Climate of Europe

Assessment of observed daily temperature and precipitation extremes

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European Climate Assessment (ECA), 2002

The authors represent an ad hoc working group of 36 institutions in 34 countries. The European Climate Support Network of EUMETNET, representing 19 of these 36 institutions initiated ECA.

Contents

Preface

Current interest in extreme weather events is motivated by the vulnerability of our society to the impacts of such events. The supposed increase in the occurence of extremes and the concern about anthropogenic climate change focuses attention on trends in extremes accompanying 'global warming'. IPCC (2001) concludes that 'most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations'. Yet, knowledge of changes in the occurrence of extremes is still limited.

In 1998 the European Climate Support Network (ECSN) initiated the European Climate Assessment (ECA) project. The key questions addressed were *'how did the past warming affect the occurrence of temperature extremes'* and *'was the past warming accompanied by a detectable change in precipitation extremes'*. These questions could be investigated Europe-wide because of the participation of almost all the climatological departments of European meteorological services and several research centres. Together they assembled a unique collection of long time series of daily station observations necessary for analysis of extremes.

I am convinced that you will enjoy reading this report that gives an overview of the ECA project. It is a worthy sequel to the 1995 assessment report 'Climate of Europe; recent variations, present state and future prospects' by Schuurmans et al. (1995). I congratulate the participants with their work. Without external financial support, a fruitful co-operation was established between 34 countries in Europe and the Middle East. In the past few years, numerous activities were undertaken to promote ECA and ensure its involvement in ongoing activities in this area. Preliminary results have already been included in the Third Assessment Report of IPCC Working Group I (IPCC, 2001). I wish to express my gratitude to all the institutions for their support and release of data. This provided the basis for ECA to become a successful ECSN project. I am grateful to the Royal Netherlands Meteorological Institute (KNMI) for co-ordinating this activity.

Volker Vent-Schmidt
Chair of the ECSN Advisory Committee
German Weather Service (DWD)

The project

Chapter 1

Background

Climate extremes are of great practical importance for living conditions and almost all human activities. Nature and man have adapted to the conditions of local climate variations so closely that large deviations may cause considerable damage. Global warming may have affected the occurrence of extreme weather events, like flood-producing rains, droughts, severe hot/cold spells and gales. So far, studies on extreme events in Europe usually had a strong national or regional signature. Other studies have used datasets with low spatial coverage, due to restrictive data policies concerning meteorological data. Clearly, co-operative projects are required to make progress in this area.

Objective

The European Climate Assessment (ECA) project started in 1998 as an initiative of the European Climate Support Network, ECSN (Box A), but soon grew into a joint activity of 36 participants *(Table 1.1)* from 34 countries *(Figure 1.1)*. The objective of ECA is to analyse the temperature and precipitation climate of region VI (Europe and Middle East) of the World Meteorological Organisation (WMO), focussing especially on trends in twentieth century observational series of extremes at meteorological stations.

Box A *European Climate Support Network*

The ECA project is an initiative of the European Climate Support Network (ECSN), which started in 1992 as a joint venture of 19 climatological departments of European National Meteorological Services (NMS's). In 1998, ECSN was turned into an Optional Programme under the umbrella of the EUropean METeorological NETwork (EUMETNET).

The main objective of ECSN is to organise improved co-operation in the field of climate and related activities in order to bring to all users of climatological services in Europe the best available quality of service through the most efficient management of their collective resources. ECSN collaborates with European NMS's, WMO and the research and users communities.

The scope of co-operative activities extends to areas such as:

- exchange of information
- data projects
- collaboration in climate research
- applications of climatology

EUMETNET is a network of 18 European NMS's. Established in 1995, EUMETNET provides a framework to organise co-operative programmes in the various fields of basic meteorological activities such as observing systems, data processing, basic forecasting products, R&D and training. The EUMETNET Council of Directors of member-NMS's approves all projects in EUMETNET programmes, including the ECA project in the ECSN Programme.

Approach

Data scarcity of extreme events makes trend analysis a delicate subject. For the same reason, little can be inferred from the occurrence of the most extreme events during recent years, even if they appear to be more exceptional than ever before. Statistical analysis of trends in very rare extreme events obtained from short observational records is particularly difficult. An alternative is to study trends in observed extremes focussing on events that occur frequently enough to obtain meaningful results. This approach was followed in the present study. But even then, extreme events can be identified in a number of different ways. In ECA, internationally-agreed predefined indices (Box B) are used to describe extremes of temperature and precipitation. The indices require a daily resolution of the time series to account for the sub-monthly time scale nature of extreme weather events.

Data collection, processing and analysis

Although Europe has a long history of routine meteorological observations, the compilation of a reliable dataset with daily resolution requires a large effort. The main reasons are that the archiving, maintaining and dissemination of daily climatological time series are the individual responsibility of European countries, each with its own storage system and data policy. Moreover, a routine exchange of quality controlled daily series of observations at meteorological stations does not exist.

Observational series of representative meteorological stations in Europe were collected in ECA to form one comprehensive daily dataset. To assure a uniform analysis method and data handling, the data were centrally processed and analysed for trends at KNMI. A lively and fruitful correspondence existed between the participants primarily by e-mail. To communicate the project approach and the results of trend analysis a website was established for the project (Box C).

Trends reported here refer to linear trends for the second half of the twentieth century. Extrapolating these trends into the future is only possible if the mechanisms behind observed changes continue to affect European climate in a similar way as in the past. Investigating these mechanisms was beyond the scope of the present assessment, as is Europe's future climate. Climate models provide the only means by which future climate can be predicted, although confidence in the ability of these models to predict changes on the regional scale of Europe is still low, in particular with respect to changes in extremes.

Box B *Indices of climate extremes*

Almost from the start of ECA in 1998, there was an active collaboration with the joint working group on climate change detection of CCL (Commission for Climatology of WMO) and CLIVAR (Research programme on CLImate VARiability and predictability).

The CCL/CLIVAR working group identified a set of climate change indices that could be derived from daily surface data and that would provide insights into changes in climate extremes (Peterson et al., 2001). On behalf of the working group, the ECA website maintains a comprehensive list of indices. A subset was selected for analysing the European climate within ECA. The international agreement on specific formulas for calculating the different indices has facilitated international collaboration. ECA's contribution for Europe has led to a joint publication about changes in climate extremes in about half the global land areas (Frich et al., 2002). Some of these results have been incorporated in the Third Assessment Report of IPCC Working Group I (IPCC, 2001).

The CCL/CLIVAR working group also initiated workshops in two regions of the world for which climate change indices were not yet analysed. ECA participated in the Jamaica workshop dedicated to the Central American region.

Box C *Website: www.knmi.nl/samenw/eca*

To facilitate easy communication between participants, a project website has been established for ECA at the start of the project. The website provides contact details, information on the project goals and background documentation. Besides, a description is given of the formulas that are used to calculate the extreme indices.

The website also gives access to project results in the form of plots of indicator time series and trend maps.

During the course of the project, new versions of these plots and maps were added as soon as data processing of new series was finished. This allowed for immediate discussion on the results obtained for each country, which has been of great value to avoid mistakes and to get meaningful interpretations of results. The website has recently been extended with online access to a selection of the daily series of temperature and precipitation in the daily dataset compiled for ECA.

