 January, but was very cold especially in eastern, central and southern parts from 24–28 January with new daily minimum temperature records (partly below -25°C). This cold spell also affected Bulgaria.

The western and central Mediterranean region and Iberia had monthly mean temperatures around normal, but also some temporary cold spells. A pronounced cold spell occurred in Spain from 7–11 January due to an invasion of continental cold air from the north-east. A minimum temperature of -16.0°C was recorded in Burgos on 10 January and other sites in the highland regions in the interior of Spain also saw minima below -10°C . Temperature anomalies in Italy were largely within the natural variability, slightly lower than normal in the north and a bit higher in southern parts. However, a cold outbreak of Arctic air occurred in Italy during the "giorni della merla" ("days of the blackbird", 29–31 January), making these days the coldest of the year.

The Middle East including the South Caucasus region as well as large parts of the Balkan Peninsula and the southern and eastern Mediterranean were very mild. Monthly anomalies were around +2–3°C above normal in and near the Middle East and the 90th percentile was exceeded over large parts of the area. It was particularly mild at the beginning of the month. In Greece, the New Year's Day was the warmest ever recorded in January in 50 years, with a maximum temperature of 29.8°C at Heraklio on Crete island. Malta reached a daily maximum of 20.3°C on 7 January and Bar at the Adriatic coast in Montenegro set a new record (21.2°C) on 8 January. In the South Caucasus, up to 22°C were reached in Georgia, and 16–18°C in the lowlands of Armenia. Azerbaijan also had a very mild period at the beginning of January, with a new maximum temperature record of 26.6°C at the station Astara, but then saw a cold spell at the end of the month. In many parts of Israel, it was the warmest January since measurements began.

Precipitation

The Arctic region was partly wetter than normal, especially in Svalbard and parts of Greenland, locally with more than 200% of the normal. However, most of Greenland was dry.

Northern, western and large parts of central Europe saw a very dry January (Fig. 1.3). Monthly precipitation totals were below 40% of the normal over large parts of northern Europe; in northern Iceland and western Norway even below 20%. Several stations in Norway registered a new monthly low precipitation record for January. The totals were below the 10th percentile over most areas of northern Europe. Little precipitation was also recorded in the northern half of European Russia due to prevailing anticyclonic conditions, with 20–40% of the monthly normal in individual central regions. Most of western and central Europe received less than 80% of the normal, locally even much less.

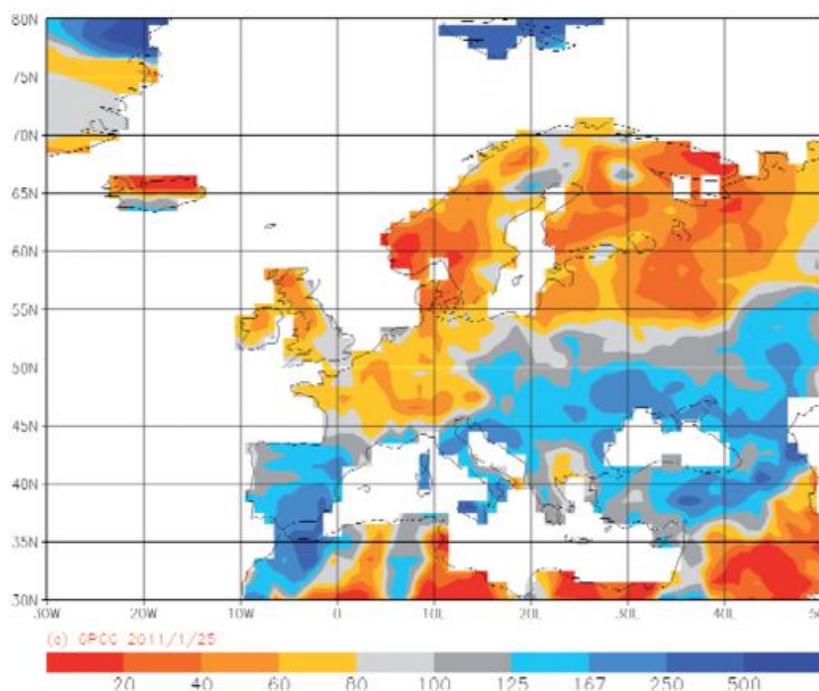


Fig. 1.3: Monthly precipitation amounts for January 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas
Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Shannon Airport in Ireland received just 30 mm of precipitation over the whole month, which was the lowest January total since 1963. On the other hand, there were also some heavy rains in Ireland, e.g. a daily total of 58 mm was measured in Valentia on 12 January, the highest for January on record.

Most of southern Europe and southern parts of eastern central and eastern Europe were wet, including eastern and south-eastern Austria, the Czech Republic, Slovakia and Hungary. Especially the areas around the Mediterranean and the Black Sea received locally more than twice the monthly precipitation totals. The 80th percentile was exceeded over most of these areas, locally also the 90th percentile.

Some special extraordinary precipitation anomalies were recorded in Italy and on the Balkan Peninsula. Heavy precipitation at the beginning of the month caused flooding and mudslides in Italy. In Slovenia, too, most of the precipitation fell during the first third of the month; partly, it was abundant, with locally more than 200% of the normal. Places in Bosnia and Herzegovina received more than 300% of the normal. Serbia was partly extremely rainy in its northern parts, and especially the number of precipitation days was high, in some places even record-breaking. Flooding due to heavy rain took place in Montenegro at the Skadar Lake and in Bojana in early January. Bulgaria recorded 6 days with thunder activity, which was unusual for this time of year.

Highest precipitation totals (300–400 mm) were reached on Sicily, in southern Montenegro and northern Albania, where a severe flooding occurred. Generally, many places around the coasts of the central and eastern Mediterranean received high monthly precipitation totals of 100 mm or more. The same was observed for western and southern Iberia and for the southern and eastern coast of the Black Sea, parts of the mountain regions of the north Caucasus and eastern Turkey. Up to more than 500% (219 mm) of the normal monthly precipitation fell in east Georgia, more than 400% in the basin of Lake Sevan in Armenia and more than 200% in places of southern European Russia. Heavy rains hit Georgia at the beginning and Azerbaijan at the end of the month. Locally, more than 125–250% of the normal precipitation fell in places of the Middle East. Israel was rainy in the north and the south, mostly due to a heavy rain event from 17 to 21 January.

Snow

Due to the low temperatures, snow persisted for the whole month over large parts of northern, central and eastern Europe and some western and southern parts of Europe. Snow, freezing weather and ice caused widespread disruption to transportation and energy supply. More than 177 people died in Europe due to freezing conditions or accidents.

The monthly mean snow depth was higher than 20 cm over large parts of northern Europe, locally much higher. However, there was less snow than normal in the northern part of Norway and the western mountains in the southern part of the country opposed to more snow than normal in south-eastern Norway. The snow depths by the end of January were the lowest in 40 years in parts of the northern Norwegian counties Troms and Nordland. In contrast, some provinces in the Baltic countries received as much snow as they had not seen for approximately 25 years.

The UK Met Office reported January snowfalls as the most significant and widespread across the UK since the mid-1980s. Thousands of schools were closed; there was severe disruption to transport networks, the water and electricity supplies to thousands of homes and businesses were interrupted frequently, and a number of fatal accidents occurred that were related to the freezing weather conditions. In early January, daytime temperatures across the UK often failed to rise above freezing, significantly prolonging the period of lying snow. 57 cm of lying snow was reported from Westgate (County Durham) on 7 January. A spell of heavy snow affected western

areas of Ireland on 13 January (Fig. 1.4), but when temperatures rose slowly to near-normal values in the middle of the month, snow turned increasingly to sleet or rain, bringing flooding in some southern areas of Ireland.



Fig. 1.4: Heavy snow at the observing station at Knock Airport, Ireland on 13 January 2010
Source: Irish Meteorological Service, from a series of pictures courtesy Mary Beston, Gerard Griffith, Liam Newman

Frequent snowfall also occurred in France and Germany during the first half of the month (particularly after the snowstorm Daisy on 10 January), some snowfall also occurred later in the month, partly interrupted by freezing rain periods. At the end of the month, Germany was mainly snow-covered with more snow in the north-east of the country than in the south. 30 cm of snow fell in one night in Rostock (north-eastern Germany) from 29–30 January during a heavy snowfall event, which affected the whole of Germany. Some stations in north-eastern Germany had near 50 cm and new snow depth records were set.

In Switzerland, it often snowed in the plains north of the Alps, but the amounts were usually small. Zürich broke its record, with 16 days of measurable new snowfall. Geneva airport, which services the busy Alpine ski resorts, was forced to close over the weekend of 8 January due to heavy snow. Heavy snowfall covered western Switzerland again in mid-January; and towards the end of the month, even greater amounts fell in the eastern part of the country.

In north-east Poland, the snow cover was 48 cm deep, the same in Ljubljana in Slovenia. In an area around Leszno in Poland, snow even accumulated to a depth of 150 cm; about 200,000 houses were left without power. Snow depth reached 280 cm on the Slovenian mountain Kredarica only on the last day of the month. Romania had snow depths of up to 147 cm in the mountain area and 20–50 cm in the rest of the country; Bulgaria also had intense snowfalls of up to 4 m due to snowstorms. 30 cm fell in Varna near the Black Sea. In north-western Turkey, snowfall was 13 cm at Edirne and 5 cm at Tekirdag on 19 January after a wintry spell.

There was also snowfall in extended areas across the northern and interior parts of Spain and even in some places in Andalusia and coastal areas of Portugal at low altitudes, where such events are rare. For the first time in 50 years, snow was reported as far south as Seville in Spain. Widespread snowfall occurred over northern Italy at the end of the month from 29–31 January.

Due to high snow precipitation in the North Caucasus, avalanche hazards persisted there throughout the month. In the South Caucasus, it was snowy all over Georgia during the first two thirds of the month, but with interruptions. Snow depth was about 3 m in the mountains of Georgia. Azerbaijan received snow at the end of the month.

Significant weather events²

January 01:	Strong south-westerly winds of up to 130 km/h over southern and western Italy (Sardinia, Sicily and Tyrrhenian regions); sea storm along the exposed coasts.
January 03:	After heavy snowfall during several days in Switzerland, 4 people died due to avalanches.
January 03–04:	Heavy hail in eastern Georgia on 03 January; tornado in the coastal zone of Georgia on 04 January, causing serious material losses.
January 07:	UK almost entirely covered by lying snow, with depths exceeding 30 cm in many northern areas and more than 50 cm in some places.
January 08–11:	Strong winds in Bulgaria (up to 122 km/h in Kurdzhali).
January 09–13:	Snow and very cold temperatures particularly affected Switzerland, Germany and Poland and caused the closure of Geneva airport, cancellation of more than 90% of flights at Frankfurt airport and trains in Germany, as well as blocked roads, broken roofs and people frozen to death particularly in Poland, state of emergency on the coasts and islands of the Baltic Sea due to coincidence of snow masses, flooding and wind (gusts > 120 km/h). This event was caused by a Mediterranean low (Daisy) that led humid air from the Mediterranean to the Balkan Peninsula and to eastern and central Europe. Albania had a severe flooding in the districts of Shkodra and Lezha. Local flooding occurred on the Sava River in Serbia due to frequent precipitation.
January 17–18:	Heavy rain (up to 111 mm in 24 hours) and thunderstorms in Greece over the Aegean Sea; flash flood on Crete island.
January 17–21:	Israel and Jordan suffered from flash floods due to heavy rain. These were probably the worst floods in over a decade in Israel. 30–80 mm widely fell in the Negev Desert in Israel on 17 and 18 January, 2–4 times more than the monthly average. This rainfall was record-breaking with regard to daily totals for many stations in the Negev. The floods claimed the lives of 15 people and approximately 700 houses were engulfed.
January 21–29:	Glaze ice and hoarfrost accretion (35–80 mm) in the northern Caucasus (southern European Russia).
January 26–28:	Snow and very low temperatures severely affected many countries (Germany, Austria, Poland, Romania, Bulgaria and Turkey). In Romania and Poland, people froze to death; in Frankfurt, Germany, flights were cancelled and Bulgaria had a snow depth of more than 4 m due to snowdrift.
January 27:	125.6 mm of daily precipitation were measured in Norway (station Lurøy).
January 28:	Estonia reported very low water levels on the Baltic Sea coast. Germany reported that snowfall and low temperatures caused many accidents and affected the air traffic again. The Island of Rügen was isolated and the surrounding Baltic Sea was frozen.

² Significant weather events of recent months are also presented in the Event Calendar of the WMO RA VI Regional Climate Centre on Climate Monitoring (RCC-CM) on the RCC-CM website of Deutscher Wetterdienst: <http://www.dwd.de/rcc-cm> - Products - Significant Weather Events – Monthly calendar

End of January: Cold and wet spell with snow and heavy rains in Azerbaijan; gusts up to 118 km/h in some places. The wave height at the oil rocks station on the Caspian Sea was up to 7.3 m, which is very rare.

February

- Cold over northern, western and central Europe, warmer than normal in the Arctic and in the south-east
- Dry in north-western and central Europe, wet in north-eastern, eastern and southern Europe
- Severe storm Xynthia over south-western, western and central Europe

Atmospheric circulation characteristics

Like the other months of winter 2009/10, February 2010 was also characterised by very strong negative NAO and AO indices, even more extreme than in January. Cold continental air from the east continued to move into Europe, reaching even the south. This month, however, the main airflow affected more the northern areas of the continent. Westerly low pressure systems were quite rare, but at the end of the month, a severe storm (Xynthia) reached south-western Europe and crossed western and central Europe, while at the same time a south-westerly airflow brought some warmth to north-eastern Europe.

Over the North Atlantic, high pressure dominated over Iceland and low pressure over the subtropics, which is the very opposite of normal conditions. The result was that the prevailing easterly flow continued even over the North Atlantic and produced a cooling there.

Also in the south-east, there was no overall change of the circulation conditions compared to January. Especially the Middle East was still affected by an ongoing warm airflow from the south, particularly in the second half of the month. Cyclonic activity was still enhanced over southern Europe and the Mediterranean. The southern Mediterranean, however, profited from a ridge over its central regions in the middle of the month.

Over eastern Europe, a quasi stationary front formed west of the Russian blocking high, causing an area of higher-than-normal precipitation.

Temperature

It was still mild in the Arctic, with anomalies above +4°C (Fig. 2.1), as a continuation of the mild conditions in January, in Greenland even up to +8°C at the west coast. Again, the 90th percentile was exceeded over southern Greenland. Daily temperature maxima reached 3–7°C at the west coast of Greenland.

February was also another cold winter month over large parts of Europe. The highest negative anomalies between -5 and -7°C were recorded in northern parts of Scandinavia, largely with absolute monthly minimum temperatures below -30°C. The cooling was below the 20th percentile over whole Scandinavia. Large parts of southern Norway recorded their coldest February at least since 1994.

It was continuously cold in north-western Europe, though with weaker anomalies than in northern Europe (down to -2°C below normal in the north of the United Kingdom and in Ireland). Yet it was the coldest February over the UK since 1991.

It was the coldest February on record in northern and north-eastern European Russia, with extremely low daily minima. On 19 February, the air temperature dropped to -52°C (or 27°C below normal) in the north-eastern regions of European Russia, which was below the absolute February minimum for the entire period of record. Another location in north-eastern European

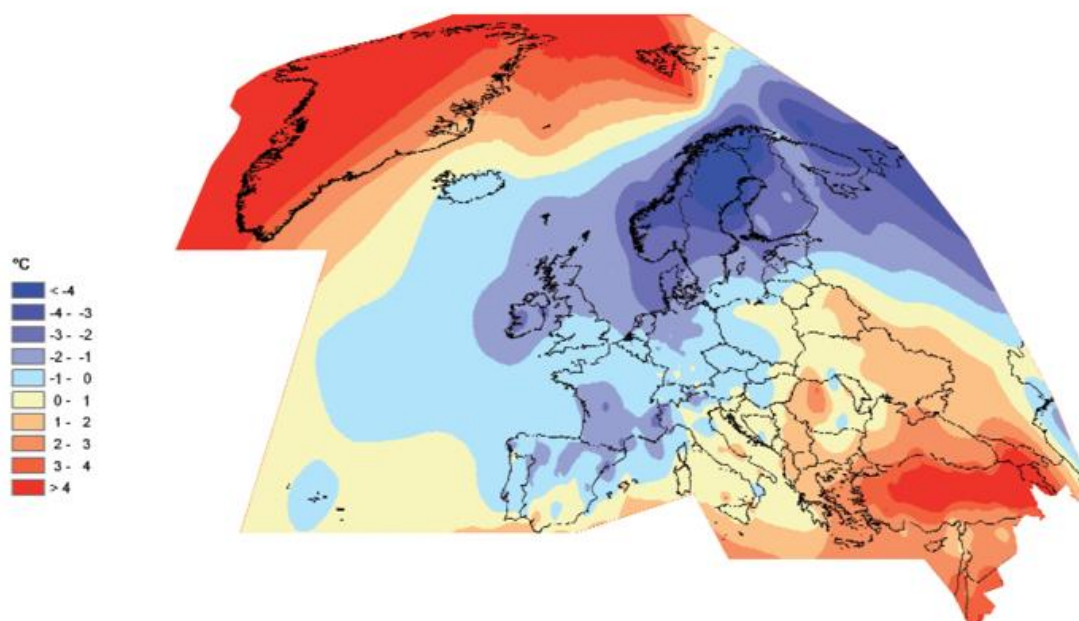


Fig. 2.1: Monthly mean temperature anomalies in February 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

Russia (station Hoseda-Hard, Nenets Autonomous District) registered the second lowest minimum ever recorded in Europe at -57.0°C (behind -58.1°C in December 1978 in the Komi Republic in north-eastern European Russia).

Different from January, monthly means in central Europe were close to normal (mean anomalies around -2°C to 0°C) due to a milder second half of the month and despite some low temperature events. Daily minima dropped below -20°C in Poland on 10 February.

The Alps saw cold weather especially in early periods of February. The first few days of February were extremely cold in Switzerland, with temperatures down to -35.6°C (La Brévine) and -25 to -30°C in Engadin. Except for one short foehn phase, the cold winter weather continued through the middle of February. In Austria, especially the first half was also very wintry before foehn brought mild temperatures.

Even parts of Iberia and the North Atlantic including Iceland and Azores were colder than normal, though not significantly (anomaly of -0.6°C in Spain). Italy, too, was slightly colder than normal, especially over northern and southern regions, and quite close to average elsewhere.

Similar to January, the Middle East and some adjacent areas were warmer than normal, with the warmer-than-normal conditions, however, extending further to south-east Europe. Deviations from normal exceeded $+4^{\circ}\text{C}$, locally even $+7^{\circ}\text{C}$ particularly in Turkey and the South

Caucasus. The warming was higher than the 90th percentile in whole Turkey and further south. In the South Caucasus, up to 25°C were reached in Georgia, 20°C in Armenia. In Azerbaijan, the first half of February was cold, with temperatures below the freezing point, the second half, on the contrary, was very mild, with maximum temperatures up to 28°C in Astara (near to the Iran border). Israel had a prolonged heat wave of more than two weeks with highest daily maximum temperatures up to 33°C and record-high daily minima up to around 18°C. It was also more than +1°C warmer than normal over the southern Mediterranean. At 24.2°C, Luqa Airport in Malta recorded its 2nd highest February maximum temperature, the station Iraklion in Greece had 28.8°C on 20 February.

Precipitation

Due to the lack of westerly airflow and high pressure over the Arctic, it was far drier than normal especially at the west coast of Norway, in Ireland and the western parts of the United Kingdom, as well as in the Arctic region and southern Iceland (Fig. 2.2). Monthly totals were less than 40% of the normal over large parts and even less than 20% at the southern west coast of Norway, locally also in the Arctic. Precipitation was below the 10th percentile over Greenland, Iceland and Norway. Nuuk in west Greenland received just 1.3 mm during the whole month. Some Norwegian stations registered a new record for the lowest monthly precipitation total for February.

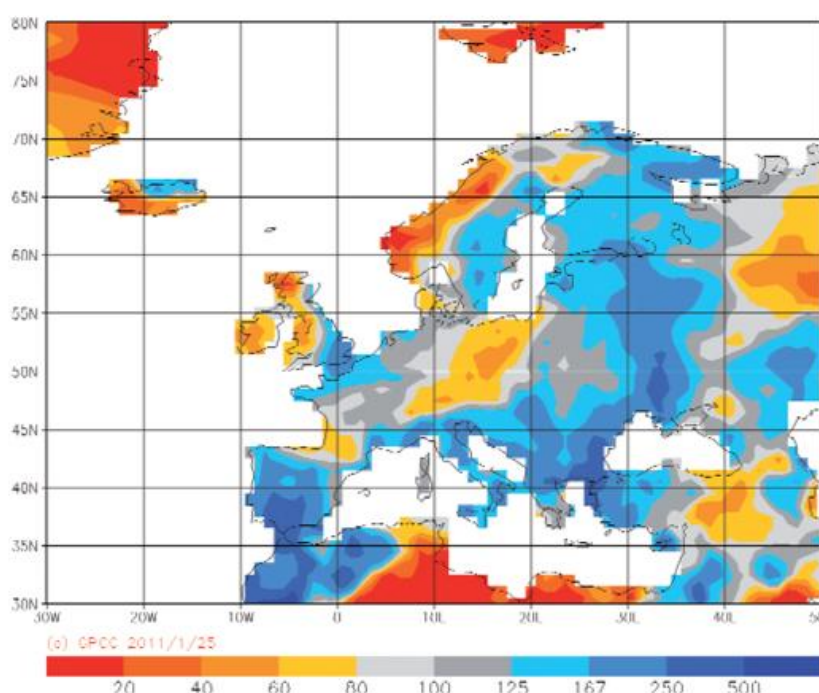


Fig. 2.2: Monthly precipitation amounts for February 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

It was also dry in large parts of eastern central Europe and in the Alpine region, north-eastern European Russia, eastern Turkey, most of Armenia, northern Syria and Malta, locally with less than 60% of the normal.

The other parts of the Region, especially most of south-eastern central, southern and eastern Europe and most of the southern Middle East were mainly wetter than normal, mostly exceeding the 90th percentile, locally more than the double of the normal total (e.g. in most of Iberia, Hungary, north and west of the Black Sea and in Jordan).

It was the rainiest February for the last 24 years in Portugal. Monthly totals exceeded historic records at many stations in southern Spain. Italy had quite high precipitation in Calabria in the south, but also in the north in the Po Valley and northern Tuscany. New records of monthly precipitation were also set on the Balkan Peninsula after some heavy rainfall events, e.g. in Montenegro. A new local daily total record for February was achieved in Belgrade (Serbia) on 25 February at 39 mm. Bulgaria reported three days of hail, which is unusual for this time of year.

In the South Caucasus, western Georgia had up to more than 250% of the monthly normal (320 mm). Azerbaijan recorded heavy precipitation during the first half of the month, especially in mountain areas, causing landslides and floods.

Snow

Similar to January, February also saw a persistent snow cover during most of the month over large parts of northern, central and eastern Europe, but also in some places in the west and south. In the middle of the month, however, mild air masses caused widespread thaw in central Europe.

In the first two weeks of February, there was almost no snow in Iceland, but snow appeared later in the month even for a few days in the south-west of the island, causing disruption to land and air traffic.

There was less snow than normal in northern Norway and the mountains of western Norway, whereas snow depths were above normal in the lower parts and along the coast of southern Norway.

There were 100-year-record or near-record-breaking snow depths in southern parts of Sweden in late February, with depths over 40 cm. At times, train and road traffic was heavily disrupted due to heavy snowfall. In contrast, snow depths were relatively small in the northern mountains of Sweden due to low precipitation. Large portions of the Baltic Sea and the Swedish west coast were covered by ice. Around 17 February, the ice extent had reached its largest since 1987.

In the United Kingdom, there were heavy snowfalls in northern England, northern Ireland and Scotland in late February, with depths up to 70 cm at a lower lying station (283 m elevation) in Aberdeenshire on 26 February.

Exceptionally high snow depths were also recorded in the Baltic countries, with new records of 78 cm at two stations in north-eastern Estonia. Large amounts of snow caused much damage to roofs and frequent disruption to road and rail traffic. In Lithuania, the monthly mean snow depth reached 26–38 cm. In north-east Poland, the snow depth rose to 65 cm that month.

In Germany, snow depths accumulated to more than 25 cm in Hamburg, 38 cm in Berlin-Dahlem (highest value since winter 1969/70) and even more than 60 cm near the Baltic Sea. Road salt stocks became short. Most German inland harbours were closed due to thick ice layers. Many flights were cancelled in Frankfurt and Munich. The roofs of several buildings collapsed.

In the higher Alps, there have been quite some accidents due to avalanches.

Slovenia, too, had widespread snow, more than normal in the lowlands and the mountains. Ljubljana registered 27 days with snow cover and a maximum depth of 43 cm. The Kredarica Mountain had 390 cm.

Romania recorded some snowy periods in the southern half of the country and in the mountain area, where the snow depth reached 183 cm.

Italy saw the rather rare event of snow in the city of Rome (Fig. 2.3) and over the coasts of the central Tyrrhenian Sea on 12 February, which is extremely unusual in that region.

Due to heavy snowfall, the mountains of the north Caucasus reported avalanche-hazardous conditions. In Georgia in the South Caucasus, a stable snow cover only persisted in high mountains with a maximum depth of 175 cm.

Snow was also to be found in Jordan (up to 22 cm in Rass Muneif from 03–05 February) and Israel in the mountains in the north at the same time.



Fig. 2.3: St. Peter in Rome under snow on 12 February 2010
Source: National Weather Service CNMCA, Italy

Significant weather events

- | | |
|-----------------|--|
| February 01–03: | A low developed between Iceland and Denmark and moved to Germany, causing heavy precipitation and a snow storm in northern and north-eastern Germany. Snow depths at eastern German lowland stations reached new records on 03 February (Hiddensee 45 cm, Teterow 51 cm). |
| February 03–05: | 30–50 mm of precipitation fell in the Negev Desert in Israel with flooding, but no serious damage. |
| February 09–17: | Abundant rain caused some of Bulgaria's major rivers to overflow (e.g. Tundzha in its lower part near the Turkish border and Ropotamo in the south-east of the country). On 16–17 February, Tundzha flooded agricultural land in the region of Straldzha and 42 towns and villages were without electricity. |
| February 10–11: | Strong southern winds with gusts of up to more than 100 km/h, heavy rain and thunderstorms over the Aegean Sea, Crete and Skiros islands in Greece; heavy rain with flooding in central and eastern Macedonia (Greece). Dust advection from Africa affected the whole of Greece. |
| February 12: | Unusual snowfalls over Rome and over the coasts of the central Tyrrhenian Sea (Fig. 2.3). |
| February 15: | Heavy rainfalls over southern Italy (Sicily and Calabria) with flooding and landslides. 2300 people had to leave their homes due to landslide risk. |

- February 20–21: In Moscow, a snowstorm produced a snow depth of 63 cm and thus broke the previous record of 62 cm set in 1966. Nearly 4,500 km of railway track had to be cleared of snow.
- February 22: Flooding in Bosnia and Herzegovina (Sanski Most).
- February 22–23: Wind gusts up to 108 km/h, coupled with extensive precipitation (up to 50 mm) on February 22 caused damage to houses and roads in Tbilisi, Georgia. Strong winds also in west Kazakhstan.
- February 25–28: More than 100 mm of precipitation in 24 hours were recorded in places in Jordan (station Swaileh) and Israel (in the Judean Mountains).
- February 27–28: Storm Xynthia affected several countries in south-western, western and central Europe at the end of the month, causing sea dikes at the French Atlantic coast to break and much damage by falling trees, etc. The mean sea level pressure was 969 hPa at its centre, when the storm arrived at the French Atlantic coast. Gusts reached up to 160 km/h along the coastline, 232 km/h on the Pic du Midi Mountain (2877 m altitude) in the Pyrenees, and exceeded 120 km/h in several places in France (Fig. 2.4), Germany, Switzerland and Spain, and 100 km/h in Portugal. Xynthia also led humid and very mild air masses to Germany (16°C near the upper Rhine valley) and 20 mm of rain in 12 hours fell around Saarbrücken (western Germany). Much damage was caused to buildings, trees and power lines; road, rail and air traffic was temporarily affected. In the French coastal town La Rochelle, streets were flooded by 1.5 m. It was one of the worst storms in coastal western Europe since 1999, although less intensive than storm Klaus in January 2009 in France. Xynthia was associated with a very high sea-level and large local tides. More than 60 people died Europe-wide, many of them during a storm surge at the Atlantic coast in western France resulting from the exceptional flooding. More than a million of people were temporarily without electricity. Further damage occurred across Spain, Belgium, the Netherlands, south-east England, Switzerland and Austria, whereas the storm reached Lithuania in a weakened state and without causing any extreme weather phenomena.