Figure 1.1 | *Participating countries in the ECA project.*

Table 1.1 | *Participants*

Country	Participant	Affiliation
Austria	Reinhard Böhm	Central Institute for Meteorology and Geodynamics
Belgium	Gaston Demaree	Royal Meteorological Institute of Belgium
Bulgaria	Anelia Gocheva	National Institute of Meteorology and Hydrology
Croatia	Marina Mileta	Meteorological and Hydrological Service
Cyprus	Stelios Pashiardis	Meteorological Service of Cyprus
Czech Republic	Libor Hejkrlik	Czech Hydrometeorological Institute
Denmark	Claus Kern-Hansen	Danish Meteorological Institute
Finland	Raino Heino	Finnish Meteorological Institute
France	Pierre Bessemoulin	Meteo-France
Germany	Gerhard Müller-Westmeier	Deutscher Wetterdienst
Greece	Magdalini Tzanakou	Hellenic National Meteorological Service
Hungary	Sandor Szalai	Hungarian Meteorological Service
Iceland	Tóranna Pálsdóttir	Icelandic Meteorological Office
Ireland	David Fitzgerald	Met. Eiraan
Israel	Sara Rubin	Israel Meteorological Service
Italy	Massimo Capaldo	Ufficio Generale della Meteorologia
Italy	Maurizio Maugeri	Istituto di Fisica Generale Applicata, Universita degli Studi di Milano
Latvia	Andris Leitass	Latvian Hydrometeorological Agency
Lithuania	Arunas Bukantis	Division of Climatology of the Institute of Geography
Luxembourg	Romain Aberfeld	Service Meteorologique du Luxembourg
Netherlands	Aryan van Engelen	Royal Netherlands Meteorological Institute
Norway	Eirik Forland	Norwegian Meteorological Institute
Poland	Miroslaw Mietus	Institute of Meteorology and Water Management
Portugal	Fatima Coelho	Instituto de Meteorologia
Romania	Constantin Mares	National Institute of Meteorology and Hydrology
Russia	Vyacheslav Razuvaev	Russian Federal Service for Hydrometeorology and Environmental Monitoring
Slovakia	Elena Nieplova	Slovak Hydrometeorological Institute
Slovenia	Tanja Cegnar	Climatological Department, Environmental Agency of the Republic of Slovenia
Spain	José Antonio López	Instituto Nacional de Meteorologia
Sweden	Bengt Dahlström	Swedish Meteorological and Hydrological Institute
Sweden	Anders Moberg	Dept. of Physical Geography and Quarternary Geology, Stockholm University
Switzerland	Walter Kirchhofer	MeteoSwiss
Turkey	Abdullah Ceylan	Devlet Meteoroloji Genel Mudurluou
Ukraine	Olga Pachaliuk	Central Geophysical Observatory, Committee of the hydrometeorology
United Kingdom	Lisa Alexander	Met Office
Yugoslavia	Pedrag Petrovic	Republic Hydrometeorological Institute of Serbia

The daily dataset

Chapter 2

Time series of temperature and precipitation

The dataset of climatological time series compiled for ECA contains daily temperature and precipitation series from over 200 meteorological stations in Europe and the Middle East (*Figure 2.1*). The dataset comprises 199 temperature series and 195 precipitation series (*Figure 2.2*). In most cases daily minimum, maximum and mean temperature are available, whereas precipitation refers to daily precipitation amount. Data coverage of Europe changes over time with an optimum in the standard normal period, 1961-1990 (*Figure 2.3*). The strong decline in data availability in recent years is due to the delay in archiving and quality-controlling meteorological data by participants and the time needed for collection in ECA.

A detailed list of station series, including the start and end dates of each series, station positions, station elevation etc. can be found in the Appendix. The series are maintained by the 36 participating institutions and about 85% is made available on the ECA website. These data can be used freely provided that the source is acknowledged.

Box D

Access to the daily data

Following the growing scientific interest in high resolution climatological time series and realising that an extensive dataset of long daily time series was built within ECA, EUMETNET urged ECSN to provide access to this dataset. This resulted in the European Climate Dataset (ECD) project, which started in 2001 being led by KNMI and the Norwegian Meteorological Institute (DNMI). The objective of ECD is to obtain approval for free and unrestricted access to ECA data, store the data in a relational database, extend the data to other climatic elements and build a web-interface for interactive access.

In this way, participating countries would collectively serve the needs of users and fulfil WMO requests with respect to the release of daily series for climate monitoring and research. The daily data series from EUMETNET countries are part of the initial release. In a second stage non-EUMETNET participants within WMO region VI (Europe and Middle East) are invited to participate in the ECD project on a voluntary basis. Good data coverage of Europe, like in the ECA project, significantly enhances the value of the published dataset.

A new application to query the data is established at the ECD website: http://www.knmi.nl/samenw/ecd. Meanwhile, 85% of the daily time series (1901-1999) can be downloaded from the ECA website.

Data quality and application

In order to judge the quality of ECA data, temperatures were compared with grid box values in the Jones dataset of land air temperatures (Jones et al., 2001) and precipitation amounts were compared with grid box values in the Hulme land precipitation dataset (Hulme et al., 1998). Both gridded datasets have monthly resolution. Although they are also based on station series, the comparison is sound because data overlap is relatively small: about 55% of the ECA stations make up only about 15% of the European stations in the gridded sets. The comparisons showed that there is general agreement between the overall magnitude of trends in the ECA dataset and those in the gridded datasets.

Apart from specific ECA goals, the daily resolution dataset has potential for a wide range of climate studies, including monitoring the current state of the climate system, reviewing events with socio-economic impacts, validation of climate models and detection of climate change. The dataset is a valuable match to similar datasets that have been developed for Australia, Canada, the former Soviet Union and the United States. The WMO Commission for Climatology explicitly welcomed the ECA daily dataset, as an important achievement of regional baseline datasets for climate research purposes (WMO, 2001). In this respect, the Commission re-affirmed the necessity to exchange data in the wider interest of community welfare and safety, both now and in the future (Box D). It also stressed the importance of co-operative links among scientific research, operational meteorology and user communities to ensure the necessary steps are taken to make adequate climate data more widely available.

Figure 2.1 | *Example of daily time series for Feodosia (Ukraine).*

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EUROPEAN CLIMATE ASSESSMENT / EUROPEAN (EUMETNET/ECSN) CLIMATE DATASET, MARCH 2002
THESE DATA CAN BE USED FREELY PROVIDED THAT THE FOLLOWING SOURCE IS ACKNOWLEDGED:

Klein Tank, A.M.G. and Coauthors, 2001. Daily dataset of 20th-century surface
air temperature and precipitation series for European Climate Assessment (ECA).
Accepted by Int. J. of Climatol., KNMI Preprints 2001-27.
Data and metadata available at http://www.knmi.nl/samenw/eca
or http://www.knmi.nl/samenw/ecd

FILE FORMAT (MISSING VALUE CODE IS -9999):

 1-10 ID   : station series id (see web-site for metadata info about station series)
12-19 DATE : date in yyyymmdd (year,month,day)
21-25 TN   : daily minimum temperature in 0.1 degrees Celsius
27-31 TG   : daily mean temperature in 0.1 degrees Celsius
33-36 TX   : daily maximum temperature in 0.1 degrees Celsius
38-42 R    : daily precipitation amount in 0.1 mm

         ID,    DATE,   TN,   TG,   TX,    R

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       177,19010119, -110,  -98,  -61,    0
       177,19010120, -120,  -78,  -57,    0
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       177,19010125,   -5,   28,   66,    0
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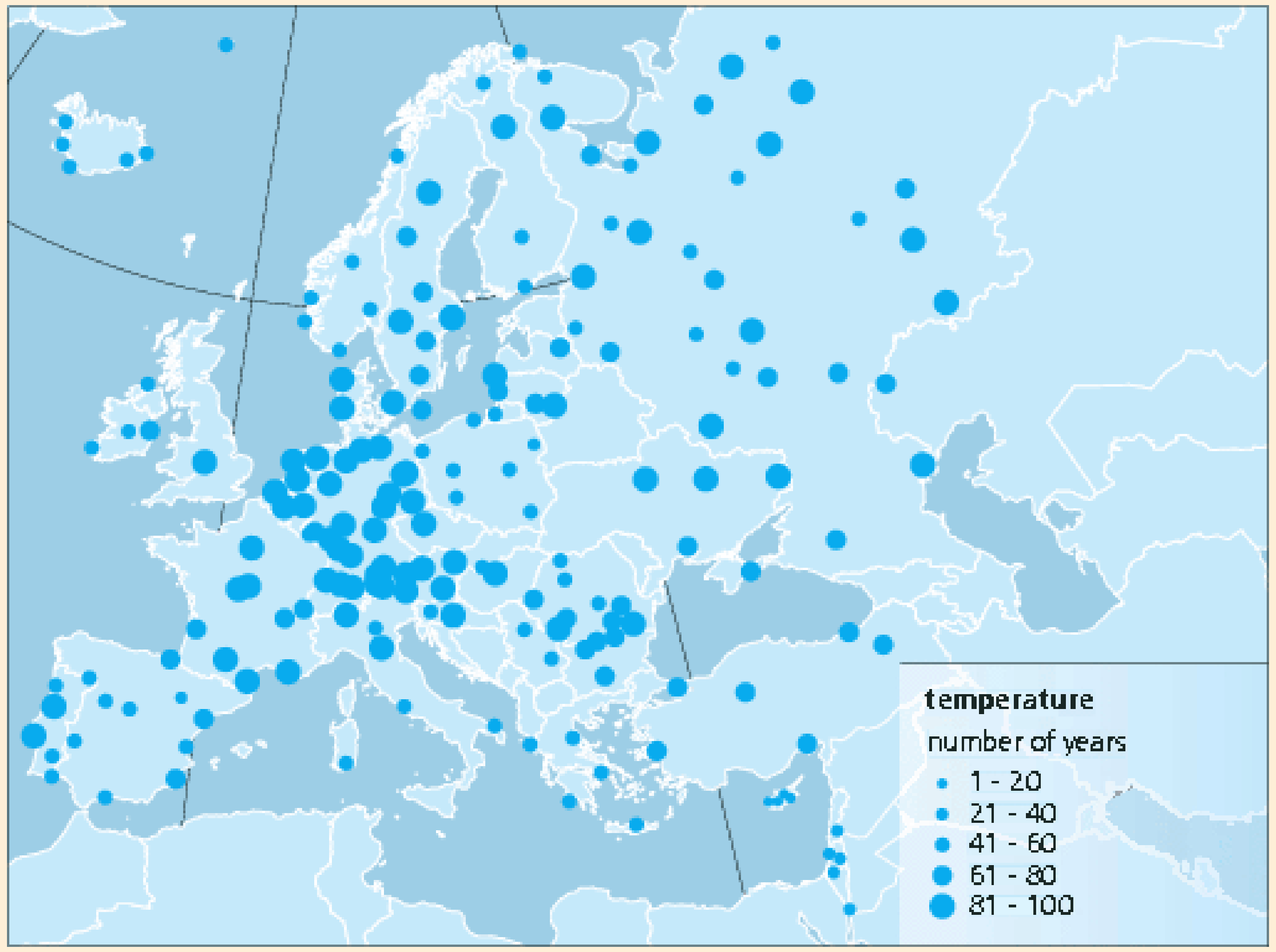


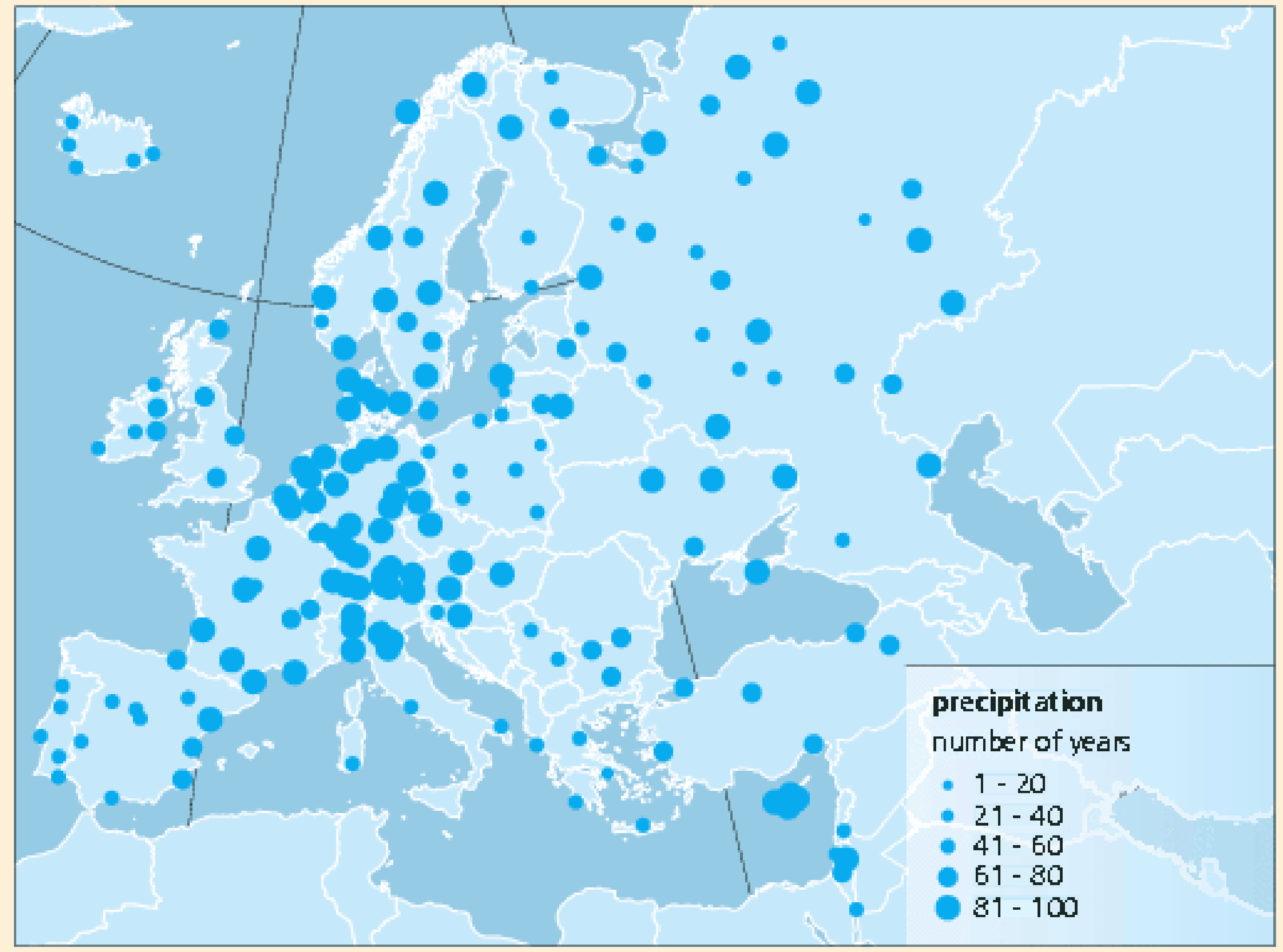
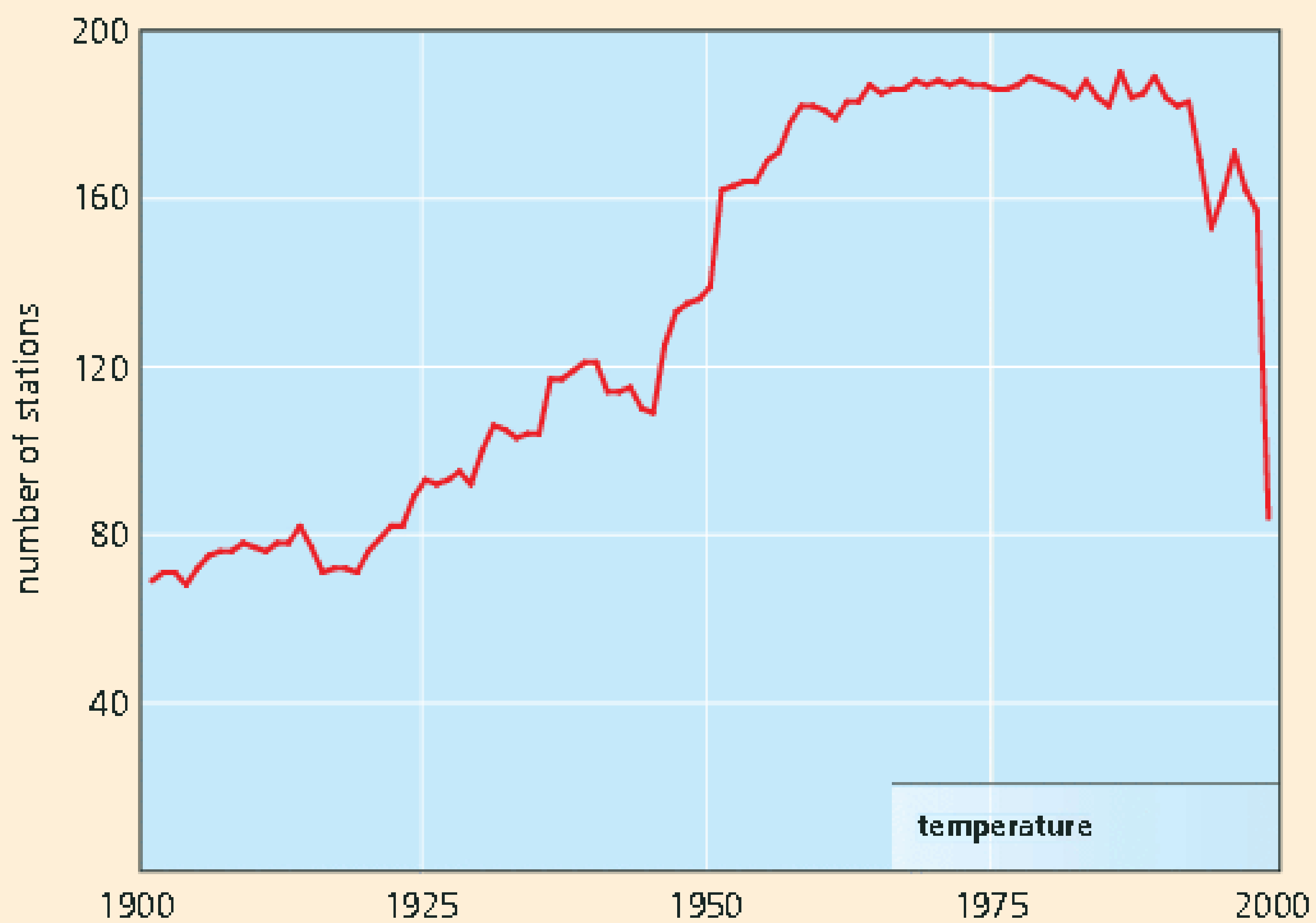