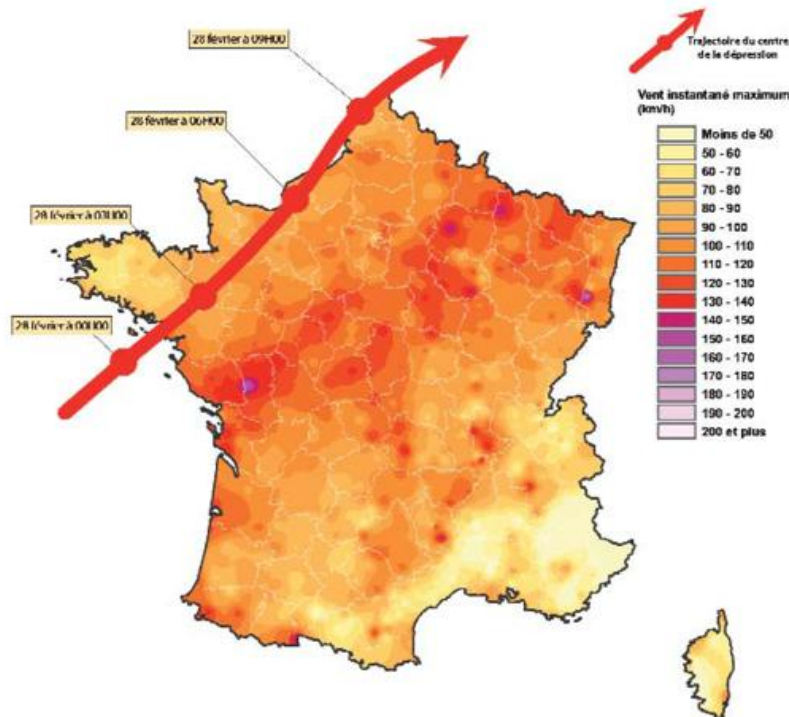


Fig. 2.4: Track of the centre of storm Xynthia (red arrow) and highest wind gusts in km/h (map) on 27–28 February 2010 in France
Source: Météo France

March

- Mostly warm, colder in northern and parts of western Europe
- Mostly wet in the north and parts of the south, dry in parts of central Europe, the Alpine region, the Arctic and at the coasts of the eastern Mediterranean

Atmospheric circulation characteristics

In March, both the NAO and the AO became much weaker compared to the extreme negative conditions of the preceding winter. This marked the beginning of the seasonal transition. However, both the Icelandic low and the Azores high were still weaker than normal.

Quite a strong Arctic low developed over north-eastern Europe, causing cold and wet weather conditions with snow in that area. Spring warmth arrived in Lithuania due to a south-westerly airflow only in the second half of the month.

In most of the other parts of the Region, cyclonic activity occurred from time to time. Especially in central Europe, the first half of the month was characterised by arctic air masses with widespread snowfall and frosts, the second half by a south-westerly flow of subtropical air masses. Apart from storm Xynthia, which developed at the end of February and lasted until the

beginning of March, only a few thunderstorms occurred in central Europe and the Alpine region at the end of the month. However, unstable weather dominated especially in southern parts of Europe.

In the easternmost parts of the Region, an upper-level ridge predominated at the beginning of the month, causing high temperatures; later, an upper-level trough caused a cyclone over the Black Sea and led to colder weather.

Temperature

It was very mild in western Greenland, with anomalies up to $+8^{\circ}\text{C}$, and over the western North Atlantic. In contrast, eastern Greenland and the eastern European Arctic were colder than normal; the regions with sea ice extended south, reaching as far as about 65°N in the east of Greenland and 75°N around Spitsbergen.

Northern Scandinavia and northern European Russia were also colder than normal, with minima around -35°C , but the anomalies were far smaller than those for the winter months, mostly between -1 and -2°C , locally below -3°C in parts of northern Norway. Nevertheless, they were below the 20th percentile. The northern part of the Baltic Sea was still frozen, as were the Barents Sea and the White Sea. However, it was slightly warmer than normal on average in the Baltic countries, since the last decade of March was $+2^{\circ}\text{C}$ to $+4^{\circ}\text{C}$ warmer than normal in Latvia and record temperatures up to 20°C were reached in Lithuania.

The rest of the Region was mostly warmer or around normal, although partly with high daily maxima and low daily minima (e.g. -18.5°C and 24.1°C in Poland, -22.2°C and 24°C in Germany, -9.4°C and 25.4°C in Bulgaria). This was due to a first wintry and a warm second half of the month in these areas. The lowest minima were measured around 07 March following a cooling of snow covered surfaces; the highest maxima occurred around 25 March due to warm air advection. Northern Greece reported frost between -3 and -5°C in the first days of March.

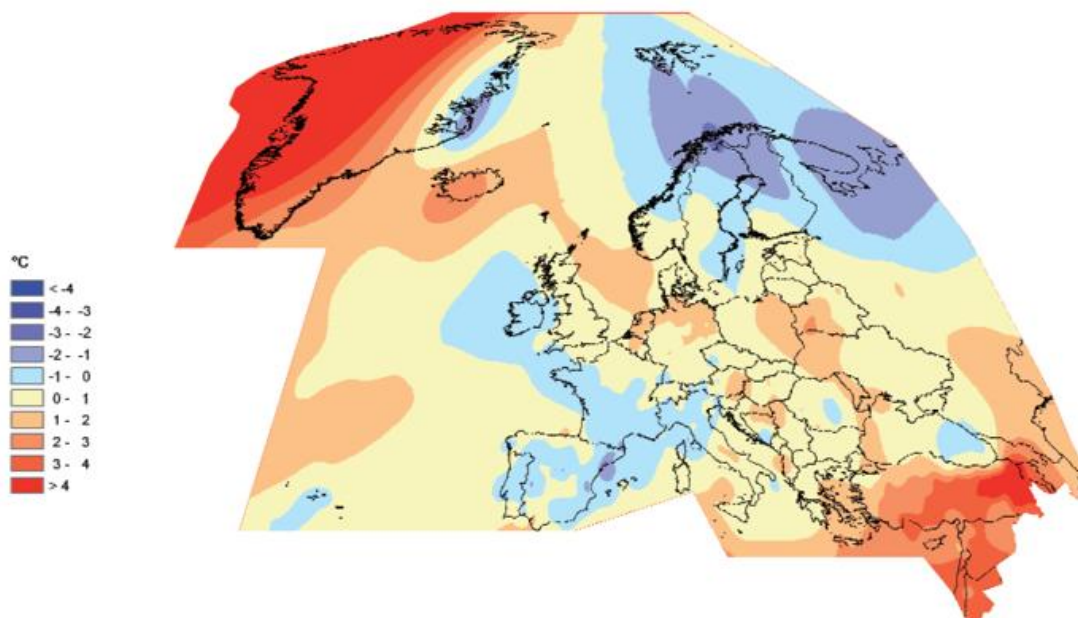


Fig. 3.1: Monthly mean temperature anomalies in March 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

The sequence of cold and warm periods was very similar in many parts of Europe. It was rather cold in the United Kingdom, particularly during the first two weeks with some night frosts, but warmer from mid-month. In Germany, too, wintry conditions continued until the middle of March, when a warm period began, which was again followed by a strong temperature drop at the end of the month. Likewise, daily maxima in Switzerland stayed below freezing in the first half of the month, and the shores of Lake Geneva and Lake Neuchâtel were frozen solid from the spray of waves blown up by strong winds. However, temperatures reached 23°C in the central plains of Switzerland on 25 March due to the warm air masses coming in from the south-west and foehn. Such temperatures had last occurred there in March in 1990, and they dropped down after an advance of cold air one day later.

Some larger areas in western and south-western Europe saw monthly mean temperatures that were slightly below normal, especially Ireland, southern France, Iberia and northern Italy. Portugal had its coldest March of the last 24 years.

Only in the north was Italy colder than normal, whereas the other parts of the country were warmer than normal. The highest warming was recorded along the coastal areas of the southern Tyrrhenian Sea, especially in north-west Sicily and southern Calabria.

Once again, it was very warm for this time of year in the eastern Mediterranean, the Middle East and the South Caucasus. Monthly anomalies were highest over eastern Turkey and parts of the South Caucasus (e.g. in the basin of Lake Sevan in Armenia), exceeding +4°C or locally even +5°C and the 90th percentile. It was the third warmest March in the South Caucasus since 1966. West Georgia recorded maxima of up to 27°C in the lowlands. The southern Mediterranean also continued to be warmer than normal. Luqa Airport in Malta had its 3rd highest March temperature since 2000 (23.9°C). Temperatures reached up to 38°C in Israel, but were not record-breaking; however, there were some extraordinary long sequences of hot days (e.g. 8 consecutive days with maxima above 32°C in the Negev Desert) last recorded in March at least in the 1940s.

Precipitation

March was characterised by quite a high spatial variability of precipitation anomalies (Fig. 3.2). The Arctic region was mostly dry, except western Greenland which was very wet. It was likewise wetter than normal in most of northern and north-eastern Europe, locally exceeding twice the monthly precipitation total and the 90th percentile. The region of Varanger (Norway, county Finnmark) registered its highest March total since 1920.

In the United Kingdom, the first two weeks were dry, but the second half saw more changeable weather with rain at times.

In most of western, southern central and parts of eastern Europe, dry conditions were prevailing, mostly with less than 80% of the normal precipitation. Especially the Alpine region was dry and mostly below the 20th percentile, despite a few thunderstorms at the end of the month. In easternmost parts of Austria (Burgenland), March 2010 was the driest March since at least 1936 (station Neusiedl am See).

Most of the southern parts of the Region were wetter than normal, namely Iberia, the western Mediterranean region, most of the Balkan Peninsula including Romania, the low Volga and the Caucasus region and western Kazakhstan. Especially in Spain, the 90th percentile was exceeded. In Portugal, it was the third wettest March of the last 30 years. Southern Italy, too, was very wet, with heavy rain especially in Sicily. Malta received more than twice its normal precipitation, west Georgia in the South Caucasus up to more than 400% (313 mm). In southern European Russia, spring floods were recorded in rivers in the last third of the month. In Romania, March was the third consecutive month with above-normal precipitation, particularly in the south.

The eastern Mediterranean and the Middle East were mostly very dry for this time of year; partly they saw less than 20% of the normal precipitation, staying below the 10th percentile. In northern Israel, monthly totals were only 5–15 mm (10% of the normal), making March 2010 one of the three driest March months in the last 70 years besides 1962 and 2004.

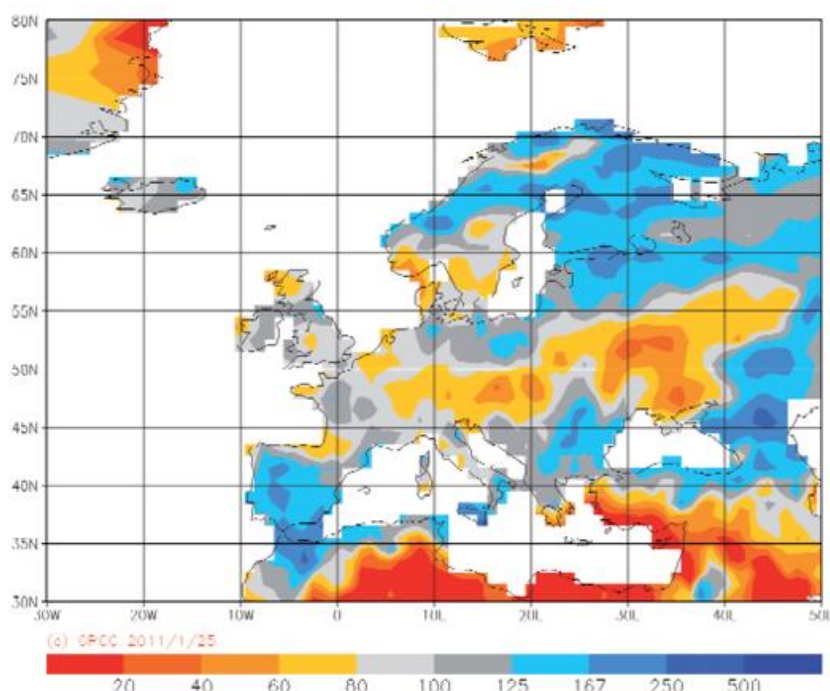


Fig. 3.2: Monthly precipitation amounts for March 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas
Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Snow

March had a persistent snow cover in northern and eastern Europe. By the end of the month, however, there was considerably less snow than normal in most of the mountainous areas of Norway. Along the coast of southern Norway, there was more snow than normal, which melted at the end of the month in the lower parts of south-eastern Norway.

Late March was notable for prolonged snow across higher parts of Scotland and Northern Ireland. In contrast, a warm late March caused an intensive thaw in Latvia.

Some spells of snow also occurred in western, central and parts of southern Europe, especially in the first half of the month. Southern France (Provence) experienced a snowfall event from 7–9 March, which then moved towards the Pyrenees region. At the same time, heavy snowfalls also occurred in parts of Germany and Spain, producing in Germany (except in the north-east) another temporary closed snow cover, which disappeared shortly afterwards in the lowlands. Barcelona saw the heaviest snowfalls since 1962, whereas the southern Pyrenees had little snow left.

Intensive snowfalls likewise occurred in Switzerland in the first half of March. On 10 March, it also snowed down into the plains of southern Tessin. Another intense snowfall period started on 26 March; snow fell below 900 meter on the northern side of the Alps, and the high crests of the southern Alps received the considerable amount of 90 cm. In Austria, frequent avalanches were reported, especially during the first two thirds of the month.

In northern Italy, up to 30 cm of snow were measured near Bologna on 09 and 10 March, up to 50 cm on the surrounding hills and up to 75 cm in the Apennines.

In the mountain areas of Romania, snow fell during the whole month. The maximum depth was measured at 254 cm in Fagaras Massif. The remainder of the country temporarily had snow. Bulgaria reported snow on 08 and 09 March. Even Greece (including the Ionian coasts) had significant snow, particularly in northern and central parts.

In the South Caucasus, a steady snow cover persisted in high mountains during the whole month, with measured depths up to 171 cm.



Fig. 3.3: Tree knocked down by snow in Ferrara (Italy) on 09 and 10 March.
Source: ARPA-SIMC, Italy

Significant weather events

- March 01: Flash floods on the eastern Azores in the early morning.
- March 03: 8 m high waves hit a cruise ship in the western Mediterranean Sea. 2 people died and 6 were injured.
- March 04: Dozens of ships were stuck in the ice in the Baltic Sea.
- March 06–11: An intense cyclogenesis over the Tyrrhenian Sea caused intrusion of cold air from the east, causing exceptional snowfall and high wind speed in several countries, namely France, Germany, Austria, Italy, Bulgaria, northern Greece, even Spain, as well many accidents and traffic disruptions (Fig. 3.3). High sea levels along the Adriatic coast with intense storms over the same area. A blizzard-like cold outbreak occurred in southern Romania. A daily total of 120 mm of precipitation was measured in Trikala (Greece) on 07 March. In north-eastern Europe, night temperatures locally dropped below -20°C in eastern Lithuania on 07–08 March.
- March 08: Greece was affected by dust from the Sahara desert.
- March 09: Storm of hurricane force (gusts up to 136 km/h) in Novorossisk (Krasnodar, southern European Russia).
- March 09–11: Snowfalls over northern Italy and heavy rain over Ionian coasts and southern Sicily due to an Atlantic storm moving to Italy on a relatively low-latitude track. Slovenia was also affected by a snowstorm with gusts up to 200 km/h in the Primorska region.
- March 22: Bulgaria reported Saharan dust and warned people suffering from asthma or similar diseases.

- March 26–30: Germany reported a severe thunderstorm on 26 March passing from the west to the east, with heavy rain, hail and wind gusts > 80 km/h (locally >120 km/h), a second thunderstorm with heavy rain occurred in northern Germany on 30 March. Austria reported high wind gusts on both days, causing fallen trees and emergency for 3 boats on Lake Neusiedl. Switzerland reported high wind gusts on the 26th as well as some thunderstorms.
- March 31: After Britain had seen its coldest winter for three decades, heavy rain, snow and gale-force winds pounded Scotland and Northern Ireland, killing one person and leaving tens of thousands without power.

April

- **Warmer in nearly the whole Region**
- **Mostly dry**

Atmospheric circulation characteristics

Similar to March, the NAO index was still negative in April. The Azores high was weak. High pressure conditions and sunny weather prevailed over nearly the whole of Europe, except in the north-east. The beginning of the month (around Easter) saw low pressure conditions, causing showers especially in central Europe.

A south Caspian cyclone, however, caused high precipitation around the Caspian Sea especially in the middle of the month.

Temperature

April was warmer than normal over nearly the whole Region (Fig. 4.1). The highest anomalies were recorded over the Arctic and in north-eastern European Russia ($>+4^{\circ}\text{C}$, up to $+8^{\circ}\text{C}$ in north-western Greenland). Daily maximum temperatures at the coasts of Greenland and on the Arctic islands exceeded 0°C . Record-breaking maximum temperatures were registered in some north-western and eastern parts of European Russia in early April. However, the northern part of the Baltic Sea and the White Sea were still at least partly frozen. Slightly below-average temperatures in Iceland were related to the eruption of the volcano Eyjafjallajökull in the middle of the month.

Over most of Europe and the Middle East, the monthly temperature deviations were greater than $+1^{\circ}\text{C}$, in both south-western and north-eastern Europe they were between $+2$ and $+4^{\circ}\text{C}$. In parts of northern and western Europe and locally on the Balkan Peninsula, the 90th percentile was exceeded. Daily maxima exceeded 20°C in the United Kingdom (although minimum temperatures were around normal and there were some frosts), and it was the warmest April in 100 years. It was also the warmest April in central England since records began in 1659. Daily maxima exceeded 25°C in central Europe and 30°C in Greece.

In western and central Europe, however, April 2010 was not as warm as April 2007 and 2009. Cold weather with minima around the freezing point dominated in the first half of April in Germany and Switzerland, but temperatures often rose above 20°C in the second half, locally even above 25°C at the end of the month. The last third of April was also warm on the Balkan Peninsula, e.g. in Slovenia and Serbia.

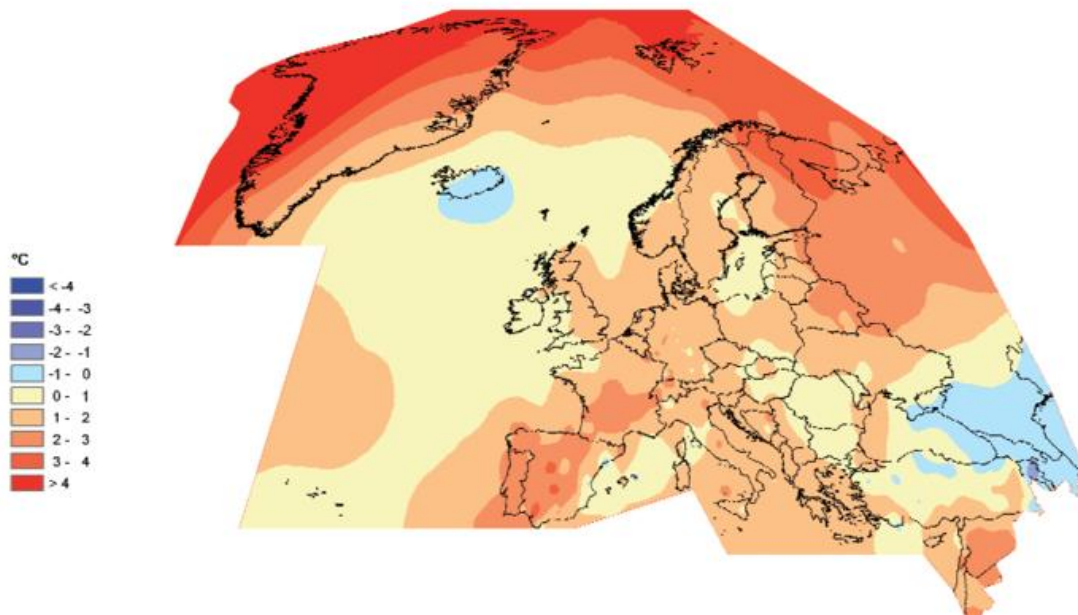


Fig. 4.1: *Monthly mean temperature anomalies in April 2010 (reference period 1961–1990) in WMO Region VI*
Source: Deutscher Wetterdienst, Germany

In Portugal, it was in fact the warmest April of the last 13 years regarding maximum temperature. It was slightly colder than normal on Iceland and in the east in western Kazakhstan and the Caucasus region. In some regions of east Georgia, minimum temperatures dropped down to 1°C in the lowlands.

Precipitation

Most of the Region saw a dry April (Fig. 4.2). It was mostly dry in the Arctic, particularly in the southern areas of Greenland. Over large parts of western and central Europe and locally in the north and east, less than 40% of the monthly totals were recorded. Over France and Germany, in the eastern Ukraine and some places in Russia, the totals were below the 10th percentile and widespread below 40% of the normal; long dry periods were interrupted by only very short thunderstorms and rain, mainly at the beginning of the month.

In the United Kingdom, however, it was not as dry as in April 2007 due to an unsettled first week with some heavy rainfalls in places. Germany had its second driest April since 1893 behind 2007. There was no measurable rain for two weeks in parts of northern Germany.

Dust storms occurred in the steppe zone of the Ukraine; they resulted in damage to the rising crops.

It was particularly dry in the southern and eastern Mediterranean. Malta received only 1.2 mm the whole month (normal is 22.5 mm). Locally, Greece and the Middle East received less than 20% of the normal. At most stations in Israel, monthly totals were less than 5 mm.

It was wetter than normal (though mostly not significantly) in some places in the north and north-east (around twice the normal in north-east European Russia and some Norwegian areas), in the eastern Alpine region and most of Italy, in Hungary, over most of the Balkan Peninsula (except Slovenia), in the east over the lower reaches of the Volga as well as in west Kazakhstan and the South Caucasus region. Convective events with large hail, heavy rain, strong wind or even tornadoes occurred occasionally in the Mediterranean area and the Balkan countries.

Serbia was extremely wet especially in its central, southern and south-eastern parts and new local records for daily precipitation totals in April were set on 20 April (stations Kraljevo 50 mm, Kopaonik 44 mm).

In the South Caucasus, various areas in Georgia received around 300% of the monthly normal (up to 377 mm in western parts), in Armenia up to 250%. Heavy rainfall and flooding of rivers occurred especially in the highlands of Azerbaijan.

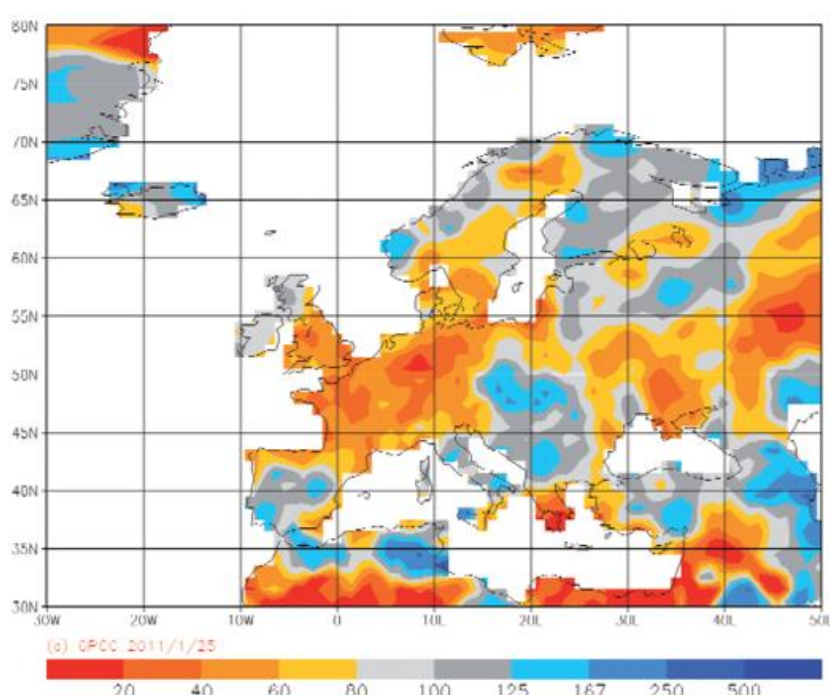


Fig. 4.2: Monthly precipitation amounts for April 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Snow

In April, only most of Scandinavia, northern European Russia and the high mountains were covered with snow throughout the month. Snow disrupted traffic in north-eastern Iceland during the first days of the month. Scottish highlands reported up to 39 cm of lying snow on 1 April due to heavy snowfalls at the end of March. On the other hand, high temperatures caused rapid snowmelt even in parts of northern Europe, e.g. in Estonia, followed by severe flooding in the Tartumaa district.

There was some local snow even in Slovenia at the beginning of the month, but only for 3 days in the lowlands, whereas it persisted the whole month in the mountains (450 cm on Kredarica on 19 April and thus the annual maximum in this place). Romania had snow in mountain regions above 1700 m altitude. In the South Caucasus, snow persisted locally on high mountains in western Georgia. In the other regions, it melted in the middle of the month.

Significant weather events

- April 07: Heavy storm around Sliven region in Bulgaria with gusts of 122 km/h.
- April 14–20: Volcano ash from the eruption of Eyjafjallajökull on Iceland on 14 April was spread across Europe by upper-level winds. Although the eruption seldom rose above the tropopause, it stopped air traffic during several days, which was the largest disruption since World War II. Up to 23 European countries were affected; more than 100,000 flights were cancelled. As a consequence of the eruption, glacier surrounding of the volcanic crater partly melted, causing flash floods that destroyed the infrastructure of the region (flooding of local roads and risk of damage to bridges). Almost 800 people had to leave their homes in a small town situated beneath the glacier and some farmland was devastated, but no fatalities were reported.
- April 24: Eleven events of avalanching in the Republic of north Ossetia (northern Caucasus, southern European Russia).
- April 27–28: Late frost in Bulgaria caused some damage to fruit trees.
- April 30: Southern Germany and Austria were hit by heavy rainfall with more than 30 mm in 24 hours at several stations. The highest 24-hour sum was reported for Waging am See: 51.6 mm.

May

- Cold in north-western, western and central Europe, warm in the Arctic and in the east
- Mostly wet, dry in the west and the east
- Severe flooding in eastern central Europe

Atmospheric circulation characteristics

In May, a meridional circulation pattern prevailed again particularly in the first half of the month. This time, most of Europe was under low pressure influence with partly intense convective phenomena, whereas high pressure dominated over the Arctic, the eastern North Atlantic in the west and over Russia in the east. The Icelandic low was dislocated far to the south-west. Cold and dry air masses from the north flowed continuously to western Europe, while warm air from the south brought warm Mediterranean air masses through eastern Europe to the polar cycle.

In western and central Europe, warmer air masses dominated in the second half due to a more pronounced zonal component.

Temperature

The Arctic region was around +2 to +3°C warmer than normal; even the northern North Atlantic was partly +2°C warmer than average. In Greenland, daily maximum temperatures exceeded 20°C at one station during the first decade of May 2010 (Kangerlussuaq in 67°N), and at three stations during the third decade. The arctic station Hopen on Svalbard set a new highest mean monthly temperature record for May and several stations in northern Norway (county Finnmark) registered the highest maximum temperature since the measurements started in the second half of the 19th century. All ice in the Gulf of Bothnia, most of the ice in the White Sea and much of the ice in the Arctic Sea had melted.

May was colder than normal over southern Scandinavia, north-western, western and large parts of central Europe including the North Sea and parts of the western Mediterranean (Fig. 5.1).

Especially the first half of the month was cold in western and central Europe, but the second half was warm. The United Kingdom, for instance, had cool weather with frosts in the first half of the month, but a warm spell from 20-24 May; Oxford had a maximum of 28.9°C and new May records were set in Scotland.

The beginning of the month (4–5 May) was also exceptionally cold in southern France, with maxima of 6–8°C in the lowlands. The second half of May, however, saw temperatures exceeding 24°C on several days over wide areas. France had its coldest May since 1996, the Netherlands and Germany since 1991. Particularly north-western Germany was cold on average, with anomalies below -2°C, which was below the 10th percentile; there were widespread frosts in the first third of the month in the northern and eastern parts of Germany as well as in northern and north-western Poland. Later in the month, temperatures in Germany reached up to 29°C on 24 and 25 May, in Slovenia up to 30°C on 25 May (station Bizeljsko). In Austria, it was the second coldest May since 1991, behind 2004.

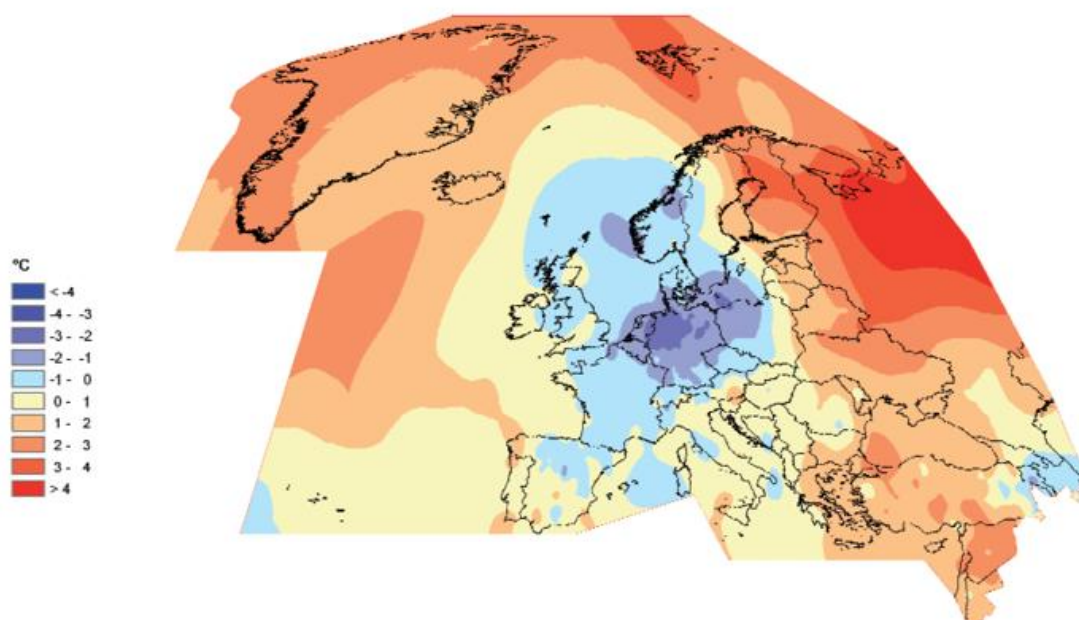


Fig. 5.1: Monthly mean temperature anomalies in May 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

Most of the other parts of the Region were warmer than normal, particularly the north-east. The highest maximum of that month in Finland was 29.6°C. Places in south-eastern Finland recorded their highest number of summer days ever seen in May. Around the middle of the month (14th, 15th), several summer days (maximum temperature of 25°C or more) were registered in Finland, Estonia and northern Russia. On 18 May, the maximum temperature rose as high as 26.4°C in Murmansk in north-western Russia, which was nearly +5°C higher than the previous record of 1984. In Lithuania, 22–27°C were measured in the second half of the month.

Anomalies were highest over northern European Russia (> +4°C), exceeding the 90th percentile. Record-breaking maximum temperatures were registered as early as at the beginning of May in several parts of northern and central European Russia, reaching 28–31°C in the central Chernozem region (near the Ukraine), i.e. +7 to +9°C above normal. The high temperatures were accompanied by hot winds and forest fires. Similar anomalies were recorded in the Volga region.

The eastern Mediterranean and almost the whole of the Middle East were at least +1°C warmer than normal. The warming was underlined by some warm spells with quite high daily maximum temperatures. Greece had a 5-day heat wave at the end of the month, with maxima exceeding 35°C. Israel and Jordan had a number of hot spells with temperatures up to 43°C in the Jordan Valley. The South Caucasus and some places in eastern Turkey were an exception in that area, recording just around normal monthly averages or even slightly colder temperatures.

Precipitation

It was very dry in most of Greenland and Iceland, western parts of Europe and southern Norway, particularly near the North Atlantic, locally with less than 40% of the normal precipitation, but also with locally heavy showers in Norway (Fig. 5.2). It was the driest May across the UK since 1991, despite some heavy showers at the beginning of the month, especially over Scotland and Northern Ireland.

Most of the other parts of Europe were wetter than normal. Large parts of northern Europe (except western parts) received more than 125% of the normal monthly average. Thunderstorms with heavy showers were recorded in many parts of Estonia, locally resulting in monthly totals of more than twice the normal.

Particularly over eastern Germany, Poland, eastern Czech Republic, Slovakia, Hungary, western parts of eastern Europe and some northern parts of the Balkan Peninsula, more than 250% of the normal was registered, exceeding the 90th percentile. In places across eastern Germany, southern Poland and Slovakia, even more than 400% were measured. This was mainly due to one heavy precipitation event in that area in the second half of the month. Large parts of eastern central Europe received monthly totals of more than 100 mm, near the border between Poland and Czech Republic even more than 300 mm, locally up to nearly 600 mm. Extreme flooding occurred especially in the catchments of the large rivers in eastern central Europe (Odra, Vistula, Danube and Tisza). However, the water levels stayed below those of the flooding event in 1997.

It was by far the wettest May on record in Slovakia and locally the wettest May in Poland. Intensive downpours over Poland and Slovakia caused serious devastation; many areas were flooded. The areas east of the Alpine region were also extreme in terms of heavy rain that month. Over large areas from Austria to Hungary, May 2010 was among the wettest ever registered, with both the precipitation totals and the number of rain days considerably higher than normal. Slovenia was particularly wet in its western parts, with locally more than 200% of the normal (Goriško), whereas some other parts of Slovenia were quite dry (50–60% of the normal).

The area with extreme precipitation extended even farther south. In Serbia, it was extremely rainy in the north (Vojvodina), with a monthly total of 195 mm measured at the station Sombor and a May record broken in Kikinda with 202 mm. In Italy, a station south of Parma recorded the wettest May since 1940 and extremely high historical values were also reached in several other places across the country.

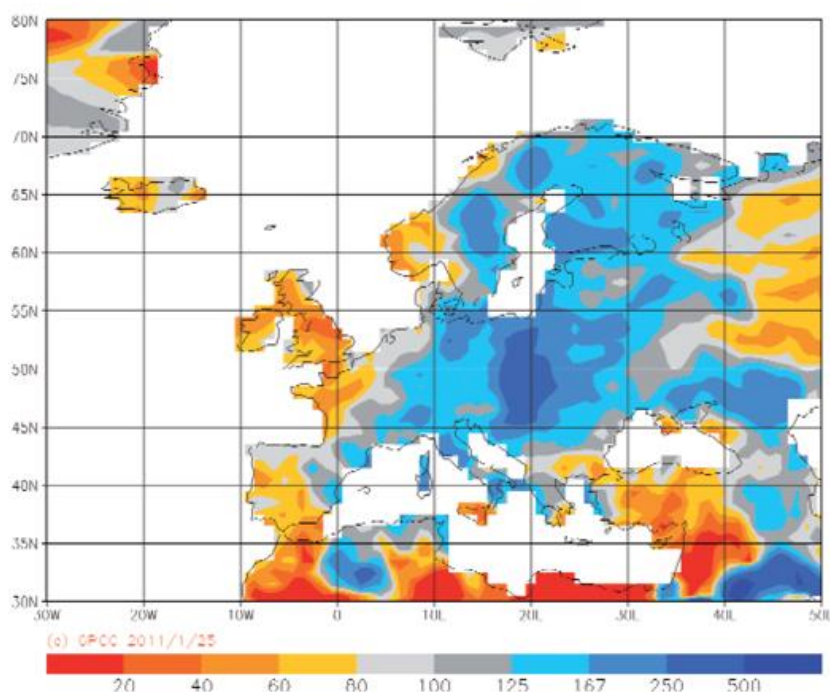


Fig. 5.2: Monthly precipitation amounts for May 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Some eastern areas of the Region, e.g. eastern European Russia (except the south) and most of the Middle East were very dry. In all these dry areas, however, the monthly totals were below the 20th percentile only in some places. Heavy thunderstorms occurred occasionally on the central Aegean Sea.

Frequent convective precipitation with hail up to 20 mm in diameter occurred in parts of southern European Russia near the Caucasus, leading to monthly totals of twice the normal and more. The Ukraine was mostly very wet, too. May precipitation was close to normal in most of the South Caucasus, but heavy rainfall with hail occurred in places especially in Armenia (resulting in monthly totals locally up to 250% of the normal) and also in Azerbaijan, where several villages around the Kura River were flooded and many houses, bridges, roads, agricultural crops and power lines damaged (estimated worth: about 62.5 million US \$). The river had risen at the fastest rate of the century.

Snow

There was still a snow cover at some stations in northern and central Scandinavia and on higher mountains in central Europe. At the beginning of the month, a cold spell produced snow even in the lowlands of southern France. In the middle and at the end of the month, snow fell in higher regions of the northern United Kingdom and Austria.

In other parts of the Region, snow had mostly melted. However, the first days of May brought some snowfall in the highlands of Azerbaijan, with depths of more than 20 cm. The high mountains in Georgia also had some snow until 8 May.

Significant weather events

- May 03-04: A depression over the western Mediterranean Sea caused strong winds at the southern coast of France, with wind gusts of more than 110 km/h at several locations, partly even more than 130 km/h. The coastline of the Cote d'Azur was hit by waves up to 7 m high (mean wave height: 4 m). The cold air with maximum temperatures of only 6°–8°C was exceptional for the season and much snow fell in the Pyrenees and the Massif Central (30 cm above 1000 m altitude, 50–70 cm between 1500 and 1700 m and 50–100 cm between 1700 and 2000 m). Snow was even observed in Carcassonne and Narbonne.
- Up to 200 mm of rainfall was recorded in the north of Mallorca Island in the western Mediterranean during this event.
- May 07: A heavy thunderstorm caused the flooding of parts of the town of Shumen (north-east Bulgaria).
- May 10-13: The Alpine region was affected by heavy rain and storm. South-western France, Switzerland, southern Germany and Austria were hit. Severe hail and high wind gusts occurred in Switzerland on the 11th. In Austria, the rain of the 13th caused the enormous damage due to landslides and flooding. 60 mm rain in one hour was recorded in the northern districts of Vienna, which were partly flooded.
- May 12: Heavy rainfall in Yerevan (Armenia): 47 mm in 12 hours.
- May 15-22: Outstanding flooding in Poland (Wisla), the north-eastern Czech Republic, Slovakia, northern Hungary, Croatia, Bosnia and Herzegovina, Serbia and Bulgaria, which was connected with very high and repeated rainfall especially in the catchment area of Wisla and Odra in Poland. Local precipitation totals for the period 15–18 May exceeded 375 mm. On 16 and 17 May, up to 200 mm of rain fell over southern Poland and the Czech Republic within 24 hours. The rains and subsequent overflowing rivers brought the worst flooding in more than a decade to Poland. Large areas of land were under water, river dams partly broke, several people died in the floods and thousands had to leave their homes. At the end of the month, the flooding also reached Germany (Oder). Some heavy rainfalls with thunderstorms and squalls, which caused trees to fall and ripped roofs from buildings, also occurred in southern Lithuania (up to 60 mm in 6 hours on 17 May). Wind speeds of 110 km/h were reported north of Budapest, Hungary.
- May 17: Flooding of the Tiber River in Italy after a rapid cyclogenesis over the central Tyrrhenic Sea and intense, but not convective rainfall of about 120–240 mm within 36 hours. The peak water level in the river was 8.90 m on 15 May, but not record-breaking. However, new records of daily precipitation were set at two stations in Lazio (Italy).
- May 18-21: Flooding of the Kura River in Azerbaijan, the biggest transboundary river in the Caucasus region as a result of heavy rainfalls in April and May. The water level reached its maximum from 18–21 May, but it continued to stay high until the end of June (Fig. 5.3).
- May 22–23: Thunderstorms and heavy rainfall (21 mm per hour) with hailstone size up to 2.5 cm in diameter occurred in places of southern Finland, causing sudden flooding with several hundred thousand euro worth of damage to properties, agriculture and transport.

- May 22–23: Heavy thunderstorm with hail and local floods in the Sporades region, Greece.
- May 24: (Whit Monday tornado). A tornado in eastern Germany (Fujita scale F2–F3) caused severe damage to roofs, trees, power lines masts and cars. Flooding of cellars due to accompanying rain and hail were reported. A little girl died in a car that was hit by a tree.
- May 25–26: Heavy rain fell in France (108 mm in Dinard, Ille-et-Vilaine, Brittany, with 67 mm within 1 hour). Hail hit Austria (e.g. Großmugl, Gänserndorf, east of Vienna), causing extended damage to wine yards and crop fields, and the south-east of Bavaria in Germany (reported hail size about 3 cm). Wind gusts also caused severe damage to roofs of buildings (Neusiedl am See).



Fig. 5.3: Damage on railways caused by flooding of the Kura River in Azerbaijan, with maximum water level from 18–21 May 2010.
Source: National Hydrometeorological department of Azerbaijan

June

- **Mostly warm, but cold in Scandinavia**
- **Dry in north-western and central Europe and in parts of Russia, wet in most of northern and southern Europe**

Atmospheric circulation characteristics

Cold arctic air moved southwards and affected particularly northern Europe where prevailing low pressure conditions caused much rain.

Over the North Atlantic, a stronger-than-normal subtropical high extended far to the north and frequently caused dry and warm conditions over much of north-western and central Europe, interrupted by occasional heavy thunderstorms. The Icelandic low was still dislocated south-westwards as in May.

High pressure influence also dominated over eastern European Russia, whereas other parts of eastern Europe and the Balkan Peninsula were much affected by intense convective events.

Most of southern Europe, in contrast, was affected by frequent and intense cyclonic activity. A cold air outbreak associated with a strong cut-off low occurred in Italy at the end of June.

Temperature

June was also warmer than normal in the Arctic region and over the North Atlantic. Anomalies exceeded $+2^{\circ}\text{C}$ and the 80th or 90th percentile over most of Greenland, western Iceland and large parts of the northern North Atlantic (Fig. 6.1). The June warmth in Iceland was particularly unusual. It was the warmest June on record both in Reykjavík (from 1871) and Stykkishólmur (1845).

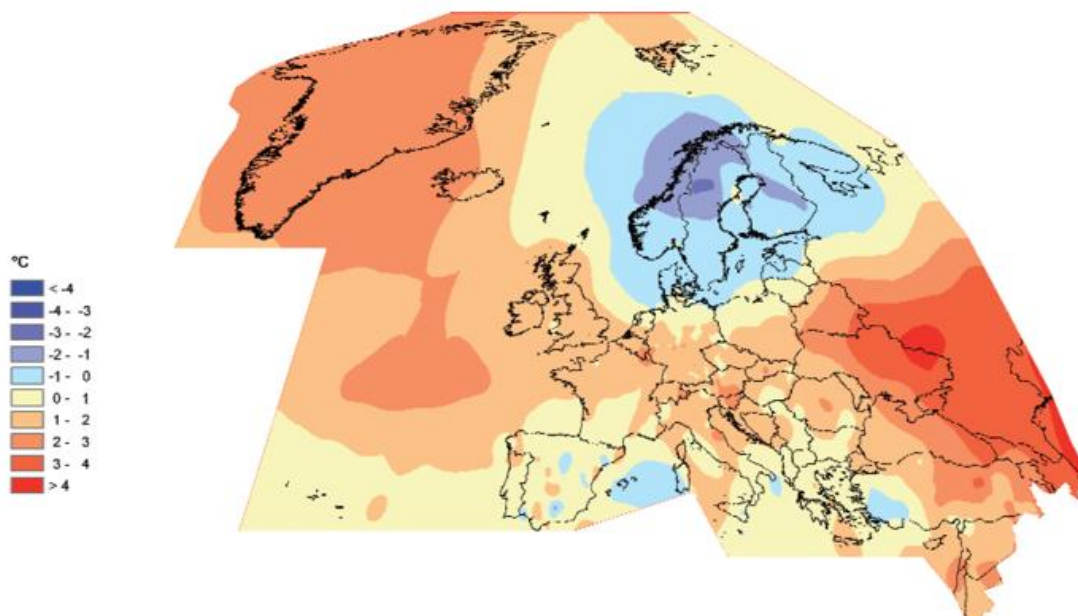


Fig. 6.1: Monthly mean temperature anomalies in June 2010 (reference period 1961–1990) in WMO Region VI

Source: Deutscher Wetterdienst, Germany

It was colder than normal across almost the whole of northern continental Europe (except small areas in northern Norway as well as southern and eastern parts of the Baltic countries) and over adjacent sea areas, with highest negative anomalies over central Sweden at around -2°C and thus below the 20th percentile. Northern parts of Scandinavia and European Russia still had frosts. However, a heat wave occurred at the end of the month in north-eastern Europe; in Estonia, it was by far the most remarkable heat wave in the 144-year time series of Tartu. Denmark also had its first summer day (25°C or more) just at the end of month on 28 June.

The other parts of the Region including the water surfaces were nearly all warmer than normal except a few areas in the south. Most of north-western, western and central Europe, the northern Balkan Peninsula and the Middle East had monthly anomalies of more than $+1^{\circ}\text{C}$,

large parts of eastern Europe more than +3°C, in the Volga region more than +5°C, in the South Caucasus locally up to +6°C. All anomalies there were above the 80th percentile, partly even above the 90th percentile.

Some daily temperatures were relatively high in north-western and central Europe. Daily maxima exceeded 30°C locally in the United Kingdom. Central Europe saw a heat wave around 10 June, particularly near the Alps in southern Germany (Munich City 33.5°C) and in the northern plains of Switzerland due to an unusually strong foehn. Another warm spell occurred in central Europe at the end of the month, but was interrupted by a cold spell around the 20 June with local ground frosts e.g. in eastern Germany, which resulted in lower positive monthly mean anomalies compared to parts of western and eastern Europe.

South-eastern Europe generally had a hot June. Serbia had a heat wave from 7–14 June in most of its parts and a higher-than-normal number of tropical days and nights especially in the southern parts of the country; new daily maximum temperature records were set at some mountain stations. The period 10–15 June was also particularly warm in Romania, setting new highest local daily minimum and maximum temperature records, whereas the end of the month was cold in the south and east of the country. After a cool beginning of June, Bulgaria and Greece had a 3-day heat wave in the middle of the month, with maximum temperatures up to 37.6°C in Bulgaria and up to 41°C in Greece (long-term mean maximum for June at Ierapetra (Crete) is 29°C).

The third ten-day period was particularly hot in most of central and eastern parts of European Russia, with daily maxima up to 41°C in the Astrakhan region. This was the beginning of an extreme and extended heat wave in Russia, which continued during most of the summer. On 25 June, a maximum temperature record for June was established in Moscow with 32.8°C. The south of European Russia experienced the hottest June that had ever been recorded in 120 years of regular meteorological observations. Western Kazakhstan was also hot, especially in the middle of the month with maxima above 40°C.

The South Caucasus had some extreme positive temperature anomalies. Maxima in west Georgia reached up to 39°C. In Baku (Azerbaijan), daily anomalies were locally record-breaking, e.g. +8°C on 5 June.

In the Middle East, June was warmer than normal in Israel and was characterised by a large number (5–7) of Sharav days with a most extreme temperature of 46.6°C in the Jordan Valley. In the last 50–60 years, a similar number of Sharav days in June occurred only once in 1993. The Sharav reached even the coastal strip of Israel, which was rather unusual for the time of year.

In south-western Europe, June temperatures were near normal in Iberia and over the western Mediterranean. It was the coolest June since 1997 in Spain. A few places in the Mediterranean region were slightly colder than normal.

Precipitation

It was a dry June in the Arctic (except parts of western Greenland), and also in north-western and over large parts of central Europe, with widely less than 50% of the normal (Fig. 6.2) and thus less than the 10th percentile. The dry weather in Iceland affected the vegetation in some areas and local water shortages were reported.

Most of northern Scandinavia was mainly wet. At the northern coast of Lapland, the monthly totals were higher than 100 mm or more than 250% of the normal, which was more than the 90th percentile. For all northern Norway, it was the third wettest June on record. In contrast, southern and western Norway received very little precipitation, making it partly the driest June there since at least 1900. Southern Sweden, Denmark and Finland were likewise dry. Locally

heavy rainfall was reported from Estonia, with intensities of up to 52 mm in 24 hours. In Denmark, it rained mainly in the first half of the month, with high intensities especially on 7 and 8 June.

Parts of central Europe were extremely dry in June. Stations in Berlin (Germany) only received 2–3 mm during the whole month, which caused the driest June on record there (since 1908 in Berlin-Dahlem). Some stations in eastern Germany did not receive any rain for 2–3 weeks. Nevertheless, some intense thunderstorms were reported, particularly near the Alpine region and in eastern central Europe. Several rainfalls and thunderstorms with hail caused damage and flooding in northern Austria. In eastern parts of Austria, June 2010 brought up to 200% of the average precipitation, in Hungary about 150% of the country's average. Most of Slovakia was also very wet.

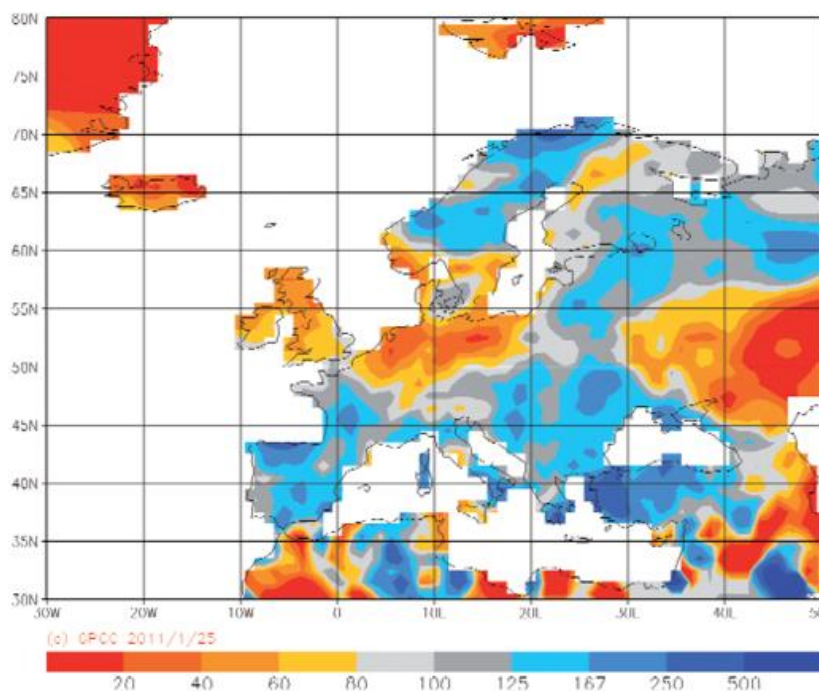


Fig. 6.2: Monthly precipitation amounts for June 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

South-western and southern Europe, too, were mostly wet with frequent convective precipitation. The 90th percentile was exceeded in many places, especially in parts of Spain, Italy, most of the Balkan Peninsula and western Turkey, locally with more than twice the normal monthly totals, e.g. in Italy in some places near the Po river. The monthly total at Ferrara was the highest of the time series starting in 1924. In south-east France, monthly totals were up to 400 mm (more than 500% of the normal) due to a heavy storm on 15 June. Only a few areas in the Mediterranean region were dry (e.g. Sicily, Malta, Cyprus).

Another area with high precipitation extended from the Balkan Peninsula northwards to the Baltic countries and northern Russia, due to a slow moving depression at the beginning of the month. On the Balkan Peninsula, totals in Bosnia and Herzegovina as well as in Serbia locally rose to more than 300% of the normal and the number of precipitation days was correspondingly high in Serbia. During the third week of June, heavy rains in Bosnia led to more than 30 landslides and caused river floods. New monthly precipitation records were set, e.g. at the Serbian station Sombor with 240 mm, 113 mm of which fell just on one day (22 June,

setting a new record for June). Monthly totals in Romania were also high (over 100 mm) in most parts of the country, in the north-east even more than 300 mm, which was more than twice the June normal in some areas.

A larger, very dry area was to be found over central and southern European Russia, western Kazakhstan and the South Caucasus region. Parts of southern European Russia received less than 20% of the normal precipitation, which was less than the 10th percentile. A particularly critical situation existed in the last ten-day period of June, when central areas of European Russia and the Volga region received no rainfall at all or only a few mm. Some places in west Kazakhstan did not have any precipitation during the whole month. On the other hand, intensive convective activity in places with hail occurred in the North Caucasus region throughout the month, with monthly totals of 150–300% of the normal. The South Caucasus, particularly the eastern parts, and west Kazakhstan saw a dry June, partly with less than 40% of the normal. Places in east Georgia and Azerbaijan had around 30%, Armenia down to 14% of the normal. Other places, especially mountainous parts of western Georgia as well as places in the south-east of the country and in northern and central Armenia, had abundant rainfall, partly combined with hail in the second decade of the month. Azerbaijan saw intensive rainfall only in the first part of the month, causing severe countrywide flooding.

The Middle East, too, was partly very dry, but was not completely without rain. In Israel, there was some rainfall of a few mm on 24 and 25 June, which is rather unusual there for a summer month, but generally the country was in the midst of one of its longest and most severe droughts since the 1920s.

Snow

In June, there was hardly any snow in the Region except on some high mountains. On 20 June, however, snowfall in the Alps came down to 1000 m altitude within a cold spell due to a cut-off low which extended far to the south. On the Kredarica Mountain in Slovenia, the snow depth decreased considerably from its highest monthly value (235 cm) to only 35 cm at the end of the month.

Significant weather events

- June 01–05: A quasi-stationary upper tropospheric depression over the northern Balkan Region (low Angela) caused heavy and long lasting rainfall, with flooding in southern Germany (Bavaria) due to 48-hour precipitation amounts between 80 and 208 mm and 24-hour amounts between 54 and 155 mm. 80 mm in 24 hours fell near Salzburg (Austria). In Hungary, the same depression caused between 50 and 120 mm in 72 hours in the southern and northern regions of the country and 30–47 mm in 48 hours in the northern region. High wind gusts occurred also (maximum 135 km/h). Bosnia and Herzegovina reported heavy rainfall on the 1st of June, with 79 mm at Gradacac. Croatia, Slovakia, the Czech Republic and Poland were also affected by high water levels in rivers and flooding. Further north, Lithuania reported heavy rain accompanied by thunderstorm and hail on the 3rd and 4th, with a maximum total of 84 mm in 8 hours at Elektrenai. Estonia reported precipitation amounts of 20–58 mm over the period 02–05 June.
- June 07–08: Heavy rainfall in Mozdok (Republic of north Ossetia, southern European Russia). 140 mm of precipitation fell in one night, which is twice the monthly precipitation normal.
- June 08: Heavy rains, which had affected Istanbul (Turkey) the days before, caused a river on the city's Asian side to burst its banks, inundating dozens of houses.