Figure 2.2 | *Stations with daily temperature and daily precipitation series in the ECA dataset. Station dots are scaled with respect to the length of the time series. For more details see the appendix.*



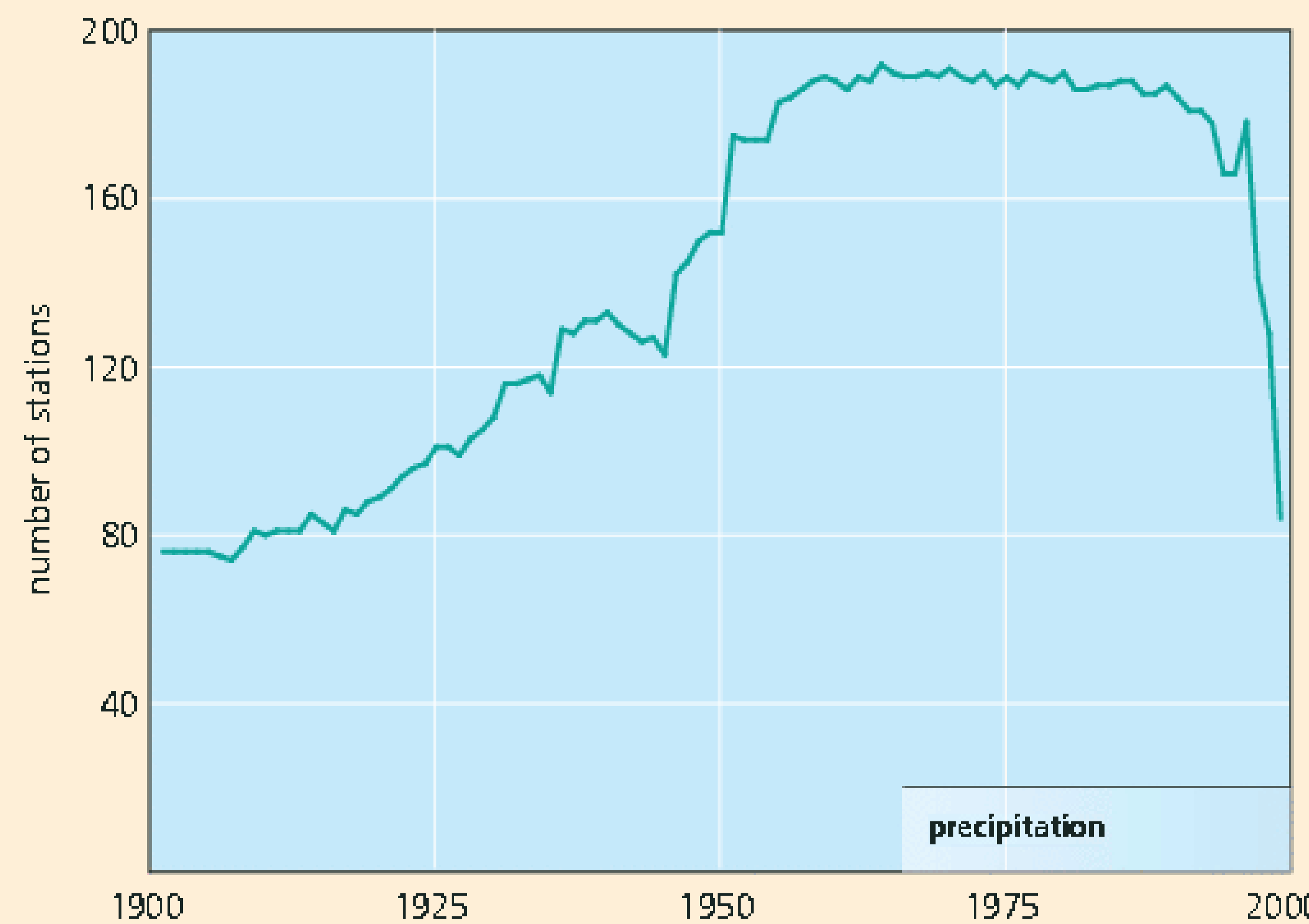


Figure 2.3 | *Number of stations with daily temperature and daily precipitation series in the ECA dataset.*

Time series homogeneity

Chapter 3

Breaks in time series

In order to use long time series for climate analysis, it is important to have reliable data without artificial breaks since inhomogeneities spoil signals of climate trends. Unfortunately, station data are particularly susceptible to inhomogeneities because several changes occur over time. Stations move to other locations or new observers or automated observing practices replace previous manual observations. Changes in the environment influence the representativiness of observations. Also, instruments and their exposure change.

The temperature and precipitation series of the ECA dataset may be affected by inhomogeneities. To illustrate the magnitude of inhomogeneities an example of the diurnal temperature range (DTR; defined as maximum temperature – minimum temperature) is given in ***Figure 3.1*** for a long station record in the Netherlands (station Eelde). Three typical observational changes contaminate the series at this station during the last century: the introduction of a ventilated observation hut in 1948, a relocation from the city to the nearby airport in 1951, and a change in sensor height from 2.2 m to 1.5 m in 1959.

Statistical homogeneity testing

Statistical homogeneity tests may be applied to detect breaks in the time series in cases where the documentation about potential homogeneity breaks is lacking or ambiguous. To assess the homogeneity of the whole ECA dataset all station series were subject to 4 common homogeneity tests (Standard Normal Homogeneity, Von Neumann Ratio, Buishand Range and Pettitt Test). The tests were applied on derived variables that are typically related with the daily resolution of the data. For temperature, the annual DTR was selected and for precipitation the number of wet days in a year.

When the Eelde DTR series ***(Figure 3.1)*** is tested, a break around 1951 is most obvious. This break is supported by the documented changes (see above). When all ECA series are subjected to the statistical tests for the periods 1901-1999 and 1946-1999, the results in ***Figure 3.2*** and ***Figure 3.3*** are obtained. The stations with smaller dots have a larger number of tests indicating a break. Three of the 4 tests are capable of locating the most probable year for the breaks, but clearly, they cannot reveal the causes.

To identify the nature of detected breaks one has to rely on supporting historical evidence about observational changes. This information is often referred to as metadata.

Metadata

Collection and interpretation of station history metadata for all European countries is difficult and time consuming. Available metadata is usually written in the native language and most of the metadata is only available on paper and not in electronic format. Because of the coding that is used, interpretation is not always straightforward. In the ECA project, as much information as possible was gathered for the periods around the year of detected statistical breaks. So far, about 65% of the statistical detected breaks could be related to station relocations, changing measuring techniques and observing practices. In most cases the changes causing breaks are station relocations, e.g. from the city centre to the out-of-the-city airport.

Box E *Homogeneity workshops*

As climatological time series are more frequently used in climate change studies, there is growing concern about the homogeneity of these series. Since 1996 the Hungarian Meteorological Service has organised three seminars on the homogenisation of surface climatological data and a fourth seminar is planned in Budapest, Hungary for 2003. In these seminars the various methods that are in use to check and adjust time series for homogeneity are brought together and compared. Also the applicability of each method to different kinds of homogeneity problems is discussed and software packages are made available.

Inhomogeneities may affect the results of climate studies, because they are often of the same size as the climatic effect studied. A recommendation from the seminars is to test the homogeneity and to homogenise climatological series before using them for climate analysis. In practice, however, this is often not feasible. Many problems with respect to homogeneity are not yet solved. One of the challenges is to find a good method to detect breaks in daily resolution series and adjust them. Adequate metadata are of vital importance in such a homogenisation process. Metadata should therefore be documented carefully and be easily accessible. Given the large number of homogenisation techniques, it is also important to accompany homogenised data with the original data and to document the homogenisation procedures.