- June 09–13: Thunderstorms with intense rain, hail, storm and tornadoes developed in a warm and moist air mass over central Europe and affected Germany, Switzerland and Austria seriously. Hailstones up to 3 cm were reported. Wind gusts up to 150 km/h (under foehn conditions) occurred in Switzerland. 30–50 mm of rain within short time intervals were reported for Germany and Austria.
- June 11–19: Thunderstorms with heavy precipitation occurred in various parts of Europe. Heavy rainfalls in northern Spain (Galicia and Asturia) caused flooding at the beginning of the second decade of the month. In France, the region Provence - Alps - Côte d'Azur was hit by an exceptional event with precipitation amounts from more than 150 mm up to nearly 400 mm especially on 15 June. This is close to the amount that typically falls in a six-month period in this area. Flash flooding killed at least 25 people and left hundreds of others stranded in cars, houses or on rooftops. The rainfall event and subsequent flooding was the worst on record since 1827. The following days until the 17th brought further precipitation to Switzerland, southern Germany and Austria, and heavy hail to Slovenia. Hungary reported severe thunderstorms with heavy rain (60mm/2h in Kiskunmajsa), hail and high wind speeds (possibly a tornado north of Szeged). Bulgaria had large hail on 16 June. Even in northern Europe (Denmark) reported a heavy thunderstorm with hail on the 15th. Sweden saw heavy precipitation up to 126 mm in 48 hours on the 18th and 19th, causing flooding and landslides.
- June 20–21: A remarkable change of the circulation with a cut-off low in the Mediterranean area brought a temperature fall of about 10 degrees to the northern and central Adriatic regions (even in Milano, the temperature fell from 25–27°C to 14–16°C from 19 to 20 June, which was followed by a sudden increase on 21 June). The Alps had snowfall above 1500 m and widespread thunderstorms occurred in northern and central Italy.
- June 22–25: Heavy rain with flooding extended over the northern Balkan Peninsula to the east. Bosnia and Herzegovina reported heavy rain with close to 100 mm on 22 June, causing river flooding, landslides and broken roads; thousands of homes had to be evacuated. Many Bosnians feared that land mines planted during the Bosnian War in the 1990s could have been shifted by the floods. Also in Serbia, a great flood was recorded in the basin of the rivers Kolubara and Jadar, which lasted until 5 July and caused significant material damage. Heavy rainfalls unleashed floods in northern and eastern Romania (maximum 24-hour precipitation reported: 163 mm). Numerous people were killed and hundreds had to be evacuated from their homes. Several roads and hundreds of hectares of farmland were inundated, dozens of houses destroyed and several bridges damaged. Moldavia was also sincerely affected by floods due to some partly intense, partly enduring rainfall episodes. Rainfall led to sudden high water levels, especially on the River Prut. 4000 people had to be evacuated, more than 1000 houses were destroyed and agriculture and forestry were severely affected. The economic damage added to 0.15 % of the gross domestic product (BIP). Western Ukraine was affected as well.
- June 23: Abundant rain in Georgia caused flash floods and damage to houses and roads, washing away bridges and farmlands. Two deaths were reported in the basin of Gldanula.
- June 29: Heavy storm around Botev region in Bulgaria with gusts of 100 km/h.

July

- **Warm in nearly the whole Region**
- **Extreme heat wave in Russia and adjacent countries**
- **North-western, central and northern Europe mostly wet, south-western Europe and Russia very dry**

Atmospheric circulation characteristics

Low pressure systems, though with relatively warm air, crossed particularly north-western Europe within a strong frontal zone. Both the Icelandic low and the Azores high were stronger than normal this month, causing much rain over Ireland and the United Kingdom, but dry conditions over south-west Europe.

A very strong and extended Russian high caused an extreme heat wave over Russia and, to a lesser extent, in other countries, particularly in eastern Europe. A strong and persistent ridge also extended over Fennoscandia, leading to exceptionally warm and dry conditions there.

Some low pressure systems with convective activity also crossed central and parts of eastern and south-eastern Europe, but were blocked by the Russian high.

The Mediterranean region was first influenced by quite strong high pressure and advection of subtropical continental air masses over the central Mediterranean and Italy. Later in the month, a north-westerly flow prevailed, which brought cooler mid-latitude maritime air into the area.

Temperature

Nearly the whole Region had a warmer-than-normal July (Fig. 7.1). Averaged over the European continent, July 2010 was the warmest on record since 1900. The anomalies were higher than +1°C over nearly all land areas, in many cases they were even much higher, e.g. in large parts of eastern Europe more than +4°C (partly more than +5°C, e.g. in the Baltic countries and Belarus) or +6°C (locally even more) in European Russia. The 90th percentile was exceeded nearly throughout the Region, at least over land areas (with exception of Ireland and the United Kingdom and some areas near the coasts). Only parts of Svalbard and a small area over the eastern Arctic Sea were slightly colder than normal. The widespread warmth was due to a strong heat wave centred over Russia and was characterised by high daily and monthly means, maxima and minima as well as an exceptionally long duration. Tropical nights occurred more often than normal, particularly in southern Russia, but also in western and central Europe and in the southern parts of the Region (with minima even >25°C, e.g. in Portugal).

In northern Europe, July was one of the warmest ever in southern and western Iceland. Norway had positive anomalies of about +1 to +2°C, but no extremely high maxima; its highest daily temperature for the month and year was recorded on 10 July at 28.7°C. Anomalies were higher towards the east and south. Denmark measured a peak temperature of 34.1°C on 11 July on the island Bornholm, which was the highest value in Denmark since 1994. A couple of stations in southern Sweden reported new all-time high temperatures since measurements began in the mid-nineteenth century. The highest temperature in Sweden this month (and summer) was 35°C and thus the highest since 1994. In Finland, the highest monthly temperature was 37.2°C at Joensuu Airport on 29 July, the highest ever measured in Finland. Finland also set a new record in the number of summer days (>=25°C): 28 days in Lahti and Puumala in the south-east of the country. Monthly average temperatures, too, reached new all-time records in many places

of Finland (the highest was again in Puumala at 23.0°C). In the Baltic countries, Estonia had the highest mean in 60 years; daily maxima exceeded 30°C for up to 14 days and several stations set new maximum temperature records. Latvia had its warmest July for 87 years. In Lithuania, it was the warmest July over the last 50 years, with maximum temperatures up to 35.5°C. Belarus recorded its highest temperatures in 100 years.

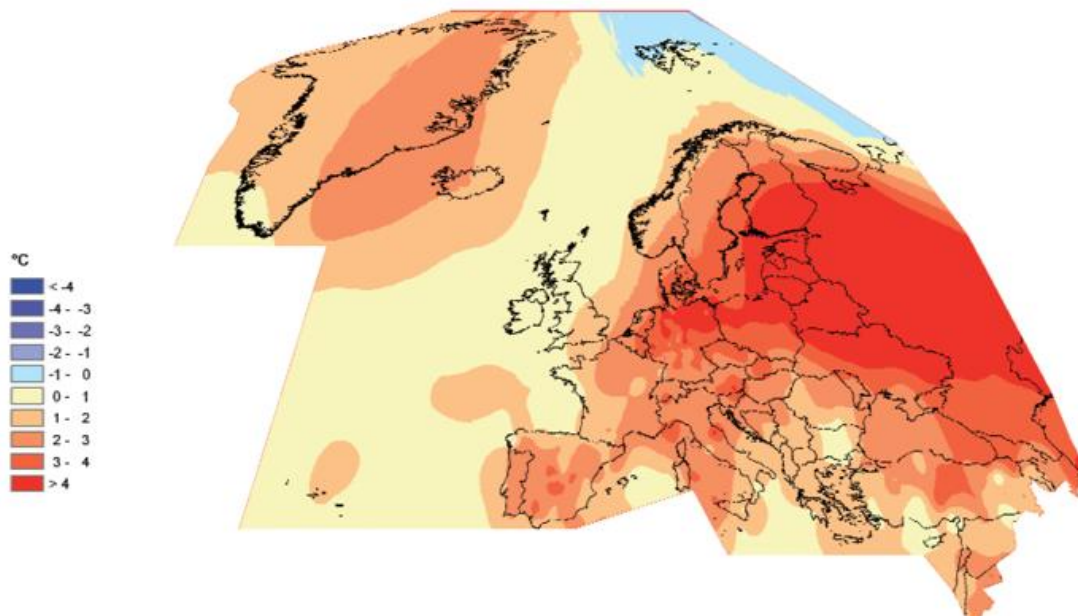


Fig. 7.1: Monthly mean temperature anomalies in July 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

In western and central Europe, high temperatures were recorded during the first half of the month in particular. Daily maximum temperatures reached more than 30°C or even more than 35°C at many places. At 31.7°C, the United Kingdom had their highest daily maximum in 2010 on 9 July. The Netherlands were +1.5°C warmer than normal, and the highest daily maximum in the country was 36.2°C, here, too, on 9 July. Belgium had a one-week heat wave during 07–14 July. Luxembourg airport had 7 days with daily maxima of 30°C or more, which is far above the 1971–2000 normal of 2.3 days. France was +1.9°C warmer than normal averaged over the whole country, which means that July 2010 was by far not as warm as July 2006. Germany saw some new maximum records on 3 July in Bremerhaven (34.1°C) and Osnabruck (36.9°C), but the highest official value in Germany was 38.8°C in Bendorf (near Rhine River). Water temperatures in the German Baltic Sea exceeded 23°C at times. Switzerland recorded a long heat wave from 8–21 July, with daily temperatures of over 30°C, but no absolute records. It was the second warmest July at the station Lugano in Tessin since measurements began in 1864. Local new records were broken in Austria, e.g. the station Graz University registered the highest July average since the beginning of measurements in 1837 (+3.6°C local anomaly). During a 15-day heat wave, the loss of ice at the tongue of the largest glacier in Austria (Pasterze) was approximately 6 cm per day. The Czech Republic generally had a warm July, too, followed by a sudden drop of temperature at the end of the month due to a strong cold front.

In the second half of the month, the eastern countries of Europe were hot. Highest deviations from normal were to be found over Russia due to a long lasting and very intense heat wave. It was the hottest July ever recorded in European Russia, particularly in Moscow (+7.6°C anomaly). Many daily maximum temperature records were broken in European Russia (Moscow 38.2°C on 29 July) and many hot days were recorded, partly with temperature maxima of more

than 40°C, and also many tropical nights. Temperatures above 40°C were also recorded in west Kazakhstan. The hot weather had deadly consequences. More than 1,600 drowning deaths were reported in July as people tried to escape the heat across Russia.

The South Caucasus was also hot, with maxima up to 39°C in various parts of Georgia. A heat wave in Armenia set an all-time record of 10 consecutive days with temperatures above 38°C. Large parts of the South Caucasus were +2 to +3°C warmer than normal compared to the monthly average.

Extremely high maxima and anomalies were also recorded in the Middle East. Jordan had its highest daily maximum at 45.6°C on 31 July at Azraq (+8.2°C anomaly). Israel, too, had a heat wave at the end of the month, with daily maxima up to 44°C in the Jordan Rift and minima up to 33°C at the Dead Sea. In the coastal plain of Israel, minima reached 27–28°C, which was a new all-month record.

The Balkan Peninsula was affected by notable warm spells, too. Slovenia had two heat waves (10–17 and 21–23 July); in some parts of the country, the temperature rose up to 37°C. High maxima above 40°C were measured in Montenegro, e.g. 40.1°C at the station Podgorica on 16 July during a strong heat wave, which was abruptly terminated on 24 July when the local daily maximum dropped from one day to the next from 35°C to around 20°C. Serbia was very hot, too, and the majority of its stations reported record-numbers of tropical nights. High temperatures in Romania during the second half of the month were related with high humidity. The highest maximum in Bulgaria was 37.4°C. Greece had two heat waves on 14 and 15 July and from 24–26 July with maxima up to 38–40°C on the mainland (long-term mean maximum for July: 32–33°C).

In the central Mediterranean, Malta had its warming peak on 24 July (38.3°C), but became much cooler in the last week of the month.

Portugal, too, had two major heat waves that month (5–8 July and 26–31 July), with temperature maxima above 40°C, and recorded its highest mean daily maximum temperature for July since 1931.

Precipitation

Most of the Arctic region saw a dry July. Especially eastern Greenland received less than 25% of its monthly totals.

July was wetter than normal over Ireland and most of the United Kingdom (except the south-east of the country), most of Scandinavia, western and southern parts of the Baltic countries and large parts of eastern central Europe and the eastern and southern Balkan Peninsula (Fig. 7.2). Monthly totals were locally higher than twice the normal (e.g. in some areas of Norway, large parts of the United Kingdom except south-eastern parts, Lithuania and southern Poland) and exceeding the 90th percentile at least locally due to some heavy thunderstorm events.

Ireland and most of the United Kingdom were hit by large amounts of rain, whereas large parts of the French coasts were significantly dry. Germany was especially dry in its north-eastern parts, locally with less than 20% of the normal and extreme forest fire risk. In contrast, some thunderstorms with heavy rain caused a wetter-than-normal southern half of the country (locally twice the normal), especially in the last third of the month. Switzerland was dry in the west, whereas thunderstorms were concentrated over the country's east and the mountains as well as Austria and Slovenia. Golf ball-sized hail fell in southern Austria in the middle of the month; the hail zone had a length of 40 km. In Slovenia, most of the precipitation occurred during the last third of the month, and it was most abundant in western parts of the country; more than

twice the monthly normal fell on the coast. Heavy rain, hail and local flooding also occurred in Romania and Greece, resulting in twice the normal monthly total. The southern Ukraine saw an extreme flooding event in the catchment of the Danube River.

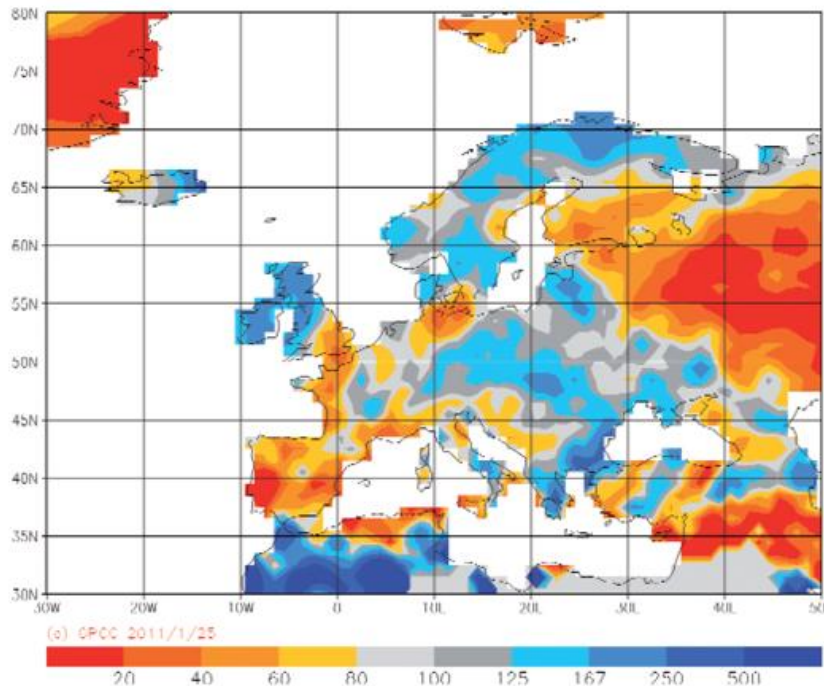


Fig. 7.2: Monthly precipitation amounts for July 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

In contrast, it was extremely dry over southern Finland, eastern Estonia, most of European Russia, western Kazakhstan and western parts of the South Caucasus. Some areas of Russia, Georgia and western Kazakhstan received less than 10 mm precipitation; this was as little as 20% of the normal and clearly below the 10th percentile. These drought conditions, the worst since 1972, destroyed nine million hectares of crop in Russia and thus an estimated 20 percent of the nation's agricultural production, including grain, vegetables and fodder. Additionally, a state of emergency was declared in Russia when 948 forest and peat bog fires covering 26,000 hectares were burning in 18 provinces. Several villages were completely destroyed, leaving thousands of people homeless. Forty people were reported killed by the wildfires. Large areas including the capital Moscow were affected by smoke, which even reached Finland, largely affecting the air quality there due to high carbon monoxide levels.

In the South Caucasus region, Georgia was mainly dry (especially in the first and second ten days of the month), though with heavy rain in places, whereas Azerbaijan and Armenia were mostly wet or near normal due to unstable weather with frequent rainfalls and thunderstorms, partly with hail. Turkey also had some areas with high rainfall, especially near mountain sites. The Middle East was generally very dry.

It was also very dry in most of the Mediterranean region, on the western Balkan Peninsula, in Iberia (around 50% of its normal) and western and southern France. Southern Sicily (Italy) registered no precipitation at all. In contrast, precipitation was abundant in various other parts of Italy. In Iberia, it was the driest July in Portugal in the last 24 years.

Snow

Snow was recorded only in a few places in northern Scandinavia and in the higher Alps. Toward the end of July, the snowline in Switzerland fell below 2500 m.

Significant weather events

- July 05: Austria was hit by heavy rain with thunderstorms. 145 mm in 24 hours (including 50 mm within 1 h) fell at a location in the Salzkammergut.
- July 06: Heavy rain in Tallinn (Estonia) with 57 mm in 24 hours (70% of the monthly normal), causing damage to shopping centres.
- July 06–07: Portugal reported a remarkable event at the southern Algarve coast in connection with a depression over the Atlantic between Madeira and Northern Africa. The sea surface pressure suddenly fell by 3–4 hPa and the sea surface level increased by 30 cm ('meteorological tsunami').
- July 08: Finland reported a thunderstorm with heavy rain of 34 mm/h in the area of Helsinki. Hail of up to 2.5 cm in diameter caused traffic disruption in eastern Finland.
- July 10: Switzerland reported a heavy thunderstorm with wind gusts up to 110 km/h, and heavy rain of around 60 mm in 1 hour (St. Bernhard, Zürich-Affoltern).
- July 11: A violent thunderstorm occurred in western Austria (Vorarlberg) in the evening. Due to a debris flow which accumulated gravel and soil masses up to 8 meter high, some homes had to be evacuated.
- July 12–13: Heavy thunderstorm over south-eastern Norway with locally very intense precipitation, e.g. 12 mm in 5 minutes in the Oslo area. Strong gusts in Norway and Sweden. Vinga station in Sweden reported a wind gust of 122 km/h, the highest gust ever reported in Sweden in July (mountain top stations excluded).
- July 12: A downburst hit the island of Helgoland (Germany) in the North Sea. At least 8 people were injured on a campsite, two of them seriously. The campsite, where about 100 people were staying, was destroyed and a light aircraft on the nearby airfield knocked over. Wind gusts of more than 100 km/h were measured in several places in western Germany (e.g. in Aachen).
- July 13: Lithuania reported heavy rain of 54 mm in 12 hours (Lazdijai) and 59 mm in 9 hours (Babtai).
- July 14–15: A series of low pressure systems passed the UK on the 14th and 15th, bringing localised flooding and strong winds to parts of Cornwall, Devon and Wales. Severe gale force winds and gusts as high as 135 km/h brought down branches, trees and even roof tiles. Uprooted trees blocked roads and power lines came down - leaving around 1,500 people without electricity.
- July 14: France reported heavy thunderstorms with many lightning strikes along a track from Paris to Eure et Loire. 40 mm of precipitation in 3 hours and wind gusts of more than 90 km/h were recorded at 6 stations, more than 125 km/h at 2 stations and more than 140 km/h at Saint-Hilaire-sur-Help. Similarly heavy thunderstorms hit Belgium at the end of a heat wave, producing 30 mm in 2 hours and wind gusts up to 135 km/h (Elsenborn). In the Netherlands, a campsite at Vethuizen was hit by severe wind gusts of a thunderstorm downburst. 2 people died and several were injured.

- July 14–16: Heavy rainfall in the village Tsakhkavan in the north-east of Armenia: 58 mm in 4 hours on 14 July and 39 mm in 2 hours on 16 July.
- July 15: Many fires in Estonia due to thunderstorms.
- July 15–16: Another thunderstorm with heavy rain hit Austria and southern Germany. 88 mm in 12 hours were reported for Preitenegg (Kärnten), 52 mm in 1 hour for St. Michael/Leoben. Hailstones up to 9 cm diameter were seen near Starnberg (southern Germany).
- July 16: Slovenia reported heavy rain: 48 mm within 45 min, a once-in-50-years event.
- July 17: Heavy precipitation records were reported by Austria: 94 mm for Kalwang (Styria), 82 mm for Puchberg (Lower Austria) and more than 100 mm in the Kitzbühel Alps. In Tyrol, heavy rain and hail caused enormous damage around Innsbruck. Streets were flooded up to 50 cm high due to hailstones blocking the drains. Vegetable crops over an area of 400 hectares were destroyed in eastern Innsbruck. Similar daily totals also fell in southern Germany.
- July 18–19: 101 mm of 24-hour rainfall had been recorded at Seathwaite (Cumbria) in the United Kingdom.
- July 21: The centre of Perth (Scotland) had been seriously affected by flooding after 40 mm of rain fell during the morning.
- July 22: Finland reported heavy rain with 60 mm/day in Sodankylä.
- July 22–26: Several heavy rainfalls with thunderstorms hit Germany: Germany reported heavy rain for its regions Bavaria, Thuringia and Saxony, with totals around 50 mm in 1 hour at several stations. The region between the Allgäu and the Berchtesgadener Land in southern Germany received more than 100 mm within 3 days. Thunderstorms with heavy rain on 26 July brought locally even around 100 mm in 24 hours. A severe hailstorm was reported by Austria (south-eastern Styria) on 23 July, with an estimated damage to agriculture of 4 million euros. Golf ball-sized hailstones damaged roofs and vehicles heavily. In Italy, heavy thunderstorms with heavy rain and wind gusts also occurred in the eastern Po valley after a persistent period of hot weather and a following cut-off low.
- July 23–24: Heavy rain in western Lithuania (85 mm in 11 hours) with hail (hailstones 3 cm in diameter) and a tornado.
- July 26: Severe hailstorm damaged fields in central Estonia.
- July 26–27: Twenty-six forest fires and 34 peat fires were burning in the Moscow region on 26 July, producing dangerous air pollution. Smog levels were five to eight times greater than normal. On 27 July, pollutant levels increased by about 50 per cent and were ten times higher than normal.
- July 26: Heavy storm around Kaliapka region (Bulgaria) with gusts of 136 km/h, water spout near Sozopol (Black Sea, Bulgaria).
- July 29–30: Finland reported heavy thunderstorms and downbursts in the south and middle of the country, with an extremely large number of lightning strikes and wind gusts up to 105 km/h during night time, which is very exceptional. Extensive damage due to falling and broken trees in central Finland.

August

- Very warm in large parts of the Region, colder than normal in parts of the Arctic and western Europe
- Continuation of strong heat wave in eastern Europe and extension to the Middle East
- Very wet in central Europe, dry in most of the north, east and south
- Again severe flooding in eastern central Europe

Atmospheric circulation characteristics

In August, a mainly meridional circulation pattern was dominating again. The North Atlantic as well as eastern Europe and the Middle East were mostly under high pressure influence and warm air advection, whereas low pressure systems crossed north-western and central Europe frequently from the north-west, bringing cold air which partly extended as far south as the Mediterranean. The airflow became more zonal in the second half of the month.

Cold and dry air from the eastern Arctic region only affected the northernmost parts of northern Europe.

Temperature

The North Atlantic, Greenland and Iceland as well as most of southern Scandinavia were mostly more than +1°C warmer than normal this August (Fig. 8.1). Southern Greenland was even more than +3°C warmer, exceeding the 90th percentile.

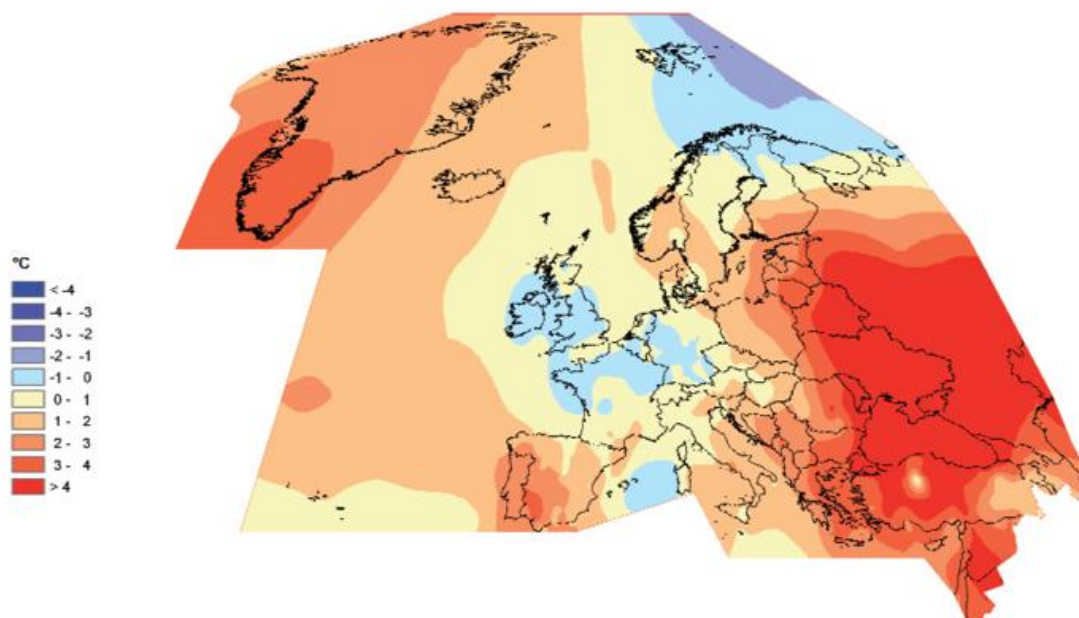


Fig. 8.1: Monthly mean temperature anomalies in August 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

Towards the east, the eastern Arctic Sea, the northernmost parts of northern Europe and Svalbard were colder than normal, with anomalies mostly between 0 and -1°C, in the east even below.

North-western, western and most of central Europe as well as the western Mediterranean had monthly mean temperatures near normal, partly slightly colder. It was the coolest August in the United Kingdom since 1993. Frost of -1.3°C was recorded in the highlands of the country on 26 August.

The Alpine region was warmer than normal. In the night 6–7 August, unusually high 25°C occurred over large parts of Switzerland due to warm air masses from the south-west. Up to 29°C had been measured in Basel at midnight.

Iberia profited much from subtropical high pressure influence and experienced a hot month. Portugal had its second highest mean maximum temperature for August since 1931. Especially in southern Spain, anomalies reached more than +3°C, which was more than the 90th percentile. Daily maximum temperatures exceeded historic records for August at several stations in the eastern half of Spain. Highest annual maxima for Spain were recorded from 25–27 August, reaching 44°C at several sites near the eastern coast in the provinces of Murcia, Alicante and Valencia. Italy was warmer than normal over most of the southern regions, Sardinia and the eastern Po Valley, whereas the rest of the country was within the natural variability of temperature.

It was extremely warm over most of north-eastern, eastern and south-eastern Europe, the South Caucasus, the eastern Mediterranean and the Middle East due to the ongoing strong heat wave, which had started at the end of June. In the whole of eastern Europe and the Middle East, the monthly mean was above the 90th percentile.

In eastern Europe, several stations measured new local daily maximum temperature records. The highest value in Estonia was 35.4°C, only 0.2°C less than the absolute country record. 35.8°C were reached in Lithuania on 15 August, and record-breaking daily maximum temperatures were reached on four days in a row (13–16 August). Belarus broke its all-time high-temperature record on 7 August with 38.9°C in Gomel in the south-west of the country. The Ukraine also saw a new absolute maximum temperature record of 42.0°C in Lugansk on 12 August. Highest anomalies (>+6°C) with daily maxima above 40°C and continued smog due to wildfires were to be found in the eastern Ukraine and south-western European Russia. West Kazakhstan, too, registered again maxima above 40°C. European Russia experienced its hottest August ever, with many new maximum temperature records, like the more than 38°C measured in July in Moscow. Maxima in Moscow were +15°C above average during the first half of August 2010. The two-month long heat wave finally broke on August 19th, when a cold front moved across western Russia, bringing rain and much cooler temperatures and clearing the thick smog that had hovered over Moscow for weeks. In the last decade of August, temperatures declined and the first frost occurred in north-western European Russia and in the upper Volga regions.

In the South Caucasus, maxima reached up to 42°C in west Georgia. There was also a large number of hot days, e.g. in Azerbaijan, with corresponding impacts on people's health. 160 cases of sunstroke were registered in Azerbaijan, nearly three times as many as in the previous year 2009. On 21 August, however, temperatures locally dropped to -4.5°C below normal.

Generally, this large heat spell with high monthly anomalies extended further south compared to July. Montenegro once again experienced a heat wave with maxima above 37°C later in the month and many fires were triggered in the hottest regions of the country. Bulgaria reported three heat waves with maxima up to 39°C, causing human discomfort and triggering forest and field fires especially in the south-east of the country. August was even warmer than July in Bulgaria.

In the central and eastern Mediterranean region, the heat wave went on for a longer time. Malta had its highest temperature on 21 August (36.0°C, Fig. 8.2) and its mean August maximum was almost +1°C higher than normal. Many Greek stations recorded both their highest ever monthly mean temperature and mean maximum temperature. High daily maxima were measured in Greece during heat waves from 13–17 August and 26–27 August at 38–41°C at many stations. The station Mut in Turkey reached a local record-breaking daily maximum of 46.7°C. On Cyprus, the station Athalassa recorded a maximum temperature of 45.6°C on 1 August, which was +8.4°C higher than normal, while the minimum temperature was at 29.0°C (+7°C above normal). This was the highest maximum temperature in Cyprus for 100 years. Monthly anomalies in Cyprus were also extremely high (around +3°C), which is considerably more than in June and July. In most parts of Israel, August was the warmest on record, mainly due to two major heat waves, partly with record-breaking temperatures up to 49°C. At times, the high temperatures were accompanied by high relative humidity. Minimum temperatures in Israel were also record-breaking and reached up to 30.0°C. Jordan also had two heat waves with the highest maximum at 48.8°C (+9.9°C anomaly from normal maximum temperature) in the Jordan Valley on 20 August.

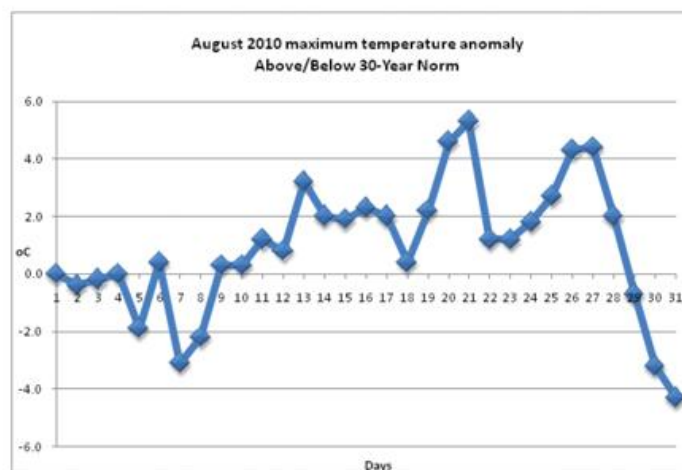


Fig. 8.2: Daily anomalies of maximum temperature in August 2010 (reference period 1961–1990) at Luqa Airport, Malta
Source: Malta Airport Met Office

Precipitation

The Arctic region (except western Greenland) and most of the northern parts of Scandinavia and Russia were dry, locally with less than 40% of the normal precipitation (Fig. 8.3), which was less than the 10th percentile. River levels in north-western Iceland were unusually low and there was water shortage in places.

Due to high pressure influence from the North Atlantic, it was also very dry in south-western France, northern Spain and particularly in Portugal. Less than 10 mm, which is less than 20% of the normal, was registered across the whole of Portugal, making it the driest August of the last 23 years. In most of these areas, especially those near to the coasts, the totals were below the 10th percentile.

South-eastern Spain, in contrast, was very wet that month with up to more than 400% of the monthly total at the south-eastern coast. This was mainly due to a heavy precipitation event on 16 August, which particularly affected some localised areas of central Andalusia just in the middle of the dry season.

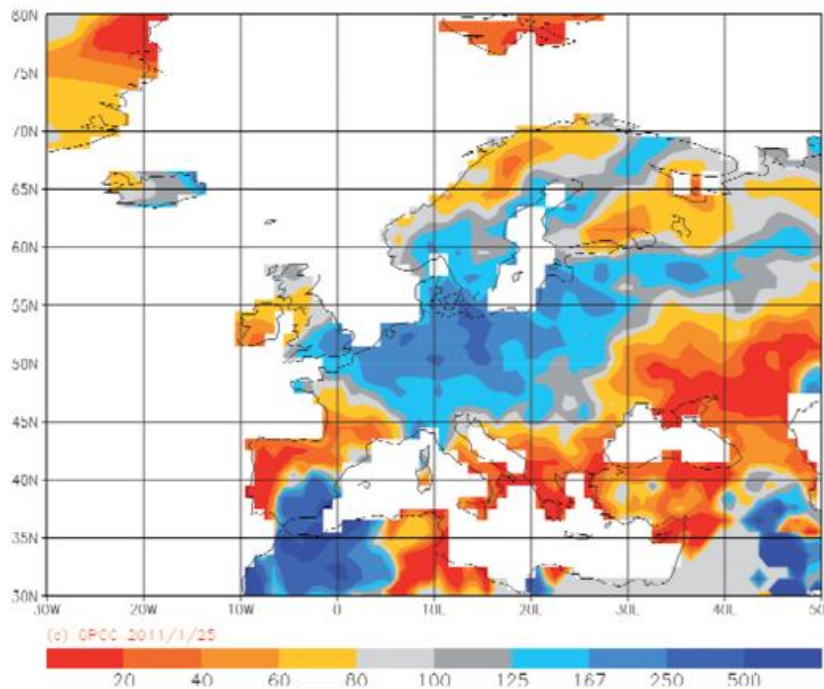


Fig. 8.3: Monthly precipitation amounts for August 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Large parts of central Europe and much of the adjacent areas (as far as south-east England in the west, southern Scandinavia in the north, some parts of Russia in the east and northern Italy in the south) were also very wet, all with totals higher than the 90th percentile due to some heavy rain events, which were locally related to storms, heavy hail and flooding.

Several places in south-eastern Norway, parts of the south-eastern United Kingdom and northern France received more than twice the normal monthly precipitation total. Some Norwegian stations registered a new August record for monthly or daily precipitation. It was the second wettest August on record in East Anglia (United Kingdom).

August was extremely wet all over central Europe. It was the wettest or second wettest August in many parts of central Europe, with heavy thunderstorms. The Netherlands saw its second wettest August since 1901 (behind 2006), with 170 mm on average, i.e. nearly three times the normal. The wettest August since 1881 was recorded in Germany, with an areal mean of more than 200% of the 1961–1990 normal, locally more than 400% (Fig. 8.4). Poland received about twice the monthly normal on average. Particularly high totals of more than 200 mm (more than 250% of the normal, locally up to 500%) were measured in the border region of Germany, Poland and the Czech Republic, mostly due to a heavy precipitation event in early August. Precipitation totals were also very high in parts of eastern Austria and Slovakia.

The Baltic countries saw an outstanding wet August, too. Ruhnu Island in Estonia received 236 mm (more than 400% of the normal), which include one heavy rain event with 97 mm in 24 hours. Most parts of Estonia were very wet, especially during the second ten days of the month. It was the third wettest August in Latvia for 87 years. Heavy downpours, squalls, thunder- and hailstorms and even tornadoes also occurred in Lithuania.

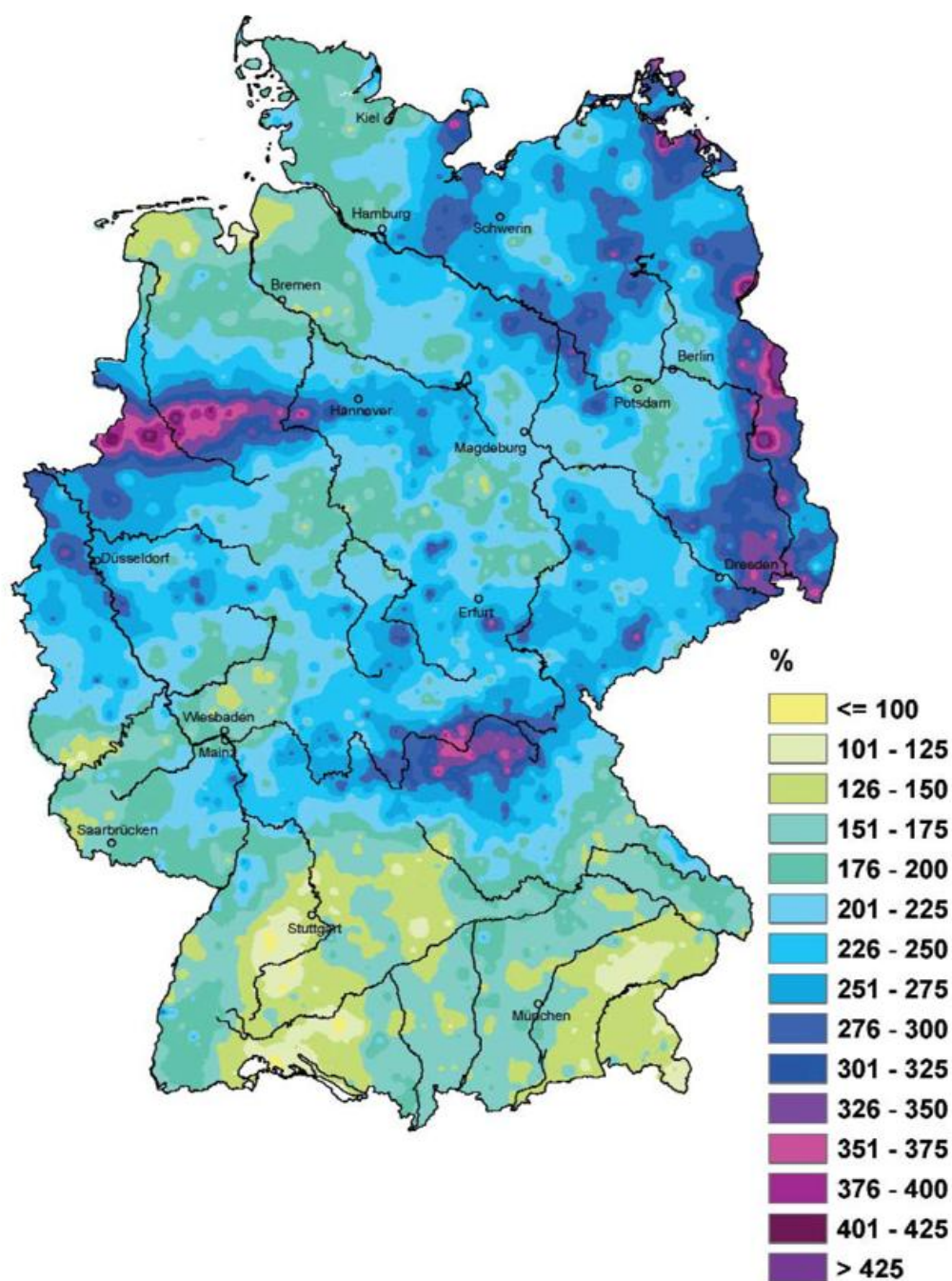


Fig. 8.4: Monthly precipitation amounts for August 2010 in per cent of the normal 1961–1990 in Germany

Source: Deutscher Wetterdienst, Germany

Towards the south, northern parts of Italy and the Balkan Peninsula were also affected by high precipitation that month. Rainfall totals in Italy were above normal over most of the northern regions and Tuscany. Locally, Serbia received up to three times the normal, with a new local record for the August monthly total set at Novi Sad (168.5 mm). Even in Romania, August precipitation was above normal in the mountainous and western regions.

Generally, it was also very dry over a large area around the Black Sea, namely in eastern Romania, Moldova, the eastern Ukraine, southern European Russia, northern parts of the South Caucasus, Turkey, the Middle East, Cyprus and even large parts of the southern Balkan Peninsula and central and southern Italy, locally with less than 20% of the normal monthly precipitation and mostly below the 10th percentile. Some of these areas were even without any rain at all or received only a few mm in the whole month, which was unusual except for the eastern Mediterranean area. The Ukraine received less than half of the normal precipitation throughout the country. There were more than 600 wildfires and 948 forest fires in 18 counties of western Russia at the beginning of August, with thousands of people made homeless. Forest fires also occurred in parts of Azerbaijan and agriculture suffered from drought there, but several days in the last third of the month were characterised by thunderstorms.

Snow

Snow was recorded in higher altitudes of the Alps only. On the first days of August, the snowline was as low as 2100 m in eastern Switzerland, covering the higher passes with a thin layer of wet snow. At the end of the month, the snowline went down to 1200 m altitude in the eastern Alps, and up to 40 cm of fresh snow was measured in the higher mountains.

Significant weather events

- August 01: Nicosia in Cyprus reached a daily maximum of 45.6°C, which was the highest value recorded since the beginning of the 20th century.
- August 04: The beginning of August 2010 was still characterised by the great heat in the east. Stations in Russia, Belarus and Ukraine reported very high temperatures. Moscow had 36.6°C, St. Petersburg 33.3°C, Luhansk nearly 40°C.
- August 04: Thunderstorm with heavy gusts and large hails in central Finland, causing damage due to fallen trees; people were injured at the camping site of Uurainen.
- August 04: Severe thunderstorms with very strong winds and hail up to tennis ball size in north-western Bosnia and Herzegovina (Bosansaka Krupa). Huge damage to infrastructure and losses in agricultural production.
- August 05: In north-west Greenland, a huge chunk of ice broke off the Petermann Glacier into the Nares Strait. The ice floe was 251 km² in size, which equals a quarter of the floating ice shelf of the Petermann Glacier. It was the largest break-up in the Arctic since 1962.
- August 06-09: Very high precipitation amounts fell in eastern Austria, eastern Germany, the Czech Republic and Poland, partly as long enduring rain and partly as very intense precipitation. This led to severe flooding of the Neisse and Elbe Rivers as well as smaller rivers like the Spree (Bautzen, east Germany). In the morning of 08 August, the water level in Görlitz (eastern Germany) of the Neisse River (707 cm, i.e. about 4.5 m above its normal level) exceeded the previous record of 21 July 1981; parts of the town were flooded. More than 1,400 residents had to leave their homes. In Poland, a water reservoir dam broke. Houses were flooded and streets and bridges damaged. Most of the rain fell in the Czech Republic, where the water level of the Elbe raised to 6 m, i.e. three times the normal value. Values of up to 200 mm in 24 hours were reported there. At least 11 people died in eastern central Europe. Damages were estimated to be over 215 million U.S. dollars in the Czech Republic alone. Southern Germany and Switzerland also had high precipitation amounts.

- August 08: Wind gusts of up to 108 km/h, heavy rain (locally 69 mm in 8 hours) and hail (diameter 2 cm) in connection with intense convective activity was reported from western Lithuania in the afternoon. It was one of the stormiest and damaging meteorological phenomena of the decade 2001–2010. A squall line formed within a tropical air mass over southern and central Lithuania. Forests (about 4 million Euro), power lines and buildings were damaged and 4 people lost their lives. The thunderstorm also affected Estonia and Finland. In Estonia, gusts reached 144 km/h and weak tornadoes occurred, causing significant damage in towns, villages and on 1,100 hectares of forests. Electricity was disrupted in 60,000 households. Several people were wounded, one person killed. Hailstones of 6–8 cm size fell during a severe thunderstorm in Pirkanmaan (Finland) and gusts up to 115 km/h were measured in the western parts of the country. Never before had Finland reported hailstones bigger than these. This was the most severe thunderstorm in a series of days with highly convective activity. Beside fallen trees and flooding which affected air and road traffic, lightning strikes caused a power blackout to 21,000 households. Several people were injured at a music festival in Pori and one died.
- August 08–09: Forest fires in Russia and prevailing south-easterly airflow brought dense smoke to the whole of southern Finland. The peak concentration of PM_{2.5} particles was measured as high as 241 µg/m³ in Imatra (south-eastern Finland), which was more than 20 times the average.
- August 11–13: Fires broke out in northern Portugal, spreading to northern Spain near the borders of Spain and Portugal during hot and dry weather.
- August 13–17: Large parts of central Europe reported intense precipitation. Daily totals were around 50 mm or more at many stations. Uccle in Belgium recorded a 48-hour total of 103.6 mm on 15 and 16 August, and precipitation was also intense in north-eastern France. Denmark was hit by heavy precipitation on the 17th, with 24-hour values of 138 mm for Billund and 157 mm for Blahøj Kirkeby. In Austria, thunderstorms on the 13th brought 64 mm in 1 hour in Eisenstadt (Burgenland), an event with a probability of once in 25–30 years. Public traffic in Vienna had to stop its service for one hour due to heavy rain, flooding of streets, and broken branches blocking railway tracks. Heavy precipitation also caused widespread damage in some regions of eastern Germany and central and eastern Slovakia, with destructive flash floods.
- August 14–16: Thunderstorms with widespread and intense precipitation that produced daily totals up to more than 80 mm particularly over northern and central Italy due to a cut-off low.
- August 16: Lithuania reported that the temperatures exceeded the highest August temperature maxima ever recorded at 12 stations. On this day, the maximum temperatures reached 28.3°C (Zoseni) to 33.1°C (Daugavpils).
- August 16: At least 2 tornadoes were observed in Hungary.
- August 16: Russia's two-month long record heat wave and drought was set to come to a dramatic end by a severe storm. In St. Petersburg, 100,000 were left without power, rail services were halted and trees fell in high winds. Temperatures around Moscow dropped to about 24°C, after nearing 40°C for weeks.
- August 16: Heavy precipitation in central Andalusia (Spain). The episode, unusual for that season, locally brought over 200 mm of rain in just a few hours and caused three deaths and damage to infrastructure, mainly houses and transport networks (road and rail).

- August 21–22: Strong N-NW wind over the Aegean Sea caused a fire at the palm-tree forest of Preveli (in the south of Crete Island). Forest fires also occurred in western Turkey.
- August 23: Gusts of violent storm in south-western Denmark and northern parts of central Europe. Thunderstorms with heavy precipitation occurred in western Germany (up to more than 50 mm/day) and central parts of the country (more than 30 mm/day in the Rhön Mountains). Tornadoes occurred in various parts of Germany and in Belgium. During the early morning hours, a hailstorm affected the north-west of Poland, bringing down trees and power lines. Properties and homes were damaged and 3 people were injured. The hailstorm was followed by torrential rain.
- August 25–26: In Turkey, the station Rize at the Black Sea coast reported 167 mm in 24 hours on the 25th. The same station had some additional 52 mm on the next day. 13 people died due to a mudslide, 168 houses were destroyed due to distorted urbanisation. 1729 hectares of field, roads and water pipes were damaged. Total economic loss was calculated to 20 million USD.
- August 26: France reported daily maximum temperatures in the south-west between 39°C and up to 41.1°C. Switzerland reported very high night temperatures from the 26th to the 27th between 20°C and up to 23.8°C over most of the country. The mountainous stations also had night time values between 10°C and 18°C.
- August 26–27: Up to more than 130 mm of precipitation fell in 24 hours in a wide band over the middle of the Netherlands. Many places experienced large-scale flooding. The eastern Netherlands and western Germany also received high precipitation totals of more than 100 mm up to 162 mm (about 200% of the monthly August normal) in 24 hours in a frontal band, which was relatively narrow in north-south direction. Swansea in the United Kingdom recorded a 24-hour total of 64 mm in the morning of 26 August.
- August 29: Copious amounts of rain triggered floods and mudslides that killed at least 12 people in the northern Turkish town of Gundogdu. Dozens of homes were destroyed and several roads closed.
- August 31: The last day of August 2010 brought snowfall in the Austrian Alps: 40 cm in 2000 m and 10 cm even down to altitudes of 1300 m.
- August 31: Heavy storm in Botev and Kurdjali region (Bulgaria), gusts up to 144 km/h.

September

- **Cold in central Europe, warm over Greenland and in the east**
- **Wet with frequent heavy rain in eastern central Europe and over the central Mediterranean, still very dry in Portugal and in the east**

Atmospheric circulation characteristics

Both the Icelandic low and the Azores high were more intense and had a more westerly position than normal in September. Thus, warm air dominated over the North Atlantic and was also led to Iceland and Greenland.

A meridional circulation pattern, however, persisted over the European continent and cold and moist air from the north extended particularly to western and central Europe, temporarily also to the western and central Mediterranean.

High pressure influence dominated over the eastern parts of the Region, and warm and dry air particularly affected the Middle East and continued to move to areas in the north-east, especially in the second half of the month.

Temperature

September was still warm over the North Atlantic and particularly over Greenland and Iceland, with anomalies of more than $+3^{\circ}\text{C}$ (Fig. 9.1), which exceeded the 90th percentile. Towards the east, the anomalies were lower; over the eastern Arctic sea, they were even slightly negative.

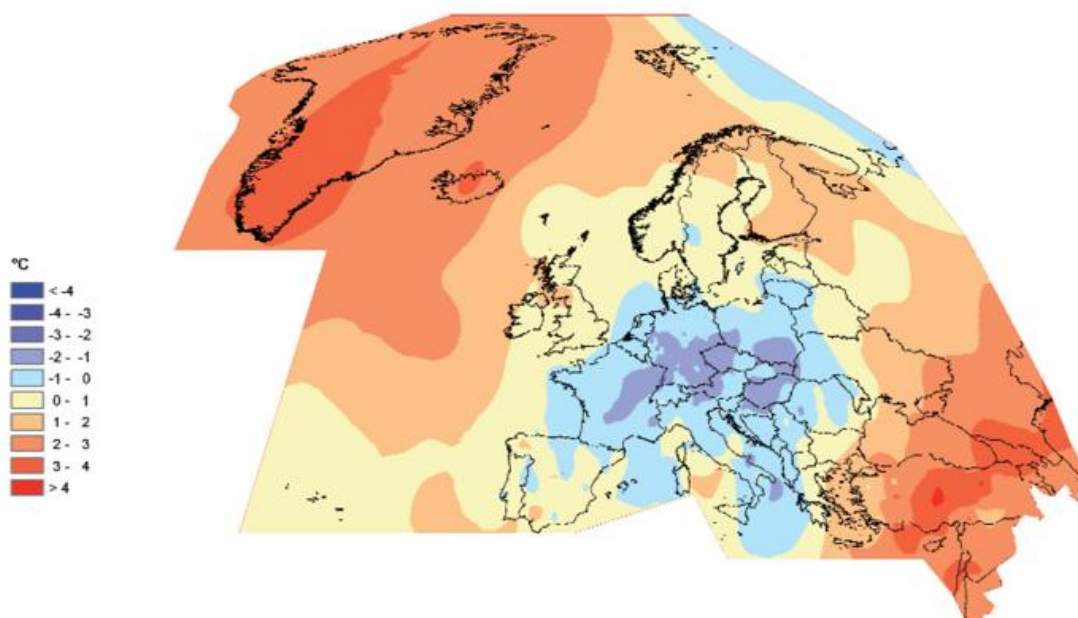


Fig. 9.1: Monthly mean temperature anomalies in September 2010 (reference period 1961–1990) in WMO Region VI

Source: Deutscher Wetterdienst, Germany

With 24.9°C, a new daily maximum temperature record for September was reached on 2 September in Greenland at the station Nuuk Airport. Iceland recorded the same peak maximum (24.9°C) on 4 September. It was the highest daily maximum of the whole year 2010 and most unusual to occur so late in the summer half year.

Northern Europe, Ireland and the United Kingdom were also warmer than normal, though with smaller deviations from the normal (less than +2°C), partly due to some cold nights. The United Kingdom saw some localised frost, but also daily maxima up to 24.6°C. Further to the south of the Region, most of Iberia also had slightly-above-normal temperatures, but the temperatures were also below the normal in some places.

Large parts of western and central Europe (including the southern North Sea) were colder than normal as well as parts of the western and central Mediterranean, Italy and the western Balkan Peninsula. Anomalies were partly below -1°C, particularly in southern central Europe, where even some local frosts occurred; but these were no extreme deviations. Temperatures reached 25°C only rarely in Germany.

It was still warmer than normal in eastern Europe, the eastern Mediterranean region and the Middle East, but the strong and extended heat area of the preceding summer in eastern Europe was retreating to the south-east. Anomalies still exceeded +2°C and thus the 90th percentile in southern European Russia, west Kazakhstan, the South Caucasus region, Turkey, the eastern Mediterranean and the Middle East. Locally in Turkey, the anomalies were higher than +4°C. Daily maxima reached up to 37°C in Greece south of the Aegean Sea and 40°C in west Georgia at the beginning of the month. Israel had once more record-breaking minimum temperatures up to more than 30°C at the Dead Sea.

Precipitation

It was wetter than normal over eastern Greenland, parts of Iceland, Ireland and parts of the United Kingdom (Fig. 9.2). The 90th percentile was only exceeded in eastern Greenland and parts of Ireland. In the United Kingdom, it was particularly wet in Northern Ireland, the wettest September there since 1999.

Because of missing westerly airflow conditions, the Norwegian coast and large parts of northern Scandinavia were very dry, as was most of the Arctic region, locally receiving less than 40% of the normal and below the 20th percentile. Places in northern Norway experienced the driest September in 25 years.

It also continued to be very dry in Portugal due to continuous high pressure influence, resulting in the second driest September of the last 22 years in this country. Monthly totals were below 10 mm in nearly the whole of Portugal, which was below the 10th percentile. The coasts of Spain, some southern parts of France and the western Mediterranean including its islands were also far drier than normal, whereas the interior of Spain was wet.

It was very wet in the whole eastern part of central Europe (except in some areas, e.g. in southern Germany and upper Austria), parts of the Baltic countries and north-eastern European Russia and, towards the south, in the north-western Balkan Peninsula and the central Mediterranean region, locally with more than 300% of the normal monthly precipitation (e.g. in eastern Germany and northern Croatia) due to some heavy convective precipitation events. In most of eastern central Europe and the north-western Balkan Peninsula, the 90th percentile was exceeded. River water levels were critically high in places and extensive flooding with significant damage occurred in Slovenia. At many Slovenian stations, precipitation was among the most abundant ever observed (up to 300% of the normal and up to more than 300 mm).

Most of European Russia, especially the eastern and southern parts, as well as west Kazakhstan, Turkey, Cyprus and the Lebanon were very dry, although this is not rare in these areas for this time of year. On the other hand, there was more than 250–500% of the normal rain locally in southern Syria and Jordan. Some places in the South Caucasus region also saw some higher-than-normal rainfalls, whereas especially Armenia received only 30–50% of the normal precipitation.