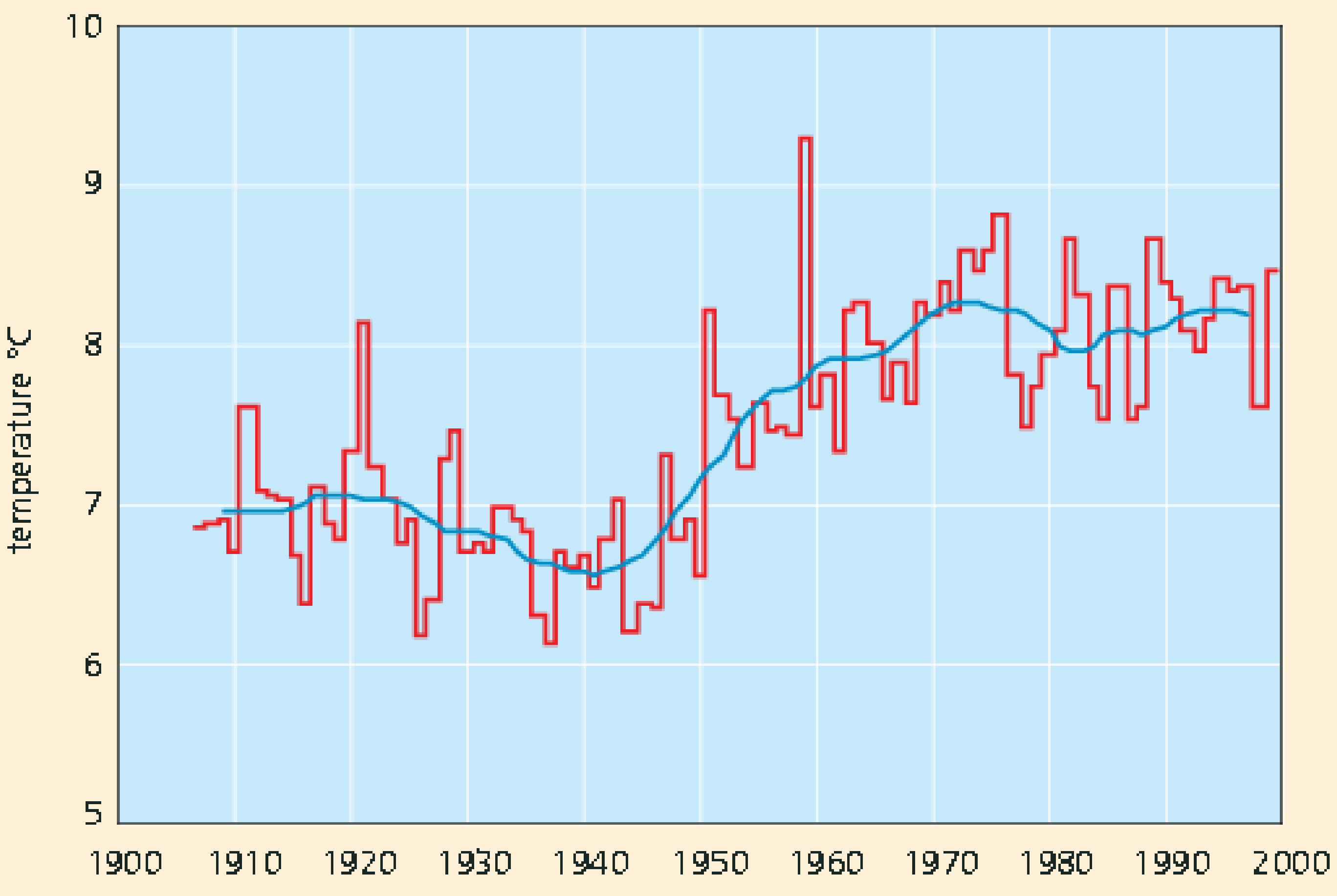
Station selection

The combination of the test results and metadata were used to select a subset of station series for trend analysis. The outcome was that, given the data scarcity before 1945 and the selection procedure, only in the period 1946-1999 station density was adequate for trend analysis of temperature and precipitation over Europe. From the 199 temperature series in the dataset, 86 series were retained. For precipitation, these numbers were 195 and 145, respectively.

The fact that a larger percentage of precipitation series is retained than temperature series does not imply that the quality of precipitation series is generally higher than the quality of temperature series. The testing variables for precipitation have large year to year variability, which reduces the probability of detecting breaks in precipitation series using the statistical tests.

A particular problem concerning the homogeneity of temperature series is associated with the effects of urban heat islands. Stations located in urban areas can show a slow increase of temperature connected with ongoing urbanisation. As the majority of stations are outside large cities and the selection procedure filters out series with large breaks, we estimate that our conclusions from the trend analysis results are robust for inhomogeneities.

Figure 3.1 | Annual mean of the diurnal temperature range (red line) at station Eelde, the Netherlands. The smoothed curve represents variations at the decadal time scale.



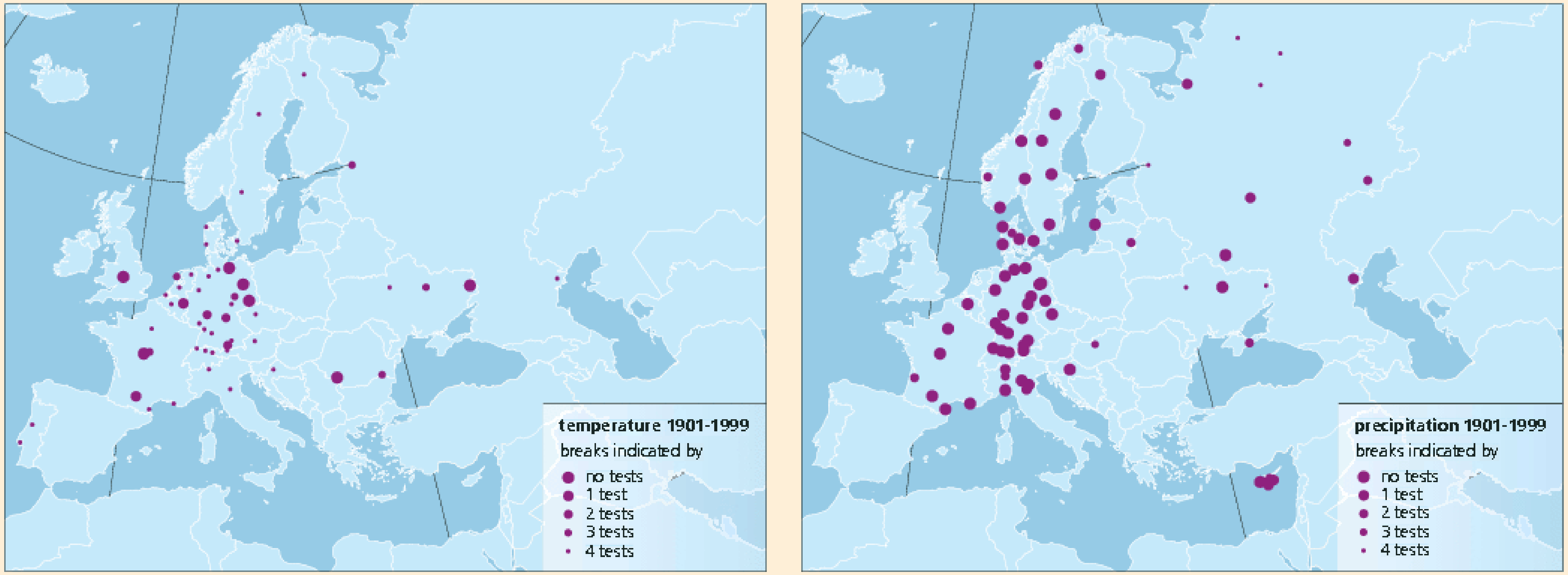


Figure 3.2 | *Number of homogeneity tests indicating a break in the series of temperature and precipitation for the period 1901-1999.*