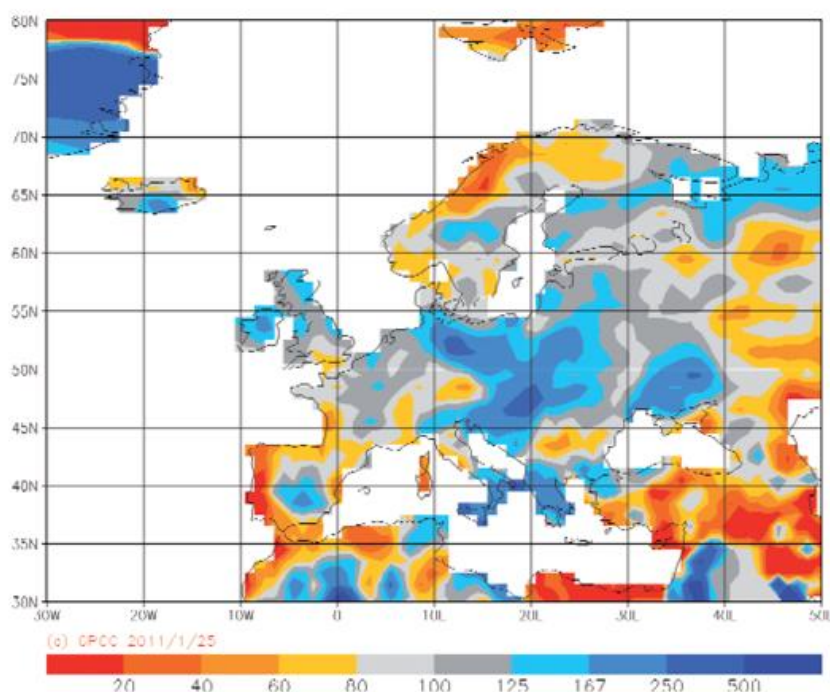


Fig.9.2: Monthly precipitation amounts for September 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Snow

Snow was only to be found in the Alps and in higher elevations of the Carpathian Mountains. Wendelstein Mountain in southern Germany (1800 m altitude) had one snow day in September, with 2 cm of snow. The highest German mountain, Zugspitze (nearly 3000 m altitude), still had 4 days without any snow. Kredarica Mountain in Slovenia had 9 days of snow, with a maximum depth of 12 cm on 28 September. Romania had snow above 1700 m altitude at the end of the month.

Significant weather events

- September 01–02: Heavy precipitation hit Poland, the Ukraine and the Czech Republic. The Czech Republic reported heavy precipitation during the night from 31 August to 1 September with daily amounts of 100 mm or more at several stations.
- September 02–04: At least 3 tornadoes were observed over northern and eastern Germany.
- September 03: Heavy storm in Botev region (Bulgaria) with gusts of 90 km/h.
- September 06–08: Along with an Atlantic frontal system, intense rainfall occurred in southern France and brought about 90 mm and more at 7 stations (maximum 310 mm at Conquerac, Gard) on 6 September, and more than 100 mm

- at 13 stations (maximum 254 mm) on 7 September. Overall, 20 stations had more than 100 mm within the 2 days; the highest 2-day sum was registered at Cardet, with 354 mm (half of the usual annual mean). Over 200 mm fell in 4 hours at Cavaillon (Vaucluse).
- September 09: Heavy rain caused severe damage at the Italian Amalfi coast. Generally, the regions of Genoa, Liguria, Amalfi, Campania and Friuli received heavy rain.
- September 11–12: Heavy rain (up to 117 mm in 24 hours) and flooding in Thessalia (central Greece).
- September 14: Turkey and Georgia reported heavy precipitation, locally more than 100 mm in 24 hours.
- September 15–16: Gusts up to 110 km/h in Denmark and northern Germany, causing disruptions of the ship traffic between Germany and the North Sea islands.
- September 17–19: Severe precipitation hit Slovenia, resulting in catastrophic floods in many parts of the country. Former records were broken at many stations; it was the heaviest precipitation event for 60 years. On 18 and 19 September, 11 and 7, respectively, out of 18 stations reported more than 100 mm in 24 hours. One station near Idrija had more than 500 mm in 2 days; it was the most severe precipitation event in the last 60 years in Slovenia. During this precipitation episode, northern Italy also had heavy rain with flooding of the Seveso River. Metro stations in Milan had to be closed for a week due to 7–8 m high accumulation of debris. Several more countries were affected by heavy rain during this episode: Switzerland, Austria, Hungary, Bosnia and Herzegovina, Greece and Spain.
- September 25–27: Heavy and long lasting precipitation of partly more than 50 mm per day and local flooding was reported by Germany, Poland, the Czech Republic, Switzerland, Liechtenstein, Austria, Slovenia, Croatia, Bosnia and Herzegovina, Romania, Bulgaria, Macedonia and Greece. The water levels of some rivers in eastern Germany rose and caused flooding of streets and agricultural areas in some places. Wind gusts in Bulgaria (regions Musala, Mouragash) of 100 km/h.
- September 26: A daily precipitation total of 179 mm was measured in south-eastern Iceland.

October

- **Cold in nearly the whole of Europe, warm in the Arctic and in the Middle East**
- **Dry in most of northern, central and eastern Europe, wet in parts of the Arctic, southern Europe and around the Black Sea**
- **Heavy rain events in the Mediterranean region and in south-eastern Europe**

Atmospheric circulation characteristics

A large low pressure zone affected the Arctic and the northernmost parts of Scandinavia. The Icelandic low itself was not well developed, but mild air masses from the North Atlantic flowed to the Arctic region. The Azores high was centred south-west of the Azores and weaker than normal.

High pressure influence dominated over large parts of northern, western, central and eastern Europe; occasionally, cold air advection from the north reached these areas with localised snowfalls in the second half of the month, but also a few warm spells occurred due to southerly or Atlantic airflow, and foehn north of the Alps.

Further in the south, there was much cyclonic activity around the Black Sea and the Mediterranean. A Mediterranean mesocyclone, originating from a cut-off low, affected the western Mediterranean basin during the second week of October.

The Middle East was still affected by warm and dry air masses from the south.

Temperature

It was very mild over the North Atlantic and throughout the Arctic region (Fig. 10.1) due to continued high sea surface temperatures. Anomalies in the Arctic increased up to +4°C. The 90th percentile was exceeded in southern Greenland, Iceland and Svalbard. Especially the first half of October was unusually warm in Iceland. The northernmost parts of Scandinavia were more than +2°C warmer than normal, whereas southern parts were colder than average.

Temperatures were close to normal on average in the United Kingdom. However, for about 10 days from mid-month, it was colder there, with northerly winds and some very low overnight temperatures. This was compensated, however, by milder air due to frontal systems from the west and also because of some warm days with up to 23.1°C due to high pressure influence.

Most of the European continent, southern Scandinavia, Ireland and most of the western and central Mediterranean were colder than or near to normal. The highest negative anomalies were to be found over eastern central Europe and the northern Balkan Peninsula (around -3°C). In eastern central Europe, temperatures were lower than the 10th percentile. It was the coldest October in Vienna since 1974. The first third of the month was still warm in central Europe; maxima continued to exceed 25°C in south-western Germany and the Alpine region in early October due to foehn. However, first frosts occurred in the lowlands of Germany and in Denmark in the middle of October. Northern Italy was also particularly colder than normal in the second half of the month.

October temperatures were below normal in most of European Russia. In the first ten-day period of the month, slight frosts were recorded locally in its western and central parts, in some places with new minimum temperature records. On the other hand, northern and north-eastern European Russia was warm in October. In Murmansk, the air temperature attained 12.4°C on 6 October, which became a new absolute record-breaking value for this time of year.

The South Caucasus region, eastern Turkey, the Middle East and the eastern Mediterranean were at least $+1^{\circ}\text{C}$ warmer than normal. Most of these areas recorded temperatures higher than the 90th percentile. In some parts of the Middle East, the anomalies were higher than $+3^{\circ}\text{C}$. Daily maxima still reached up to 32°C in west Georgia at the end of the month, when other parts of the South Caucasus were already affected by cold air masses. Jordan experienced three heat waves in October, with highest daily maxima at $42\text{--}44^{\circ}\text{C}$ in the Jordan Valley (anomalies $+8^{\circ}\text{C}$ or more); the conditions were similar in Israel, with up to 42°C even in the coastal plain, where the highest October temperatures for the last 50–60 years were reached.

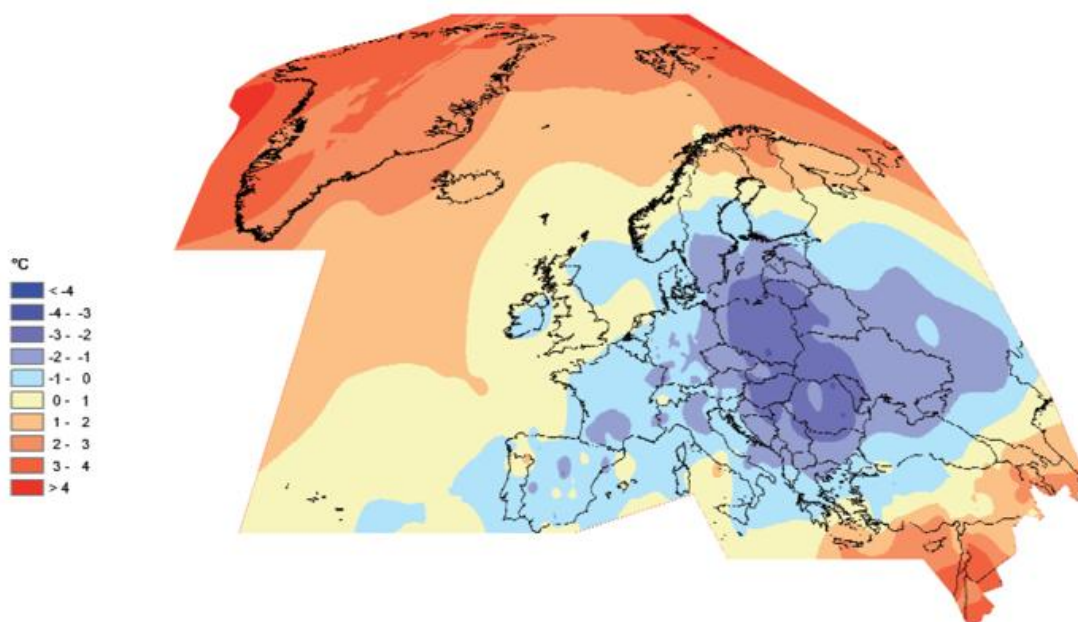


Fig. 10.1: Monthly mean temperature anomalies in October 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

Precipitation

It was wetter than normal in most of the Arctic region, especially in Svalbard (240% of the normal) and the northernmost parts of Scandinavia (Fig. 10.2).

In the United Kingdom, precipitation was close to normal in many areas, but it was drier than average in the west.

Nearly all other areas in northern, western, central and eastern Europe were drier than or close to normal. Fog was very frequent and long-lasting, especially near water surfaces in central Europe. The largest relative precipitation deficits were to be found in eastern Germany, Poland and central Sweden, with totals of 20% of the normal or less. In these two areas, the totals were lower than the 10th percentile.

Western parts of Iberia, France and the western Alps were wetter than normal, partly with more than 125% of the month's normal total, in southern France even 200–300% and in Lisbon in Portugal more than 300% of the normal precipitation.

The areas around the Black Sea and further east as far as west Kazakhstan as well as most of the Mediterranean region were also wetter than normal due to some heavy rain events. For the areas around the Black Sea, the 90th percentile was exceeded. Many of these areas

received more than 200% of the normal, e.g. some locations in Greece (Fig. 10.3). Locally, the totals were much higher, up to more than six times the normal in Turkey (e.g. Ankara). Malta had its 3rd wettest October since 1951.

The Middle East and Cyprus saw a very dry October (only 3 mm in Larnaca (Cyprus) compared to the normal of 19 mm; 4 mm in Damascus (Syria), normal: 12 mm). Israel and Jordan mostly received less than 60% of their normal total, locally less than 20% or even no precipitation at all.

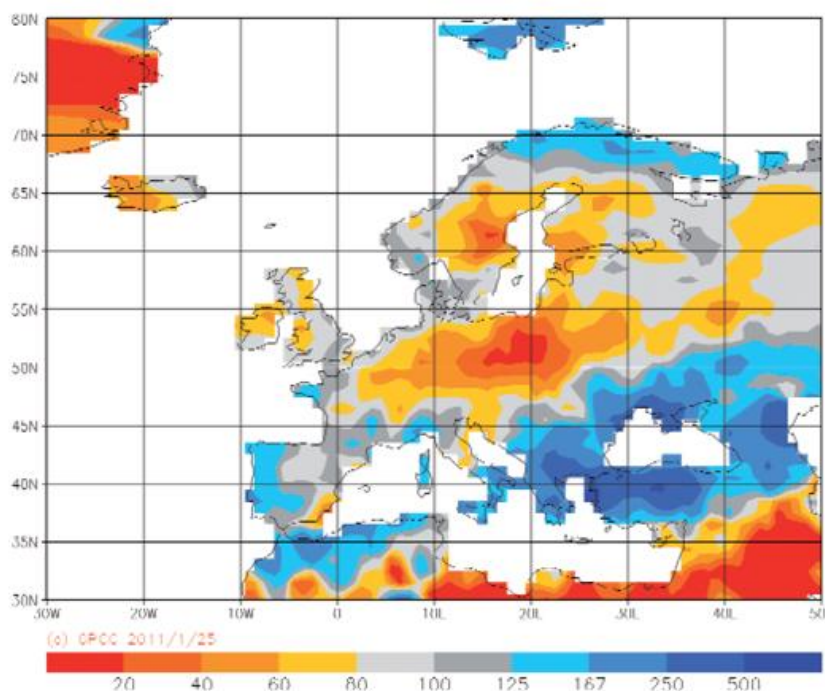


Fig.10.2: Monthly precipitation amounts for October 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

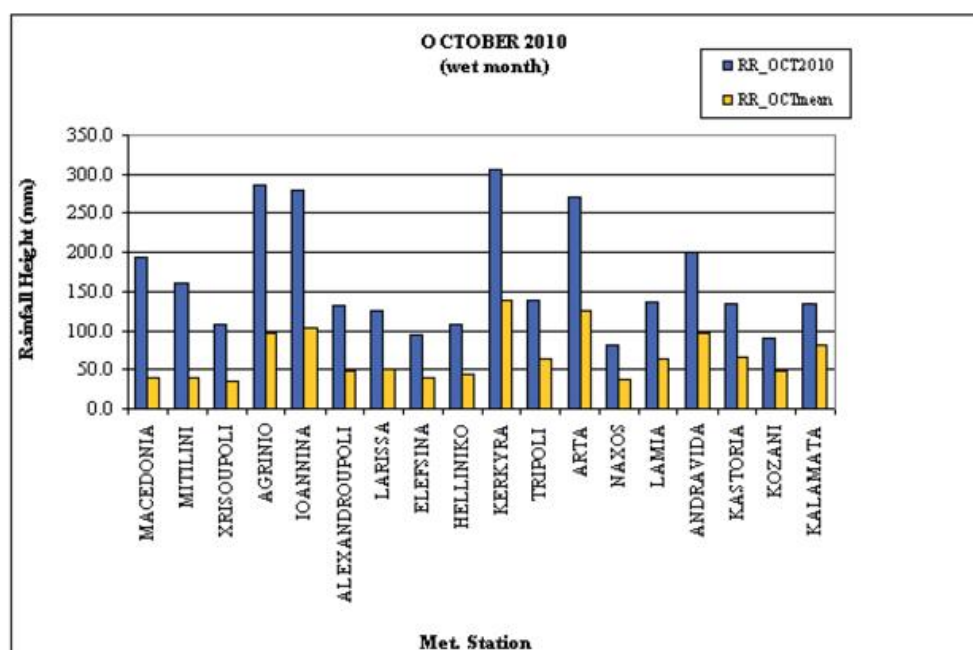


Fig. 10.3: Monthly precipitation amounts for October 2010 for some stations in Greece compared to the long-term mean (various reference periods)

Source: Hellenic National Meteorological Service (HNMS), Greece

Snow

Snow fell over most areas in Scandinavia and northern Russia as well as on the higher and lower mountains in central and parts of southern Europe. On 21 October, first snow fell in southern Germany down to 800 m altitude; on 25 October, first snowfall occurred in some alpine valleys down to 500–700 m altitude, with up to 20 cm of fresh snow in Carinthia (Austria). There were 18 days of snow on Kredarica Mountain in Slovenia (depth of 65 cm on 26 October). Azerbaijan in the South Caucasus region had some snow in the highlands, with depths up to 21 cm at the end of the month.

Significant weather events

- | | |
|----------------|---|
| October 05: | Italy reported heavy rain at the Ligurian coast. 3-hourly precipitation values in some places (Pero, Monte Gazzo and Pegli, all around 300–400 mm in 24 hours) exceeded the mean monthly values. On Monte Gazzo, one third of the mean annual precipitation amount fell within 6 hours. |
| October 09–12: | Rainy episodes in southern France led to several-day precipitation sums of more than 200 mm. |
| October 12–14: | Dust advection from Africa with wet deposition affected the whole country of Greece. |
| October 13–14: | 123 mm rainfall in 24 hours was recorded in Bursa (Turkey). The return period of such an event is about 200 years. Lots of flooding and landslides occurred. Schools were closed for two days. |
| October 15–16: | Heavy rain (47–93 mm) and flooding of the rivers (water level 340–916 cm) in southern Krasnodar (southern European Russia) caused the death of 15 people. Mudflows in the mountains. |
| October 18–19: | Greek authorities declared a state of emergency on the Aegean Sea islands of Ikaria and Chios after flash floods left two people dead. Another ten people were trapped in their cars and had to be rescued. Authorities received 450 calls from owners of flooded homes and businesses. The daily precipitation sums of Naxos (55 mm) and Mytilini (82 mm) were well above the 50-year-return amounts for October based on the 1990–2009 time series. Islands of Xios and Ikaria received more than 200 mm in 24 hours. |
| October 25: | In Austria, the weight of the snow (up to 50 cm in mountainous regions) caused power lines in the Tyrol region to break. |
| October 26–28: | Heavy rain and thunderstorms in central and eastern Macedonia (Greece), with up to more than 200 mm in 24 hours. Heavy rainfalls also in Turkey, resulting in many flood and landslide events. Schools were closed for two days. |
| October 29–30: | Heavy rain hit Lisbon in Portugal with a daily total of 79 mm, 71 mm of which fell within 3 hours. Streets and places of the city were flooded. |
| October 30–31: | France reported an episode of extreme rain, with more than 100 mm of rain in 48 hours in the south-east of the country. The values partly were comparable or exceeded the mean monthly precipitation sums of October. |

November

- Cold in western and northern Europe, particularly in Scandinavia, very warm in central, eastern and south-eastern Europe and the Middle East
- Most of Europe wet, but very dry in the north and in the Middle East
- Early cold spell and widespread snow at the end of the month

Atmospheric circulation characteristics

Cold Arctic air extended to most of Scandinavia, but came under prevailing high pressure influence. South of this high pressure zone, cold air from the north-east also moved temporarily to central, western, north-western and even south-western Europe, especially during the last week of November, leading to significant snowfalls and hard frosts at the end of the month. In addition, several deep Atlantic low pressure systems came from westerly directions and crossed north-western, western, central and eastern Europe, some of them were quite extended and intense. Numerous cyclonic disturbances also reached the Mediterranean area and Italy. During the first half of the month, mild subtropical air masses reached central and eastern Europe.

The Middle East and the South Caucasus region, temporarily also eastern and south-eastern Europe, continued to be mostly under the influence of high pressure and warm air.

Western Greenland was affected by a prevailing southerly flow of mild air from the North Atlantic and the Greenland high was stronger than usual.

Temperature

It was mild in western Greenland, with anomalies $> +4^{\circ}\text{C}$; the central North Atlantic was also warmer than normal (Fig. 11.1). In southern Greenland, the 90th percentile was exceeded.

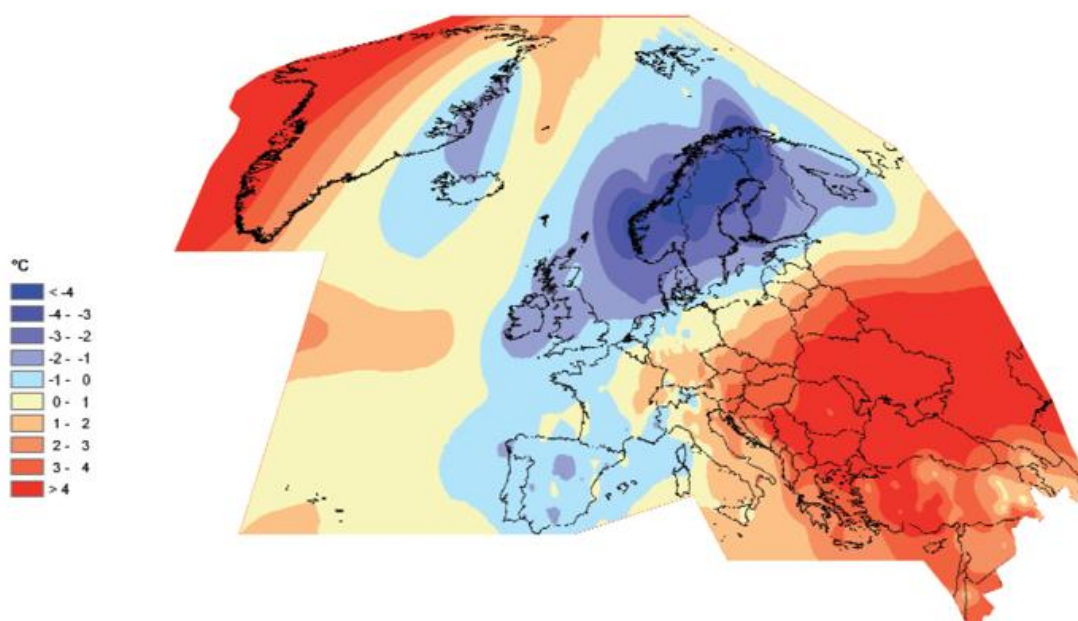


Fig. 11.1: Monthly mean temperature anomalies in November 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

Northern and large parts of western Europe were colder than normal, including the Arctic Sea. Especially the northern half of Scandinavia was very cold, with anomalies below -5°C , in Norway locally below -7°C . Temperatures were below the 10th percentile in nearly the whole of Norway (except the coasts) and most of Sweden (except the north-east). There was already ice on the Arctic Sea north of 78°N . Norway had its coldest November since 1919, the United Kingdom since 1993.

Central Europe was mostly warmer than normal, in southern and eastern parts even between $+1$ and $+4^{\circ}\text{C}$; only north-western Germany, the Netherlands and Luxembourg were slightly colder than normal.

The month started very mild in western and central Europe. During the first ten-day period of November 2010, it was unusually warm in several western and central European countries. On 4 November, high daily maximum temperatures of up to 19°C were recorded locally in the United Kingdom and widespread in Germany (except in the north of the country); later, on 14 November, 20°C were exceeded in Dresden in eastern Germany, which set a new local record for that time of year. Poland's maximum temperature reached up to more than 21°C , and Austria reported up to 23.7°C , both on 5 November; locally, these were new November records. The northern plains of Switzerland had up to 18°C , some valleys up to 21°C in the middle of the month due to foehn.

The cooling came particularly towards the end of the month in northern, western and central Europe. The Scandinavian countries reported very low temperatures that time, with a lowest minimum in Norway of -35°C at Karasjok-Markannjarga on 27 November. At many Norwegian stations, the records of the monthly mean temperatures and the absolute minimum temperatures were broken in the days 26–30 November. Similarly extreme low minimum temperatures were reported from Sweden with -36.6°C in Nikkaluokta in Lapland on 24 November or -34.4°C in Kvikkjokk-Arenjarka on 25 November (which was the lowest value since measurements started in 1888). Storlien-Visjövalen had -24°C on 28 November and thus its lowest temperature in November since 1962. Finland, too, experienced the coldest November days ever recorded. In Mariehamn on the Åland islands, the temperature was as low as -20°C .

The night of 27 to 28 November also brought extremely low temperatures to the UK; many November low temperature records were broken. In Wales, -18°C was recorded, in Scotland 15°C . Low temperatures were also measured in western France, with -10.1°C on 29 November at Mauron (Morbihan) or -15.3°C at Orleans (Loiret). Some stations in Germany, too, recorded very low temperatures at the end of November, locally less than -15°C on 30 November in south-east Germany. The Swiss station La Brévine registered -31.4°C on 30 November (a new record in 45 years); Poland recorded -14°C on 28 November.

Even Spain reported lowest minimum temperatures of -9.6°C on 29 November at Soria and -7.2°C at Leon-Virgen del Camino. These values were the lowest measured since 1942 and 1938, respectively. Portugal also reported lowest temperatures between -5 and -7°C on 29 November. The whole month was slightly colder than normal in almost whole Iberia and the western Mediterranean.

Most of eastern and south-eastern Europe, including south-eastern parts of central Europe (Slovakia, Hungary), Italy, the eastern Mediterranean as well as the Middle East and the South Caucasus region and the south-eastern Baltic countries were considerably warmer than normal. The 90th percentile was exceeded in almost all these areas. Lithuania had daily maxima up to 15°C in many places, breaking all previous records for November.

Anomalies were widespread above $+4^{\circ}\text{C}$ in south-eastern parts of the Region; they were highest in the eastern Ukraine, southern Russia and west Kazakhstan (Fig. 11.2) as well as in eastern Montenegro and parts of Israel, with more than $+6^{\circ}\text{C}$; locally in Belarus, the Ukraine, Moldova, Serbia (Fig. 11.3), Bulgaria and at high elevations in Armenia, they were more than $+5^{\circ}\text{C}$.

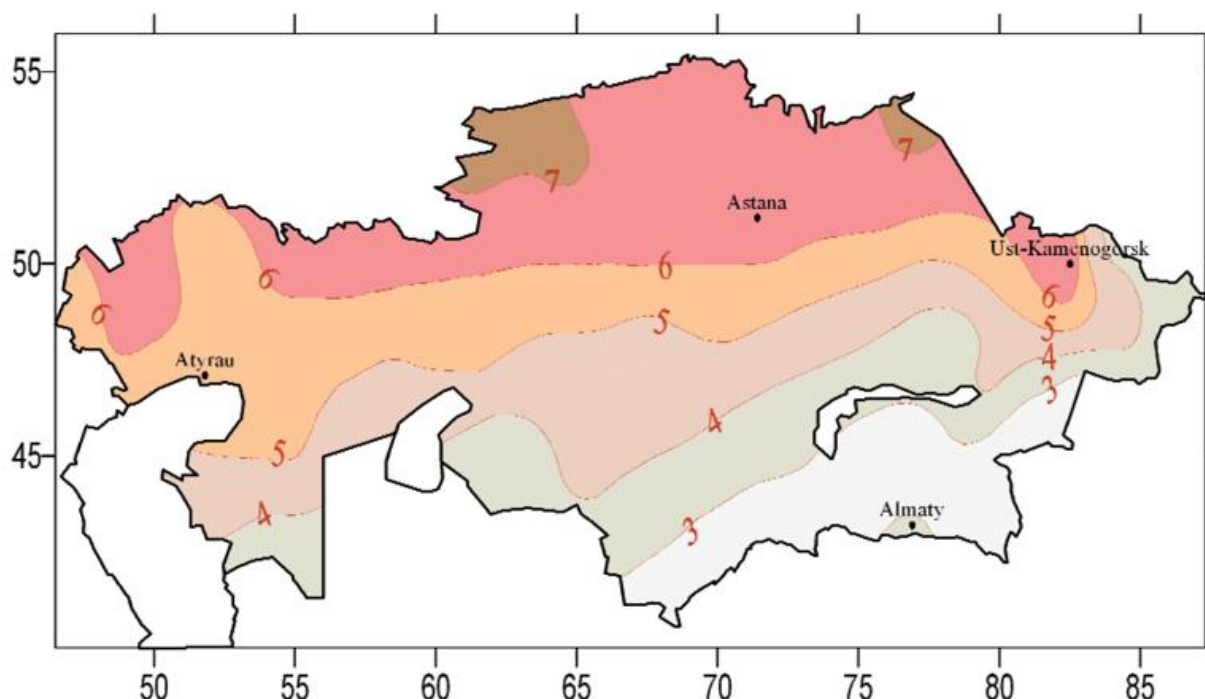


Fig. 11.2: Monthly mean temperature anomalies in November 2010 (reference period 1971–2000) in Kazakhstan
Source: Kazhydromet, Kazakhstan

The warm November in south-eastern Europe was characterised by several heat waves, which resulted in the high November averages. On 9 and 10 November already, warm air masses from Africa led to exceptionally high temperatures in that area. In Bosnia and Herzegovina, November was warmer than October, as had last been the case in 1963. It was the warmest November in 50 years in eastern, south-eastern and central Serbia, although no new records of maximum temperature were set. Instead, the duration of the heat was long; a 15-day heat wave took place in Serbia during the first two ten-day periods of the month. New maximum temperature records for November were set at 19 stations in southern and south-western Romania as well as at many stations in Bulgaria (highest maximum 28.9°C).

The first ten-day period was also particularly warm over most of European Russia and November temperature records were exceeded in many of its cities. In Moscow, 14.4°C was reached on 10 November, breaking an old record of 1927 (12.6°C) for that day of the year. Sochi, which is located at the Russian Black Sea coast, attained 22.1°C on 29 November, 1°C above the previous local record for that day of the year in 1990. During the first half of November, temperatures in European Russia were around $+10^{\circ}\text{C}$ above average. The extreme temperatures meant that badgers and hedgehogs could not go into hibernation and some species of hares and red squirrel did not receive their warmer winter coats. This can negatively affect the animals when regular temperatures return.

In the South Caucasus, daily maxima in west Georgia and Azerbaijan still reached up to 27°C . It was the warmest November since 1966 in Armenia.

In the Middle East, it was the warmest November on record in the mountain region of Israel, and up to 37°C were reached in the coastal plain and the Negev.

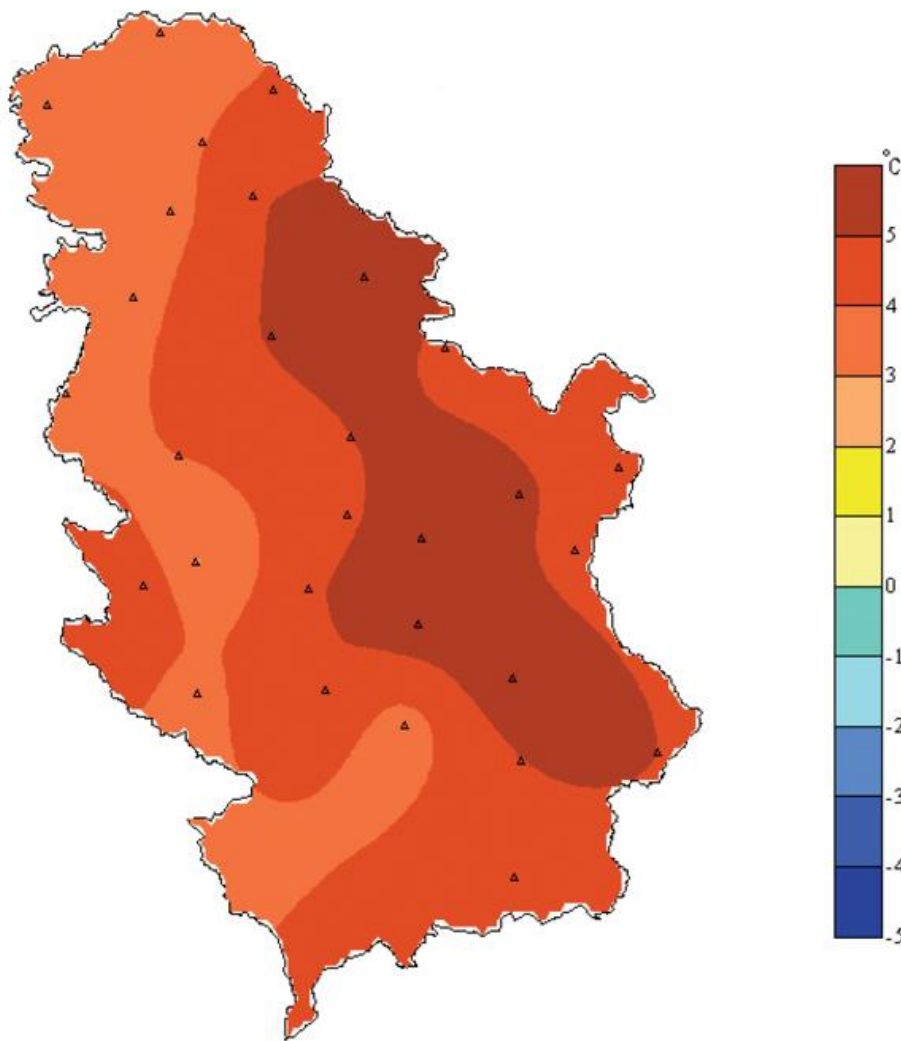


Fig. 11.3: Monthly mean temperature anomalies in November 2010 (reference period 1961–1990) in Serbia

Source: Republic Hydrometeorological Service of Serbia

Precipitation

It was mostly very dry in the Arctic region, in northern and central Scandinavia and on the Kola Peninsula (Fig. 11.4). Monthly precipitation totals were below the 10th percentile in nearly all these areas and locally less than 20% of the normal, in Greenland even below 10%. For south-eastern Norway, November 2010 was the second driest in the series going back to 1900.

In most of western, central and eastern Europe, including a large area around the southern Baltic Sea, precipitation was above normal. South-eastern Sweden was affected by heavy rain with some flooding. The United Kingdom was not so wet on average (close to normal in most areas), but heavy rain occurred in the first half of November. Several flooding events affected south-west England, northern France and Belgium. Locally, Germany and Poland, received more than 300% of the normal and high totals of 100–200 mm fell in many places in western parts of Europe. The 90th percentile was reached especially in eastern Germany, Poland, south-eastern Belarus and parts of western Russia.

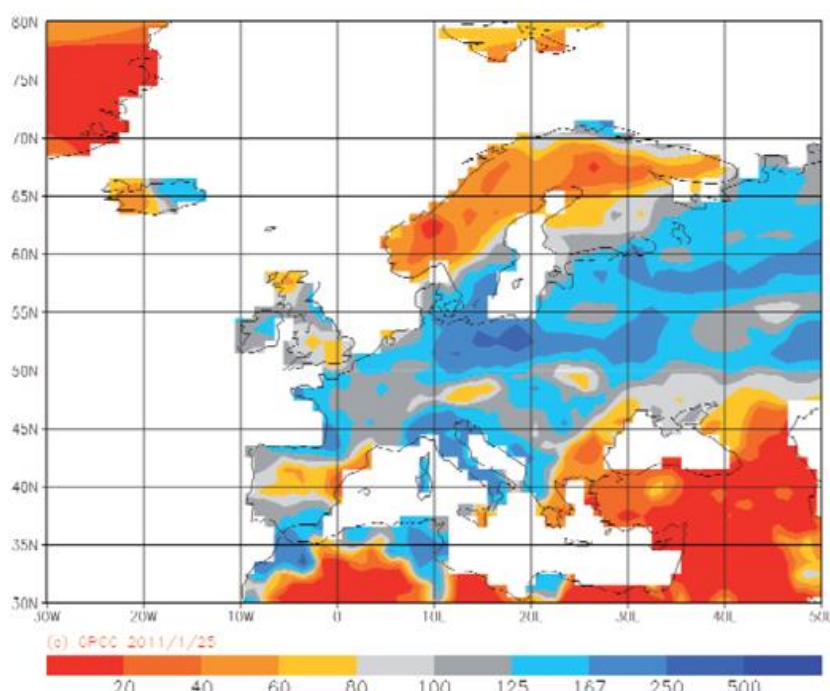


Fig.11.4: Monthly precipitation amounts for November 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Southern Spain, the central Mediterranean, most of Italy and most of the Balkan Peninsula (except the east) were wet, with more than 125% of the normal totals. Three new monthly precipitation records were set in Italy, one of them at a station close to Piacenza, which had its highest monthly total of the time series starting in 1921, another one in Napoli with a monthly record total of 415 mm. More than 200% of the normal fell in places in Slovenia and Bosnia and Herzegovina, and almost as much in Montenegro. Especially in the second half of the month, heavy precipitation occurred in Montenegro and Bosnia and Herzegovina, in the former case within a series of 14 rainy days. 12 municipalities in Montenegro (out of 21) were continuously flooded, water levels in the lakes and rivers rose rapidly and more than 1,600 people had to leave their homes.

It was very dry near the Black Sea, over large parts of Greece (except the Epirus region in the north-west, which was very wet due to heavy rain especially at the end of the month), in the Caucasus region (north and south), Turkey, Cyprus, the Middle East, Malta and parts of north-eastern Spain, mostly with less than 20% of the normal precipitation. The totals were below the 10th percentile in the Caucasus region, Turkey and the Middle East. Many of these areas had only a few mm of precipitation or set new low precipitation records for November. Barcelona received only 6 mm of precipitation (8% of the 1961–90 normal). None of the stations in eastern Georgia received more than 5 mm; partly, there was no precipitation at all, like in places in Azerbaijan, Armenia, Turkey and Cyprus. It was the driest November in Cyprus since 1901 and the driest on record in Armenia, where not even a trace of rain was reported during the whole month, although November–December normally is the second rainy period there beside April–May. Several places in the Middle East (Syria, Lebanon, Israel, Jordan) were also completely rainless, which was not normal for that season. It was one of the three driest November months in Israel in the last 70 years; only 1946 and 1966 were also rainless at such a large scale.

Snow

In nearly all parts of Scandinavia and northern Russia, there was a snow cover during almost the whole month.

Snowfall was unusually heavy in northern Iceland during the middle of the month, whereas the south and west of the country only had light snowfall. A snow depth of 85 cm was reported at the station Kråkemåla in southern Sweden, setting a new November record for this area. Early heavy snowfall also affected large areas of northern and western Estonia due to the lake effect. Several Estonian stations measured new November snow depth records.

Since most of the month was very mild, snow came late in the month to most of the medium and lower regions of north-western, western, central and eastern Europe and was widespread in the last week of November. In central Europe, snow started to fall on low sites on 22 November. The United Kingdom saw its most significant and widespread late-November snowfalls (more than 40 cm) since 1965, particularly in eastern Scotland and north-east England, and its earliest widespread snowfall since 1993. At the end of the month, many countries were mostly snow-covered. In Germany, mountains of about 1,000 m altitude had 30–60 cm of snow, and even locations in the northern lowlands received up to 40 cm, the international airports Berlin, Munich and Leipzig between 1 cm and 16 cm. There were 200 flight cancellations at Frankfurt airport, Europe's third busiest international airport.

In the Alps, there was some snowfall already early in the month. Switzerland reported snowfall with up to 30 cm above 1,500 m altitude. Later, snowfall also occurred in lower areas and it snowed down to 600 m altitude locally on the southern side on the Alps. Austria, reported snowfall in lower places, too, e.g. in Bregenz (8 cm), Eisenstadt (10 cm) and Klagenfurt (20 cm). Kredarica Mountain in Slovenia had 275 cm on 30 November, setting new snow depth record for November since the beginning of measurements at that station. In the high mountains of Slovenia, snow persisted the whole month; at the end of the month, it also arrived in the lowlands, except the regions near to the coast.

Romania had a thin snow layer in some areas during the last ten days of the month; the depth exceeded 35 cm in some mountain areas.

In Montenegro, a long period of rain combined with higher-than-normal temperatures led to a rapid snowmelt in the mountainous regions.

In the south, there was some snow on higher and lower mountains, even in Iberia. Portugal reported snow at the stations Villa Real, Viseu, Braganca and Penha Duradas.

Significant weather events

November 01–02: Flooding in Veneto (Italy) after cyclogenesis over northern Italy and intense precipitation, locally exceeding 300–350 mm in three days. An area of about 140 km² was flooded; more than 6,500 people were isolated or displaced. The motorway between Verona and Vicenza was closed for a few days.

November 04: Heavy rain in the northern half of Germany, locally more than 70 mm in 48 hours, with flooding of streets in Hamburg. Strong wind gusts at the coasts and on mountains (141 km/h on the Brocken Mountain in Germany).

- November 08–11: Heavy rain led to a flood situation in the Italian province of Salerno. 300 people had to be evacuated. Greece also had a heavy storm in Kerkira and north Peloponnese, with precipitation and flooding at daily totals up to 127 mm on 09 November. Heavy rain in Montenegro caused the water level in Morača (Podgorica) to rise by 10 m in just 48 hours.
- November 08–12: Two deep areas of low pressure affected the United Kingdom and Ireland, the first bringing the lowest November mean sea level pressure to Heathrow Airport since its records began in 1949. Rain from the first system caused flooding in Emsworth in Hampshire. Homes were also flooded on the Isle of Wight, roads were closed and two schools were forced to shut. The second system brought a lot of damage and disruption due to the wind. Gale-force winds and torrential rain caused damage, with power lines brought down and bridges closed. The worst hit areas were northern England, north Wales and Northern Ireland, with gusts of around 130 km/h. Some 6,000 people in Northern Ireland were left without power. All ferry sailings across the Irish Sea were cancelled for a time. There was some localised flooding in Scotland.
- November 11–14: A depression north of Ireland ("Carmen") brought intense rain and strong wind to large parts of northern France. In Granville (France), 48 mm of rain fell in 24 hours. The United Kingdom and Ireland also reported high wind speeds of > 100 km/h in gusts, with a maximum wind gust above 165 km/h at Capel Curig (Conwy, UK). The same low Carmen caused heavy rain in large parts of central Europe, due to a very stable zonal cold front. 2 people drowned in a flood in the Beaumont region (Belgium). In central and western Belgium, rivers and creeks flooded cellars and streets in many locations. Rail traffic was also affected. The station Uccle had 40 mm of precipitation on 13 November and accumulated 100 mm from 09 to 13 November, causing inundations especially in the centre of the country. In two days, Belgium received as much rainfall as it normally gets in a month. The Netherlands reported between 30 and 80 mm between 12 and 14 November, for Suid-Limburg 90–100 mm. The rain caused flooded streets and land-slides. Germany received heavy rain as well, with 48-hour values between 50 and more than 90 mm in a band between the Eifel and the Elbe east of the Harz Mountains. Highways near Dortmund and the fish market in Hamburg-Altona were flooded.
- November 15–16: Ben Gurion International Airport in Israel had to be closed for several hours during the night due to visibility limitations. Seven consecutive nights with heavy mist and fog occurred in the coastal plain, which is uncommon for that area and time of year.
- November 16–17: Heavy rainfall in the southern United Kingdom (Cornwall and parts of Wales) caused flooding and landslides. In Cornwall, streets and the mainline railway were closed and flash flooding affected over 100 houses. Heligan (Cornwall) received over 40 mm of rain in 2 hours. Ireland also reported localised flooding. Although damage was widespread, no fatalities or injuries were reported.
- November 16: Germany received rain over a wide frontal band (depressions Ditte in the southern Baltic Sea and Emilyya in the Mediterranean Sea), peaking to about 35 mm in 24 hours in Thuringia and northern Bavaria. The higher mountains had snow.

- November 23: Thunderstorm with isolated hail at some locations in Romania (Calarasi, Medgidia, Videle).
- November 27: Hail was registered in 19 out of 27 administrative regions of Bulgaria.
- November 27–28: Southern Spain and the Balears received heavy rain (e.g. Murcia 191 mm, Menorca 88 mm in 24 hours) due to a deep trough extending far south.
- November 27–30: A lot of flights were cancelled due to snowfall in western and central Europe. 1,700 car accidents were counted in the German region of Northrhine-Westfalia. Many streets were closed throughout the country. Wind partly caused additional problems. The relatively warm southern Baltic Sea fed additional moisture into the air and caused even more snowfall in the eastern Holstein area (northern Germany), causing public traffic to break down and schools to be closed. In south-eastern Austria (Burgenland) and Hungary, the snowload was so heavy that trees and power lines broke and many thousands of households were without electricity.
- November 29–30: Heavy storms in Bulgaria in the regions Morungash, Cherni and Botev, with gusts up to 122 km/h.

December

- **Very cold over most of Europe, warmer than normal in Greenland and the south-east of the Region**
- **Dry in northern and north-western Europe and in the South Caucasus region, wet in south-western, central and eastern Europe**
- **Long duration of snow cover in central Europe**

Atmospheric circulation characteristics

Similar to the previous winter 2009/10, December 2010 also saw extremely high negative North Atlantic Oscillation and Arctic Oscillation indices. High pressure was dominating over Greenland and Iceland, low pressure in the Azores region, which is the reverse of normal conditions. As a result, there was no westerly flow, but cold air from the Arctic spread out over nearly the whole European continent. A quasi-stationary front over central Europe persisted for several days, separating cold air from the north and milder air in the south. Especially in middle latitudes and in southern Europe, there was much low pressure activity, initiating frequent precipitation which came often as snow due to the low temperatures, temporarily in the southern half of central Europe also as rain.

Only some parts of south-eastern Europe, the Middle East and the South Caucasus region were mostly affected by warm and dry air from the south.

Temperature

It was warmer than normal in the Arctic, particularly in Greenland as well as in Svalbard, the very north of Norway, Iceland and large parts of the North Atlantic (Fig. 12.1). Anomalies in western Greenland exceeded $+7^{\circ}\text{C}$ and the 90th percentile.

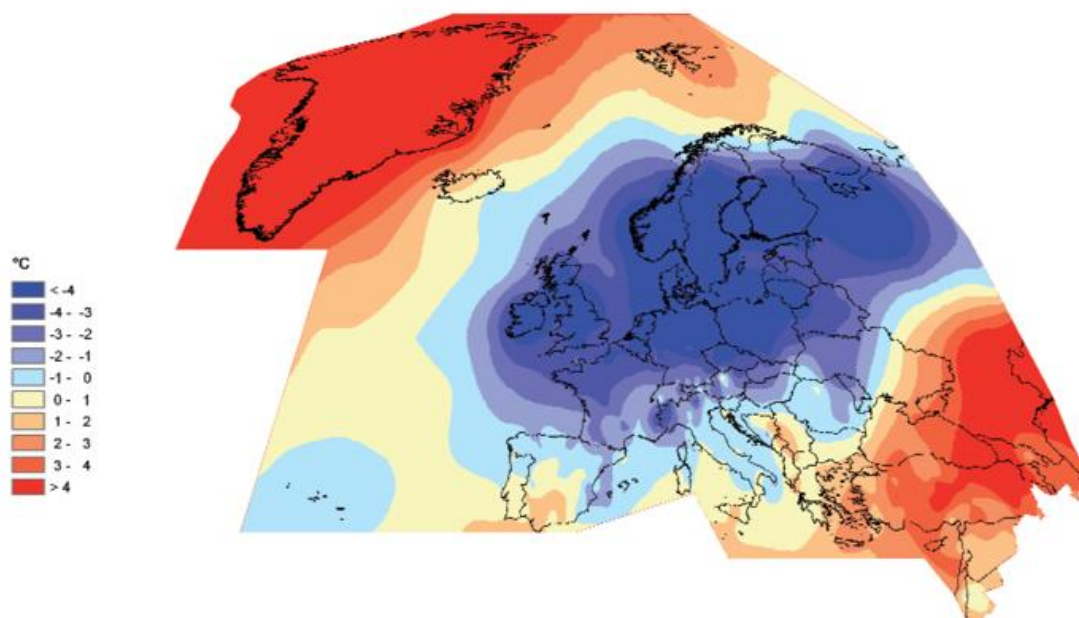


Fig. 12.1: Monthly mean temperature anomalies in December 2010 (reference period 1961–1990) in WMO Region VI
Source: Deutscher Wetterdienst, Germany

Most of Europe, including adjacent ocean areas, experienced a very cold December, particularly during the first three weeks, except some parts of the south and south-east. Temperatures were below the 10th percentile over a large area covering the southern parts of northern Europe, the whole of north-western, western and central Europe and the northern parts of eastern Europe. In large parts of northern and central Europe, the anomalies were below -5°C , in many places even below -6°C . Highest negative monthly anomalies were as much as -10°C below normal at some locations in Norway and Sweden. High mountains in Switzerland (Jungfrauoch, Säntis) were around -3°C colder than normal.

Many places in Scandinavia had their coldest December on record. Some stations in southern Sweden also experienced the lowest minimum temperature, e.g. the station Linköping/Mamslätt reported -27.6°C on 23 December and a monthly mean of -8.2°C . The lowest temperature in Sweden in 2010 was -42.1°C at the station Nikkaluokta on 20 December. The harsh winter weather caused widespread problems for railway and road traffic, just like in January and February 2010. At -23.0°C on 22 December, the station Holbaek recorded the lowest temperature in Denmark since 1987. For Denmark as a whole, it was the second coldest December on record (only slightly behind 1981).

It was the coldest December in the United Kingdom in the last 100 years; the central England temperature record displayed its coldest December since 1890. In large parts of western and central Europe (Netherlands, Belgium, France, Germany), it was the coldest December in more than 40 years, in south-eastern parts of central Europe only since 1996 (e.g. in Vienna, Austria).

Minimum temperatures were also very low in western and central Europe and some local records were broken. Temperature minima in the United Kingdom dropped well below -15°C in several locations between 18 and 25 December and remained below freezing during the day. On 23 December, Castlederg (County Tyrone) recorded -18.7°C , which was the lowest temperature ever recorded in Northern Ireland.

The lowest temperature in the whole of the Netherlands was -16.9°C on 20 December. Daily minima down to -18°C were recorded in north-eastern France. Daily minima below -20°C were measured in Germany and Poland, causing deaths due to freezing. The Czech Republic reported on 5 December that 68 of 151 stations recorded the lowest minimum temperatures for many years. In the higher Alps (altitude 3440m in Austria), minima were below -30°C ; similarly low temperatures had last been measured there in 1981.

The number of frost days (minimum temperature $<0^{\circ}\text{C}$) was also outstandingly high in western and central Europe. It was the highest number for December in the United Kingdom for over 50 years. Southern parts of northern Europe and northern parts of central Europe had frost almost the whole month (e.g. Luxembourg, Germany, Denmark, Poland, Lithuania), which was far above the normal of e.g. 17 days in Luxembourg or 15 days in Denmark.

In the south, even the Azores islands were colder than normal as a consequence of colder-than-normal sea surface temperatures due to an ongoing strong La Niña. Furthermore, northern Spain, the western Mediterranean, most of Italy and the northern Balkan Peninsula were colder due to several cold spells reaching the south throughout the month. Anomalies in northern Italy were below -2°C in places. A daily minimum of -48.3°C was recorded at Pale di San Martino on 27 December, the lowest temperature ever recorded in Italy. Like in Croatia, it was only slightly colder than normal on average in Slovenia because of two mild spells during the month.

In contrast, the south-east of the Region and the southern Mediterranean saw once more a mild month. It was warmer than normal in southern parts of the Balkan Peninsula, Turkey, the Black Sea, the eastern Ukraine, southern European Russia, west Kazakhstan, the South Caucasus region, Cyprus and the Middle East. The monthly mean temperatures were higher than the 90th percentile in nearly all of that area, partly even higher than the 98th percentile.

High temperature maxima were measured in southern Italy and on the Balkan Peninsula, locally with new records, e.g. in southern Italy and at Mostar in Bosnia and Herzegovina, the latter with 19.4°C on 9 December (previous record in 1971). Maxima up to 23°C were reached in Bulgaria. Especially the first half of the month was mild in Greece. In the second half, some extremely cold days were also recorded in south-eastern Europe. Zabljak in Montenegro had a daily maximum of -10.7°C on 14 December, the lowest daily maximum for that day of the year in 50 years. Similarly, Western Macedonia, too, had cold temperatures even below -12°C ; even Greece experienced a considerable cooling later in the month.

In contrast, high monthly anomalies were observed in southern European Russia ($> +7^{\circ}\text{C}$ in individual regions) and in west Kazakhstan, Azerbaijan, Armenia and central Turkey, all up to $+5^{\circ}\text{C}$ or $+6^{\circ}\text{C}$. Daily maximum temperatures near the Black Sea coast in European Russia and west Georgia reached up to 25°C (at the Russian station Wladikawkas in the North Caucasus even 27.1°C on 6 December, a new winter maximum temperature record for Russia), and roses bloomed in the north Ossetia valleys in the North Caucasus. On 26 December, Stavropol (also in the near area of the North Caucasus) still reached 17.1°C , exceeding the previous temperature record of 1954 by $+6^{\circ}\text{C}$.

The eastern parts of the South Caucasus region also registered a new 100-year record of 22.7°C in Baku (Azerbaijan) on 12 December (previous record was in 1906). Similarly, Armenia recorded $20\text{--}24^{\circ}\text{C}$ in the lowlands of its very southern and north-eastern parts.

Israel was especially warm on the first days of the month, with temperatures reaching up to 31°C in the coastal plain, the Negev and the Jordan Rift.

Precipitation

Nearly the whole of the Arctic region (except western Greenland), northern European Russia, Scandinavia, the United Kingdom and Ireland were far drier than normal (Fig. 12.2). The monthly totals were mostly smaller than the 10th percentile. Locally, they were less than 20% of the normal.

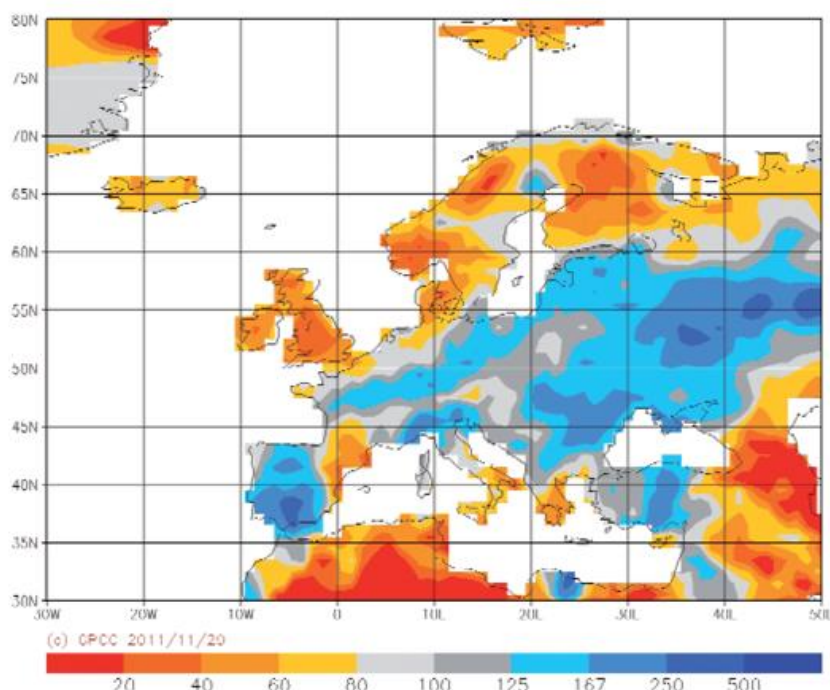


Fig.12.2: Monthly precipitation amounts for December 2010 in per cent of the 1951–2000 normal in Europe and adjacent areas

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany

Less than a third of the average rainfall was recorded over large parts of the United Kingdom. It was the driest December over the UK since 1963 and the third-driest in the 100-year series.