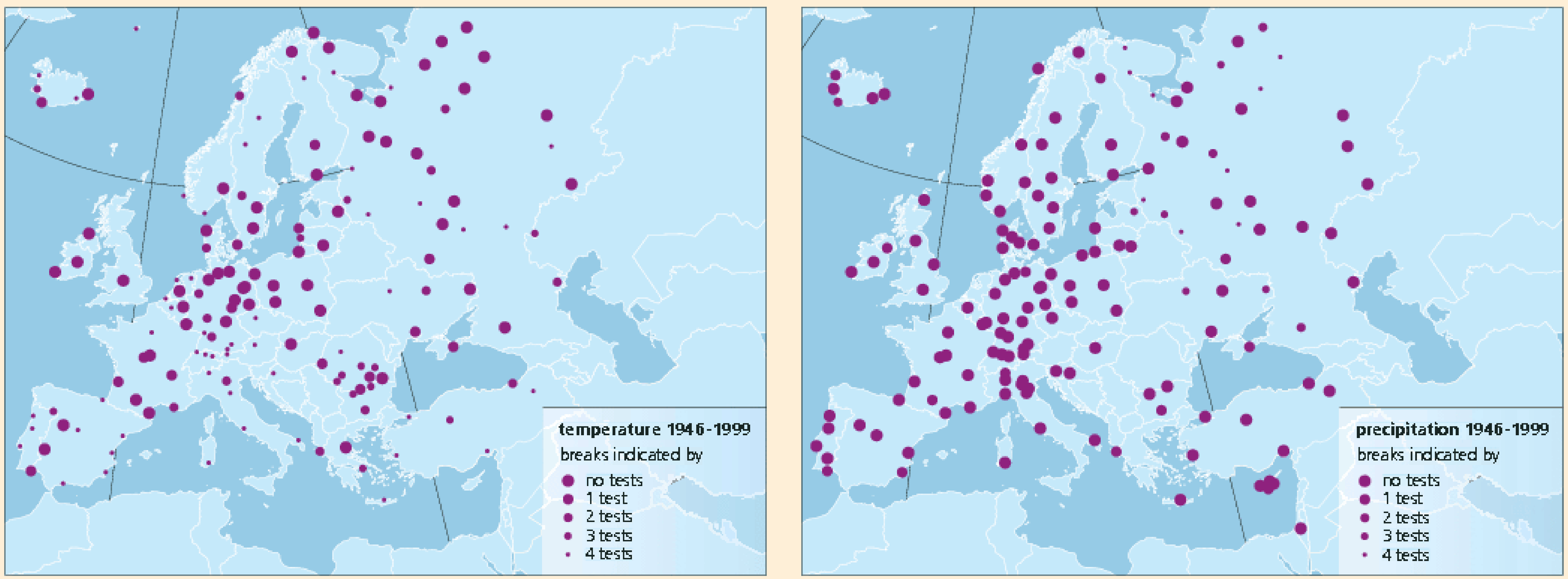


Figure 3.3 | *As Figure 3.2, but for the period 1946-1999.*

Trends in temperature and precipitation extremes

Chapter 4

Indices for analysing extremes

For the period 1946-1999, an analysis was made of trends in extreme temperature and precipitation indices in Europe. Consistent with the mean warming in this period, temperature generally shows decreases in cold extremes and increases in warm extremes at most stations. However, the trends in extremes are dependent on the indices used to express these extremes. The definitions of the selected indices for ECA follow standardisation of the CCL/CLIVAR working group on climate change detection. To allow trend analysis, the selected indices refer to events that occur on average once every month, rather than once a year or once-in-a-lifetime ***(Table 4.1)***.

In this chapter we present the results of trend analysis for extreme indices after describing the changes in mean temperature and precipitation at ECA stations over the second half of the 20th century.

Trends in mean temperature and precipitation

The annual mean temperature series for 15 selected stations in different climate zones of Europe are depicted in ***Figure 4.1***. Apart from year-to-year variations, each of the series exhibits distinct decadal variations. For an indication of the spatial coherence of the station series, ***Figure 4.2*** gives the correlation between the station Jena (Germany) and all other stations for the period 1946-1999. As expected, correlation is decreasing with distance and spatial coherence is high. A strong coherence is also seen for the trend pattern ***(Figure 4.3)***. Between 1946 and 1999, 31% of the stations show a warming trend significant at the 5% level (Students t-test). Only 4 stations (5%) show significant cooling trends.

As illustrated in ***Figure 4.1***, at many stations there is a clear increase in temperature at the end of the century and little change or slight cooling in the 50s, 60s and early 70s. On the basis of this characteristic, the analysis period 1946-1999 is divided into two sub-periods 1946-1975 and 1976-1999, similar to the periods identified in the global mean temperature record by Jones et al. (1999) and Karl et al. (2000). ***Figure 4.3*** presents trends of temperature at ECA stations for the period 1946-1999 and the sub-periods 1946-1975 and 1976-1999. In the 1946-1975 sub-period, a cooling trend is seen throughout southern and western Europe. The cooling is most dominant in the summer half of the year (not shown). In the 1976-1999 sub-period, temperature trends are positive all over Europe. Warming is seen both in summer and winter (not shown).

At many stations the 1946-1999 increase in mean temperature is accompanied by a stronger warming of the (night-time) minimum temperature compared with the (day-time) maximum temperature. This is reflected in the 1946-1999 trends in the diurnal temperature range (DTR) in ***Figure 4.4***. The DTR decreases at the majority of stations. This is consistent with the decrease in the diurnal temperature range since about 1950, reported for more than 60% of the global land area in Easterling et al. (1997). Decreases in diurnal temperature range are brought in connection with observed increases in cloud cover over land (Dai et al., 1999), dampening the diurnal cycle of the radiation balance at the surface (IPCC, 2001). Remarkably, there are not that many decreases at European stations in the 1976-1999 sub-period. Instead, the warming in this sub-period is often accompanied by a positive trend in the DTR (not shown).

In comparison with temperature, the spatial coherence of precipitation is generally lower due to its inherent higher variability. This is seen in the ECA dataset for the spatial correlation pattern of the annual precipitation amount between 1946 and 1999 ***(Figure 4.2)***. The spatial patterns of the trends in the annual precipitation amount and the number of wet days ***(Figure 4.5)*** are also less clear than for mean temperature. There is an indication of increasing precipitation in the northern part of Europe consistent with the increases in precipitation reported for mid- and high latitudes by IPCC (2001). For many stations the percentage change in the precipitation amount is different from the percentage change in the number of wet days. Thus, the trends in precipitation amount are not the consequence of changes in the number of wet days alone; average precipitation intensity has changed as well.

Trends in temperature extremes

Many of the indices of extremes selected from the agreed list (Box B), refer to counts of days crossing a threshold. For instance, the count of days with minimum temperature < 0°C is expressed in a frost day index and the count of days with maximum temperature > 25°C is expressed in a summer day index. ***Figure 4.6*** shows that the trends in the 1946-1999 period indicate significant warming at 45% of the stations for frost days and at 12% of the stations for summer days. Cooling is apparent at 6% of the stations for summer days and at no station for frost days.

Indices like frost days and summer days that are based on absolute thresholds often have physical, hydrological or biological significance. On the other hand, absolute thresholds, like 0°C in the definition of frost days, are less suitable for a spatial comparison of climate signals. Over an area as large as the European continent, year-to-year variability in frost day counts relates to the variability in the spring and autumn temperatures for the northern part of Europe, whereas in the southern part of Europe annual variability in frost day counts is determined by winter temperature variability only (Heino et al., 1999). Likewise, the threshold of 25°C in the definition of summer days samples variations in summer temperatures in the north and variations in spring and autumn temperatures in the south.

Temperature thresholds can also be defined for each station relative to the local climate. Thresholds can be set to a certain percentile of the temperature distribution. Indices of day counts based on such thresholds are better suited to compare climate signals between stations, countries and regions. In ***Figure 4.7***, the trends in the day-count indices based on the 10^{th} and 90^{th} percentiles of daily mean temperature are presented for the 1946-1999 period. These indices are referred to as cold days and warm days, respectively. They are expressed as anomalies relative to the mean annual cycle in the standard-normal period, 1961-1990. Both the trends in cold days and the trends in warm days indicate warming.

For climate change detection, it is interesting to analyse if this warming in the cold days and warm days is 'symmetric'. As illustrated in ***Figure 4.8***, symmetric warming means that the entire temperature distribution shifts towards higher temperatures. This implies that the decrease in cold days (shaded blue in the figure) matches the increase in warm days (shaded red in the figure). Averaged over Europe, the observed trends in cold days and warm days do indeed show symmetric warming between 1946 and 1999. Consistent with the difference between the blue shaded area and the red shaded area in ***Figure 4.8***, the average increase in warm days (2.0 days/decade) is larger than the average decrease in cold days (-1.4 days/decade). There is an indication for 'asymmetric' changes in cold days and warm days in the two sub-periods. In the 1946-1975 sub-period of average cooling, the warm days decrease, but the cold days do not increase. In the 1976-1999 sub-period of average warming, the warm days increase more than expected from the corresponding decrease in cold days. An asymmetry is also seen when spells of at least 5 consecutive cold or warm days are considered in this sub-period (not shown). The number of cold-spell days even increases, which would normally be associated with cooling rather than warming. Indications of asymmetric temperature change in sub-periods can be consistent with symmetric warming in the full period, since at different time scales different mechanisms can play a role.

Box F

Conferences and journal papers

During the course of the project, preliminary results have been presented at a number of conferences and workshops. At a special 1999 IPCC meeting in Asheville, US, the potentials of standardised indices of climate extremes were explored. In 2000, ECA was the subject of 3 lectures at the third European Conference on Applied Climatology held in Pisa, Italy (Klein Tank and Wijngaard, 2000). The same year, ECA's approach to homogeneity issues was discussed at the third Budapest workshop on homogeneity (Wijngaard and Klein Tank, 2000). In 2001, an ECA poster was presented at the Climate Conference 2001 held in Utrecht, the Netherlands. Later that year, the use of indices was illustrated during the European Environment Agency (EEA) expert meeting on climate change indicators in Copenhagen, Denmark. The WMO Commission for Climatology (CCL) devoted one of the scientific lectures to the ECA project in its thirteenth session in Geneva, Switzerland. This gave the opportunity to present ECA to representatives of 82 member countries of WMO and 7 international organisations.

The first scientific paper describing the ECA dataset (Klein Tank et al., 2002) has been accepted for publication in the International Journal of Climatology. A second paper on the homogeneity of ECA data and a third paper on trends in temperature and precipitation extremes in Europe are in preparation.

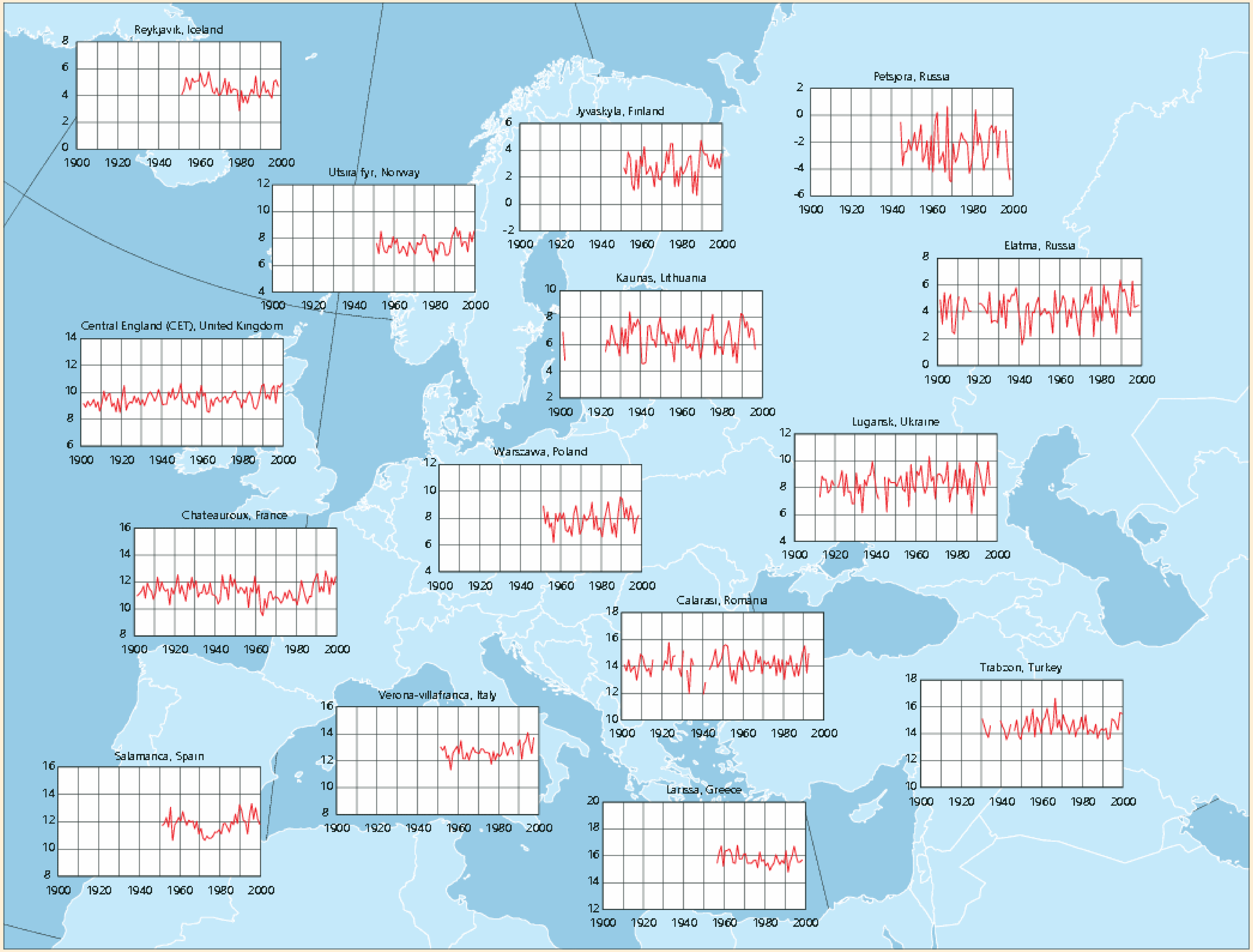
Trends in precipitation extremes

Averaged over Europe, many of the selected indices of wet extremes show significant increases in the 1946-1999 period, but positive and negative trends in extreme precipitation are found at neighbouring stations scattered all over Europe. This is illustrated in ***Figure 4.9*** by the trends in the annual number of days with precipitation ≥ 20 mm and the annual maximum 5-day precipitation amount. Clustering of trends with the same sign is limited to relative small areas. The usually large local differences in heavy rainfall events are a possible explanation for trend differences at nearby stations.

The majority of significant trends in extreme precipitation events are positive and seen at stations where total amounts increase (see also ***Figure 4.5***). The trends in the percentage of annual precipitation amount due to very wet days, which are defined relative to the local climate at a station, are shown in ***Figure 4.10***. These results are included in Frich et al. (2002) who investigated world-wide trends in extremes.

Our findings for extreme precipitation indices in Europe do support the IPCC (2001) statement that 'it is likely that there has been a statistically significant increase in the amount of heavy and extreme precipitation events when averaged across the mid and high latitudes', although this support is weak. Looking at the results of all precipitation indices considered (based on absolute thresholds as well as percentile thresholds), only about 20% of the stations have significant trends at the 5% level.

Figure 4.1 | Annual mean temperature at 15 stations in Europe.