Large parts of western, central and eastern Europe were mostly wetter than normal. Strasbourg in eastern France had more than 300% of its normal precipitation due to a quasi-stationary cold front. The 90th percentile was exceeded only in some areas of central and eastern European Russia (around 400% of the normal in Kasan), the Ukraine and Romania. Latvia saw its wettest December for 87 years. Monthly precipitation totals in Lithuania amounted up to 95–120 mm in the western border regions, which was 150–200% of the normal. There was a huge flooding on the rivers of Transcarpathia, causing damage to settlements and infrastructure; historically high water levels were reached.

Some areas in the southern parts of the Region were wetter as normal, such as the Azores Islands, most of Iberia, northern Italy, most of the Balkan Peninsula except the south and most of the western half of Turkey due to some heavy rain events. Monthly precipitation in Iberia was among the highest in Europe and thus consistent with the tendency for above-normal precipitation in this region during negative NAO periods. On the Azores Islands as well as locally on the Balkan Peninsula (e.g. in Bosnia and Herzegovina), monthly totals were close to 400% of the normal or more; in southern Spain, they were higher than 300%, exceeding the 90th percentile. The wet weather also led to flooding of the north Hungarian rivers. In Serbia, the number of precipitation days was high, whereas the monthly totals remained within their normal range in most parts of the country.

On the other hand, many parts of the Mediterranean region (eastern Spain, central and southern Italy, Malta, Greece and Cyprus) were dry, partly with totals of less than 60% of the normal, although heavy downpour occurred and caused floods in the Greek regions Epirus and Crete.

A large area in the south-east of the Region (western Kazakhstan, southern European Russia, South Caucasus region, eastern Turkey and eastern Syria) was very dry, locally with less than 20% of the normal. The totals were below the 10th percentile particularly in western Kazakhstan and the South Caucasus region. It was the driest December on record (since 1966) in Armenia; only 2 mm of precipitation were registered in Yerevan, less than 10% of the normal. Other places of the Middle East (in the Lebanon, northern Israel, Jordan) were wetter than normal.

Snow

Heavy snowfalls disrupted traffic severely in many parts of Europe. Large areas of northern and central Europe, including the Alps, were covered by snow almost the whole month, partly reaching depths of more than 40 cm in the lowlands of central Europe, which is quite rare. Snow depths were even higher than at the beginning of the year. Roads, railways and air traffic were severely affected. Airports were forced to close in the Netherlands, Belgium, France, Germany and Switzerland. Many schools were closed, too.

Snowfalls occurred in almost all areas of the United Kingdom, especially in the first week, reaching depths of over 40 cm in parts of north-east England and eastern Scotland; 30 to 40 cm fell locally in parts of central Scotland in the morning of 6th. There was further widespread snow across the UK from mid-month to Christmas. The snowfalls were comparable to those experienced in January 2010, and were the most widespread and significant in December since 1981.

The Netherlands had just two days which were completely free of snow. Uccle in Belgium had 21 snow days that month, the highest number ever recorded since 1901. In France, particularly over Ile-de-France, such conditions of frequent snowfall and very low temperatures had not been observed for the last 30 years. It snowed for 14 days in Paris-Montsouris, leading to a total depth of 12 cm, the highest depth at this station since 1980; other French stations reached similar records.

Large areas of central Europe saw a white Christmas, which is unusual in the lowlands. Germany had its first white Christmas in most of the area since 1981. On 25 December, even the area near the Rhine River reached snow depths above 25 cm, which is quite extraordinary for that region. Around Berlin, the maximum snow depths of December 2010 were partly the highest December depths ever measured in more than 100 years. For the first time ever, Denmark saw a second nationwide white Christmas in a row (after 2009).

The Alpine region received a lot of snow, too. At 31 cm, a December snow depth record was broken in Geneva (Switzerland), forcing the airport to close for hours. Bern and Zürich also got new local snow depth records for December (57 and 58 cm, respectively). Before, such depths of fresh snow had been measured only in 1962 and 1979. Another snowstorm hit the plains of Switzerland on 17 December, bringing a widespread layer of 10 cm or more. On Christmas Day, the lowlands of northern Switzerland from Geneva to Lake Constance were covered in white and that remained until the end of the year. Snow also lay over the whole country of Austria already from the beginning of the month, reaching extraordinary depths also at lower stations. In Vienna, a maximum snow depth of 28 cm was measured, which happens approximately every 20 years and had not occurred for the last 29 years. Likewise, about 30 cm of snow fell in the Czech capital Prague on 2 December. On Kredarica Mountain in Slovenia, a maximum depth of 400 cm was recorded on 25 December, which was the highest depth ever measured there in December. Snow was also to be found in the lowlands of Slovenia for a period of 2–4 days; 35 cm were registered in Ljubljana.

In north-eastern parts of Europe, there were also unusually large amounts of snow in coastal areas in southern Finland. In the Helsinki area, the recorded snow depth of 67 cm was close to the deepest ever recorded. Estonia reported record-breaking snow depths from 20 out of 31 stations, with depths of 37–60 cm on 10 December. These values were the highest since December 1965 or earlier. The monthly average snow cover in Latvia was four times the normal, and it was the second snowiest December there for 87 years. At Christmas, however, a warmer spell with freezing rain occurred, causing an ice layer covering almost the whole country. Trees falling on power lines due to icing caused prolonged power failures. In Lithuania, a record-breaking mean depth of 39–56 cm was reached at the end of the month. Poland had a snow cover on all days of the month at most of the stations, with maximum snow heights of typically about 20–40 cm.

Even in the south of the Region, there was some snow, at least temporarily. Portugal had some snowfall in the highest areas of its northern and central parts. Italy saw depths of 10–30 cm. The Italian Isle of Capri experienced its first snow in 25 years on 3 December. On the Balkan Peninsula, a sudden heavy snowfall occurred across Bosnia-Herzegovina after a cold front passage in early December. From 17–19 December, it snowed in the whole of Montenegro. Further temporary snowfalls occurred in Macedonia and northern Greece; the station Larissa in eastern Greece received 30 cm of fresh snow on 16 December. Turkey had a widespread snow cover on two days. By the end of the month, a thin snow cover of 22 cm had formed on the slopes of the Aragats Mountain in Armenia at altitudes higher than 3000 m. In west Kazakhstan, heavy snowfall combined with temporary strong cooling occurred at the beginning of the month. Some non-accumulating snow was measured even locally in Jordan.

Significant weather events

December 02–05: In Israel, a large forest fire in the Carmel Mountains near Haifa broke out after a very dry 9-month period. It caused the death of at least 44 people. Continuous dry weather and strong winds prompted it to become one of the biggest wildfire in Israeli history and made it difficult to extinguish the fire. Over 41 people died in a bus caught in the flames. Around 17,000 people had to leave their homes and almost 5,000 hectares of land were burned.

December 02–05: A powerful Mediterranean cyclone first brought strong southern winds and then abundant rain to the west and the north of Bulgaria. The rivers coming downhill from the steep mountain of Vitosha into the capital city of Sofia flooded the freshly built ring highway. In the aftermath of the heavy rain, a part of the main road that links Sofia to Greece came to collapse, practically cutting the south-west of Bulgaria off from Sofia for as long as one week (Fig. 12.3).

Flooding and mudslides were also reported from northern Albania; more than 12,000 people had to leave their homes and 14,000 hectares of farmland were destroyed. Locally, the River Drina rose to its highest level in more than a century. Streets in the town of Shkodra were inundated by six and a half feet (two meters) of water. The only ways into or out of town were by boat or helicopter. Extremely heavy precipitation was also registered in eastern and southern parts of Bosnia and Herzegovina on 2 December; it was the wettest period on record there since beginning of measurements (Fig. 12.4). In northern Bosnia, the heavy rains triggered a landslide in the city of Tuzla, three people were killed. In southern Croatia, the River Neretva reached its highest level in 50 years, flooding 700 homes in the town of Metkovic.



Fig. 12.3: Bridge over the river of Dzherman (south-west Bulgaria) destroyed during passage of a powerful cyclone on 02–05 December 2010
Source: bTV, provided by the National Institute of Meteorology and Hydrology, Bulgaria



Fig. 12.4: Flooding in Gorazde (Bosnia and Herzegovina) after extremely heavy precipitation on 02 December 2010
Source: Gorazde.tvsa.ba, provided by the Federal Hydrometeorological Institute, Bosnia and Herzegovina

- December 03: High tides in Venice (Italy) reached 1.36 m above sea level, flooding more than half of the lagoon city, including the central St Mark's Square. The water level marked a record high for Venice. The tide was pushed up by a combination of heavy rains and strong winds that hit large parts of northern Italy.
- December 04: Overflowing of the lake of Ioannina city (western Greece) due to successive rainfall events starting already in November.
- December 05–08: Heavy precipitation affected extended areas in western Iberia, especially central and north Andalusia. 4-day totals ranged between 160 and 334 mm, and daily totals of 100 mm or more fell on 07–08 December in Andalusia (regions of Cordoba and Seville). The Guadalquivir River caused severe flooding near Seville, where dozens of homes had to be evacuated and at least 2 people died. A tornado developed in Portugal near Serta and devastated an industrial area (even a hall made of metal). The tornado was classified category EF3 on the extended Fujita scale.
- December 06–13: 113 settlements in the Ulyanovsk region (central European Russia) were cut off from electricity because of glaze ice layers of 18–50 mm, causing state of emergency.
- December 07–09: Snowstorm Monika and its very active slow moving front caused abundant precipitation in large parts of central Europe. The front separated cold air masses in the north with frequent snowfall and warmer air masses in the south with rain. On 09 December, freezing rain caused the temporary closure of Frankfurt Airport (Germany). Storm Monika also contributed to a considerable increase in snow depth in Estonia (e.g. 38 cm in 24 hours in Väike-Maarja). Road and rail transport was seriously affected. The snow load caused much damage to roofs, trees and power lines.
- December 09: During a strong cold front at the station Kab-hegy in Hungary, a record wind gust of 170 km/h was measured.
- December 10: Severe rain and flooding forced hundreds to leave their homes in the western Ukraine. The worst affected region was Zakarpattia.
- December 11–13: Strong northern winds with gusts over 100 km/h over various islands in the Aegean Sea within an extratropical cyclone. Heavy rain and floods affected particularly Greece, western Turkey, later also the Lebanon and Israel, especially the coasts and harbours. On the Greek island of Samos, coastal roads were closed due to fallen rocks. Along the coast of Lebanon, waves up to 10 m high were observed. Stormy wind and high sea motion caused a transport ship to sink near the coast of Israel and heavy damage to areas close to the sea shore. Five people lost their lives. In Israel, the winds also knocked out power to hundreds of people and downed trees. In Jordan, highways were closed as winds reached speeds above 90 km/h and sand limited visibility severely. On a positive note, the storm ended a lengthy drought in Lebanon, Syria, and Israel.
- December 15: Sorvaag (Faeroe Islands) had winds up to 135 km/h with 150 km/h gusts (on nearby hill) within snow squalls on passage of a powerful cold front. The temperature fell from 9°C to -5°C with a wind chill below -15°C. Conditions were less extreme on Shetland and Orkney, yet still harsh with freezing gales and bursts of snow.

- December 15–18: Abundant snowfall in Italy after an intense cold spell (temperatures between -12 and -15°C in the region of Friul) and due to a frontal system with strong warm advection in the middle troposphere moving from north-western to south-eastern Italy. Florence had 10 cm of snow and even the coasts saw some snow which lasted just for one or two hours on 17 December. Greece and Macedonia also had very low temperatures (below -12°C in western Macedonia) and snowfall. A station on Crete (Greece) reported 41 mm of daily precipitation on 16 December.
- December 18: Heathrow Airport in London was closed in the run-up to Christmas due to heavy snowfall.
- December 23–24: Ship traffic in the harbour of Hamburg (Germany) was affected by ice. Parts of the islands Fehmarn and Rügen in the German Baltic Sea were cut off from the outside world. Just before Christmas, snow and freezing rain affected air and road traffic considerably in northern and eastern Germany.
- December 25–26: Freezing rain in central European Russia. Operation of Moscow airports was brought to a standstill owing to ice. Hundreds of settlements were cut off from electricity.
- December 30: Heavy storm in Botev region (Bulgaria) with gusts of 100 km/h.

ECSN Activities Report 2010

Support and co-operation in best climate practices

Responsible Member: KNMI; Programme Manager: Aryan van Engelen

The objective of ECSN, the European Climate Support Network, an optional Programme of EIG EUMETNET, is to support its members in their climate practices in order to provide better products and services to the European user community for the benefit of the environment, safety, economy and health.

In 2010, this objective was realised by a range of activities: running new programmes and projects (ECA&D, ECSM/RCC-CM, EUMETGRID, PEP725, Climate Change Services and HIST-EU), focusing on a better understanding of Europe's past, present and future climate and the provision of data and products, participating in or collaborating with major EU research projects: ENSEMBLES, MILLENNIUM and EURO4M, communicating and co-operating with other parties, such as WMO, WMO-RAVI, EEA, ESA, EUMETSAT, EUMETNET-EUCOS, EUMETNET-SRNWP, and co-ordinating activities: preparing and organizing the climatology programme of the EMS-ECAC 2010 and the ECSN Data Management Workshop 2011.

EIG EUMETNET

As of 1 January 2010, all (EUMETNET) activities (including ECSN) were transferred to the new EIG EUMETNET, which now has the legal status enabling it to sign contracts with third parties, bid for EU projects and employ staff. The three strategic goals over the next (10) years are: to improve efficiency by means of programme activities and changing to shared services, to invest collectively in science, technology and skills and to be an essential partner for EU/EC whenever capabilities and services from the meteorological community are required. It has been recognized that there is a need for more extensive European climate (change) services than are currently offered by EUMETNET. A new working group on Climate Change Services (co-ordinated by KNMI) was established to survey the European needs and the role to be played by EUMETNET and its Members, taking account of the Members' capabilities which include the Regional Climate Centres. The ECSN programme was extended by another year until 1 January 2012 and the PM ECSN was appointed as Interim Programme Manager Climate.

EUMETGRID (Met.no, <http://eumetgrid.eu>)

The main objective of EUMETGRID is to provide seamless access to the best available high-resolution gridded data sets in Europe and their related products and services. To achieve this goal, a main task is to develop and maintain a sustainable pan-European data infrastructure for accessing and distributing gridded climate information, based on the NMHS's sustainable observational networks, databases and meteorological infrastructures.

Highlights:

- EUMETGRID started with a kick-off meeting in Oslo on 25-26 January 2010.
- 24 European countries participate in EUMETGRID.
- EUMETGRID wiki has been established.

ECSM/RCC-CM (DWD, <http://www.dwd.de/rcc-cm>)

The aim of ECSM (European Climate System Monitoring) was to build a sustained operational Web platform for climate monitoring products in WMO RA VI. These efforts complement successful regional climate monitoring activities, such as the RA VI Bulletin, the European contribution to the annual BAMS Article on the State of the Climate, European contributions to the annual WMO Statement on the Status of the Global Climate, ECA&D, etc. All these activities are basic components of a systems approach for co-ordinated operational climate monitoring in WMO RA VI. Based on the analysis of a questionnaire on RA VI operational climate monitoring requirements (Gocheva, Hechler, Dec. 2007), the systems approach aims at implementing a RA VI RCC (Regional Climate Centre) node for climate monitoring.

Highlights

- 24 countries contribute to ECSM/RCC-CM.
- ECSM has been integrated into the technical platform of the RCC on Climate Monitoring (RCC-CM), which is currently in its official pilot phase.

ECA&D-ENSEMBLES/MILLENNIUM/EURO4M (KNMI, <http://eca.knmi.nl>)

The European Climate Assessment and Dataset (ECA&D) is aimed at creating and maintaining a pan-European set of high-quality daily observational data series and, on the basis of derived climate change indices, at producing assessments of climate change in Europe. ECA&D is based on a data set (E-OBS), which currently includes approx. 4,800 stations and over 26,000 time series. It was originally developed as part of the ENSEMBLES and MILLENNIUM projects (EU-FP6) and is now maintained and elaborated as part of the EURO4M project (EU-FP7). Like ECSM, it will serve as a platform for a RA VI Regional Climate Centre on Climate Data (RCC-CD).

Highlight

- ECA&D will be the technical platform of the RCC on Climate Data, currently in the official pilot phase.

PEP725 (ZAMG, www.zamg.ac.at/cost725)

Phenology is the study of the timing of recurring biological events in the animal and plant world, such as leaf unfolding and flowering of plants in spring, fruit ripening, colour changing and leaf fall in autumn, as well as the arrival and departure of migrating birds and the timing of animal mating. During the past decade, phenology has rapidly become an important tool for climate change impact studies.

Under Cost Action 725, a prototype database of European phenological records was set up. An ECSN project under the name PEP725 aims at the establishment and sustainable management of a full-scale phenological database.

Highlights

- Work plan and work packages have been defined.
- Kick-off in Dublin on 17 June 2010

Roadmap for embedding observation requirements from climatology in EUCOS

The roadmap aims to define a EUCOS Surface Climate Land Station Network (ESCLSN) as the climate counterpart of the EUCOS Synoptic Surface Land Station Network (ESSLSN). Key considerations of the roadmap are:

- The observational network should provide data sets that serve climate impact assessment and adaptation to climate variability and change.
- The network should become part of the EUCOS concept.
- The network should cover the whole of RA VI.
- The network should include terrestrial in-situ surface observations.
- The network sites should be available for electronic access (E-VCOMP).
- The design should be based on expert selection of stations from existing networks (WMO-SYNOP, EUCOS, RBSN, RBCN, GSN, ECA&D) and fulfil the demands of the major (European) climate services and projects, such as GMES, RCC, CCS, ECA&D, EUMETGRID, EuCLIS, SRNWP etc.
- Selection should be made according to the site and instrument criteria arising from the mentioned services, WMO and WMO-GCOS.
- Highest priority should be given to climatological reference stations.

HIST-EU (ZAMG)

The Responsible Member of the successfully completed HRT-GAR project (ZAMG) launched this initiative in order to extend the current HIST-ALP project (aiming at the creation of a database of long-term monthly homogenised series over the Greater Alpine Region) to the whole of Europe, with the following two main objectives:

- To extend HIST-ALP to HIST-EU with a climatological network described as long-term, of appropriate density, quality-improved, homogenised and of European relevance.
- To support data rescue activities to achieve an optimal European station density.

Highlights

- A questionnaire on potential user requirements was distributed and obtained a very positive response.
- Proposal elaborated.

10th EMS Annual Meeting and 8th European Conference on Applied Climatology (ECAC), Zürich, ETH, 13-17 September 2010

The theme of the conference was: "High-resolution climatology – towards climate change services".

The session programme dealt with the following four major topics, which had been agreed with WMO GFCS:

- Monitoring for a reference climate and monitoring change
- Understanding processes and climate change
- Services translating science to users
- Plenary sessions on communication and adaptation strategies for climate change

The conference attracted a large number of experts (630) from 44 countries and high-quality contributions. Especially the Climate Services session and the Plenary sessions on Communication on Climate appeared to be very attractive.

ECSN Data Management Workshop (DMWS) 2011, Edinburgh, UKMO, October 2011

UK Met Office offered to host the DMWS 2011 in Edinburgh from 12-14 October 2011.

The Ozone Layer over Central Europe in 2010

Wolfgang Steinbrecht, Hans Claude, and Ulf Köhler - Deutscher Wetterdienst

2010: Highest ozone columns in 25 years

The annual mean ozone column for 2010 substantially exceeded the long-term mean since 1968 for the first time again after many years. At nearly 340 DU, the annual mean for 2010 reached the same high level as recorded in the 1980s, as shown by Dobson and Brewer measurement series at Hohenpeissenberg station in southern Germany (Fig. 13.1). The last time Hohenpeissenberg recorded similarly high annual means was in 1984, i.e. 26 years ago. Practically all monthly means of 2010 are above the long-term median (50th percentile), partly even above the 67th percentile.

Satellite data from Bremen University in Germany and from KNMI in the Netherlands showed that this distinctly positive development was not only observed at Hohenpeissenberg, but also for almost the whole northern hemisphere.

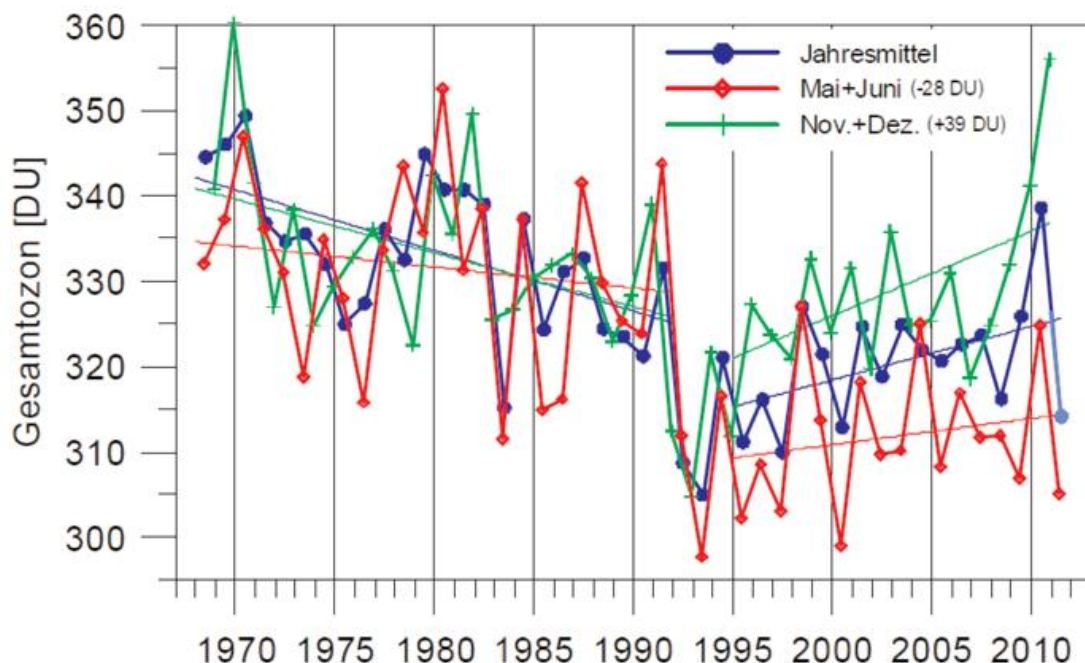


Fig. 13.1: Ozone columns above Hohenpeissenberg. Blue: Annual mean ozone levels. Red: Mean ozone for May and June, shifted downwards by 28 DU. Green: Mean ozone for December and January, shifted downwards by 39 DU. The annual mean for 2011 is only an estimate (data for November and December of 2011 not yet available).
Source: Deutscher Wetterdienst, Germany

On average, the ozone columns in 2010 remained below normal only between 0°N to 20°N, from central America across the Atlantic to northern Africa, over wide areas of the tropics, and also in some parts of the southern hemisphere. In general, the spatial distribution of the 2010 ozone anomalies suggests increased transport of ozone from the tropics towards northern latitudes due to an increased Brewer Dobson circulation (in particular during the first half of the year). The importance of the quasi-biennial oscillation (QBO) of stratospheric winds over the equator should not be underestimated: easterly wind shear (between 50 and 20 hPa) in the tropics, if persisting from the end of the previous year into late spring, causes the Brewer-Dobson circulation to increase in strength.

As a result, more ozone than normal is transported northwards (e.g. in 2010, 1998, 1994). If there is a westerly wind shear, however, less ozone will be transported polewards (e.g. in 2008, 2002, 1997). The difference between the easterly and westerly phase of the QBO can reach up to 20 DU (see the years 2010 and 2008 in Fig. 13.1). In Europe, ozone columns also correlate highly with the North Atlantic oscillation (NAO) index, which roughly describes the distribution of high and low pressure areas over the North Atlantic. Positive index values are accompanied by low ozone levels above central Europe, and vice versa. In 2010, the values of the NAO index were as negative as in the 1960s. This coincided with frequent trough situations and low pressure activity over central Europe down to the Mediterranean and with high ozone columns. On the contrary, the local ozone minimum in western Russia probably resulted from the stationary, high-altitude anticyclone residing there in the summer (record summer with continuous heat-wave and forest fires).

What about the effects of chemistry? Ozone-depleting chlorine and bromine in the stratosphere have been decreasing for around 10 years now. Model computations show that from the chemical viewpoint no such large ozone increase can be expected from one year to the next. The chemical ozone increase induced by declining chlorine would only result in ozone columns that are about 4 DU higher than those of the mid-1990s, and almost equal to those of 2008 and 2010. Even though we do not yet know, or fully understand, all the factors that are responsible for the high ozone columns in 2010, it is a pleasure to finally be able to report again about 'good ozone columns', such as those during the 1980s – although the levels decreased again in 2011. The beginning chemical recovery of the ozone layer certainly has its share in this increase, despite the fact that globally – but not in Europe – the year 2010 was one of the warmest in terms of surface temperature.

Ash cloud from Eyjafjallajökull volcano affects ozone over Bavaria, Germany

The volcanic eruption of Iceland's Eyjafjallajökull ('island mountain') glacier in April 2010 is not the first volcanic event in the last two years to become clearly visible in the measurements taken at DWD's Hohenpeissenberg Meteorological Observatory. Already in August 2008, and again from the beginning of July 2009, the lidar at Hohenpeissenberg had recorded plumes of ash from the volcanic eruptions of Kasatochi (Aleutian Islands) and Sarychev (Kuril Islands). Unlike Eyjafjallajökull, these two volcanoes ejected their ash clouds high into the lower stratosphere (up to approx. 20 km). From there, stratospheric winds rapidly dispersed the aerosol clouds across the northern hemisphere, carrying them as far as central Europe despite the large distance. In comparison with the much more violent eruption of Mount Pinatubo on the Philippines, however, their impact on climate and ozone layer is negligible.

However, with a maximum height of only 10 km, the ash plume from Eyjafjallajökull did not reach the stratosphere. But due to Iceland's geographic location, it did enter the mid-latitude west wind drift and was rapidly carried to central Europe. During the first days of this extraordinary event, there were no means to directly and quantitatively measure the concentration of dust in the air. Instead, indirect methods were used to determine at least height and extent of the cloud.

Ozone being a highly reactive gas (which oxidises and decomposes very readily on almost all surfaces), it should be possible to detect volcanic ash by the effect it would have on the vertical distribution of ozone. This is why, extra ozone sondes were launched in addition to the DWD's regular ozone measurement programme. One of these supplementary sondes launched on 17 April 2010 must have flown through the ash cloud between about 3,000 m and 6,500 m. In fact, the ozone concentrations recorded showed a dramatic decrease, down to nearly 0 ppmV, before rapidly increasing again.

Conclusion: tropospheric ozone concentrations over Hohenpeissenberg were severely reduced due to increased surface reactions within the volcanic ash cloud. This means that it is possible to make qualitative statements about the presence of volcanic ash clouds and their dispersion. Other measurements have shown, however, that the impact of sulphur dioxide or other air pollutants on the ozone measurements should be small (see DWD Ozone Bulletin No. 126 (2010) for more details: www.dwd.de/ozonbulletin).

List of Sources

This bulletin is an extended version of the publication

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The following other sources have been used:

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- WMO statement on the status of the global climate in 2010. WMO-No. 1074.
- NOAA NESDIS/NCDC (USA) Climate reports 2010:
<http://www.ncdc.noaa.gov/climate-monitoring/index.php>
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- Klimastatusbericht (Climate Status Report 2010) (DWD).
- Die Witterung in Übersee. DWD, Global Climate Review Vol. 58 (2010).
- WitterungsReport Express. DWD, Vol. 12 (2010).
- Various other sources for figures as indicated in the captions.
- Special sea ice information sources as indicated in the text.
- Guest contributions from the European Climate Support Network of EUMETNET and the DWD's Hohenpeissenberg Meteorological Observatory (Germany).