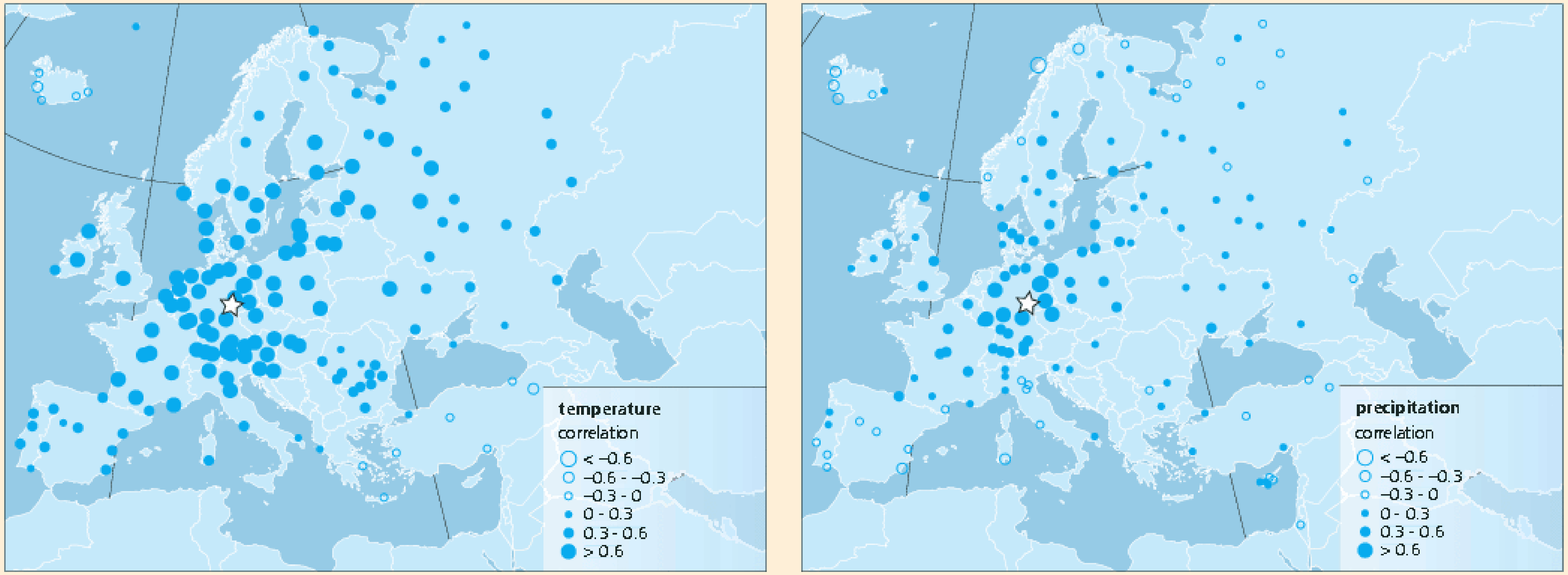


Figure 4.2 | *Correlation between Jena ☆ and other stations in the ECA dataset (1946-1999) for annual mean temperature and precipitation amount.*

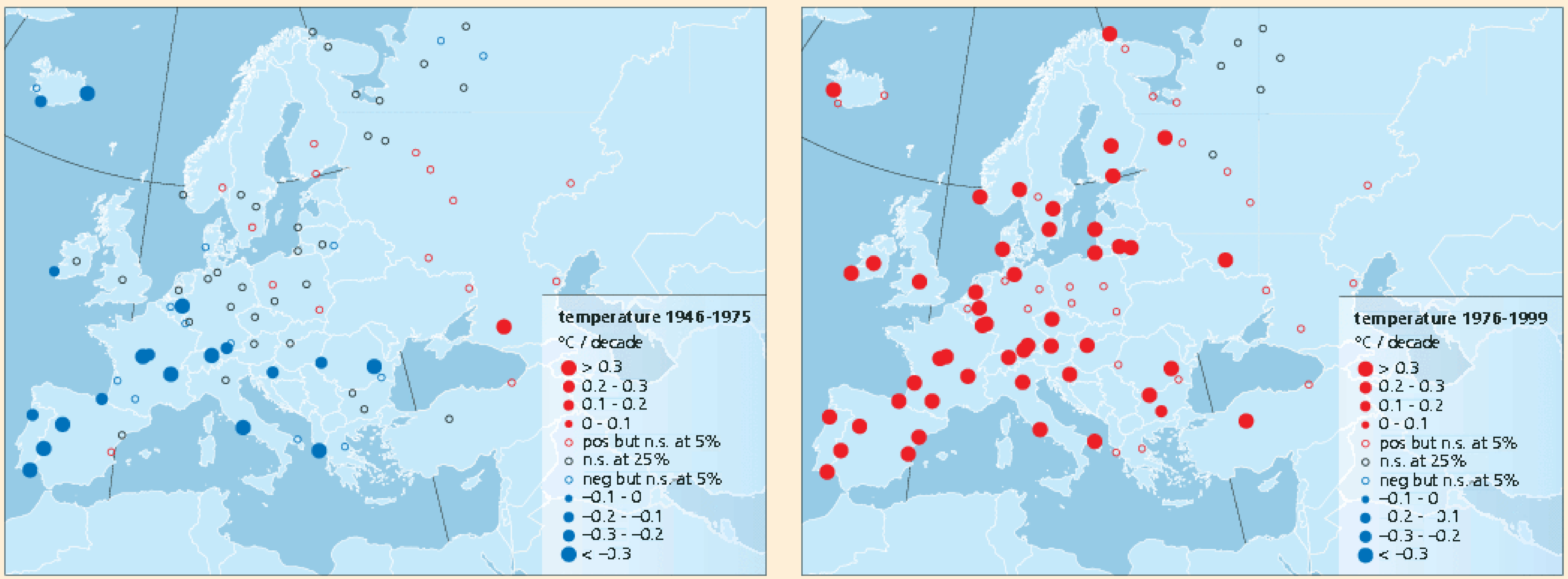
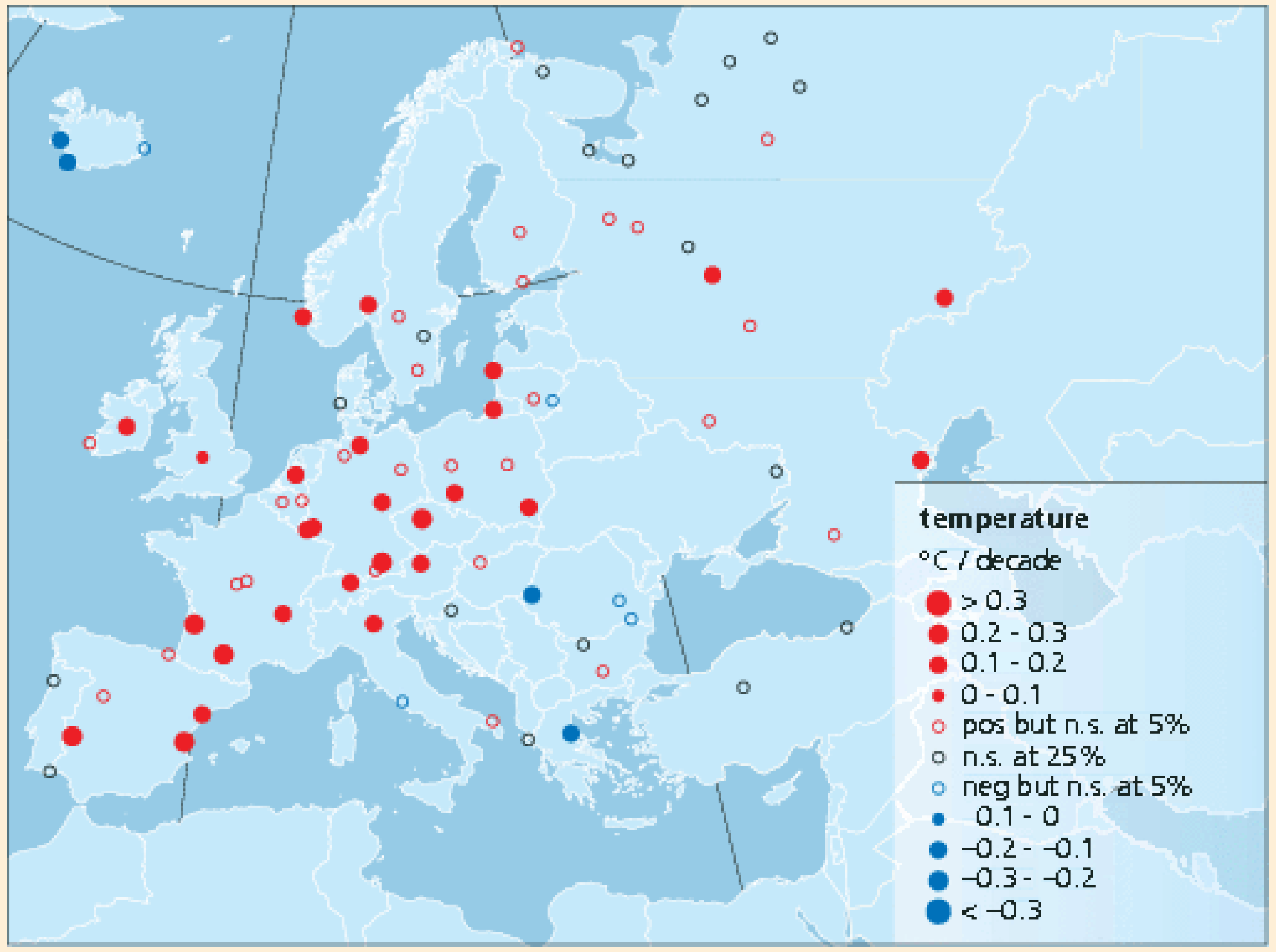


Figure 4.3 | *Trends in annual mean temperature in the 1946-1975, 1976-1999 and 1946-1999 period, see next page.*

Figure 4.3 | *(left) Trends in annual mean temperature in the 1946-1999 period.*

Figure 4.4 | *(right) Trends in diurnal temperature range (DTR; maximum – minimum temperature) in the 1946-1999 period.*



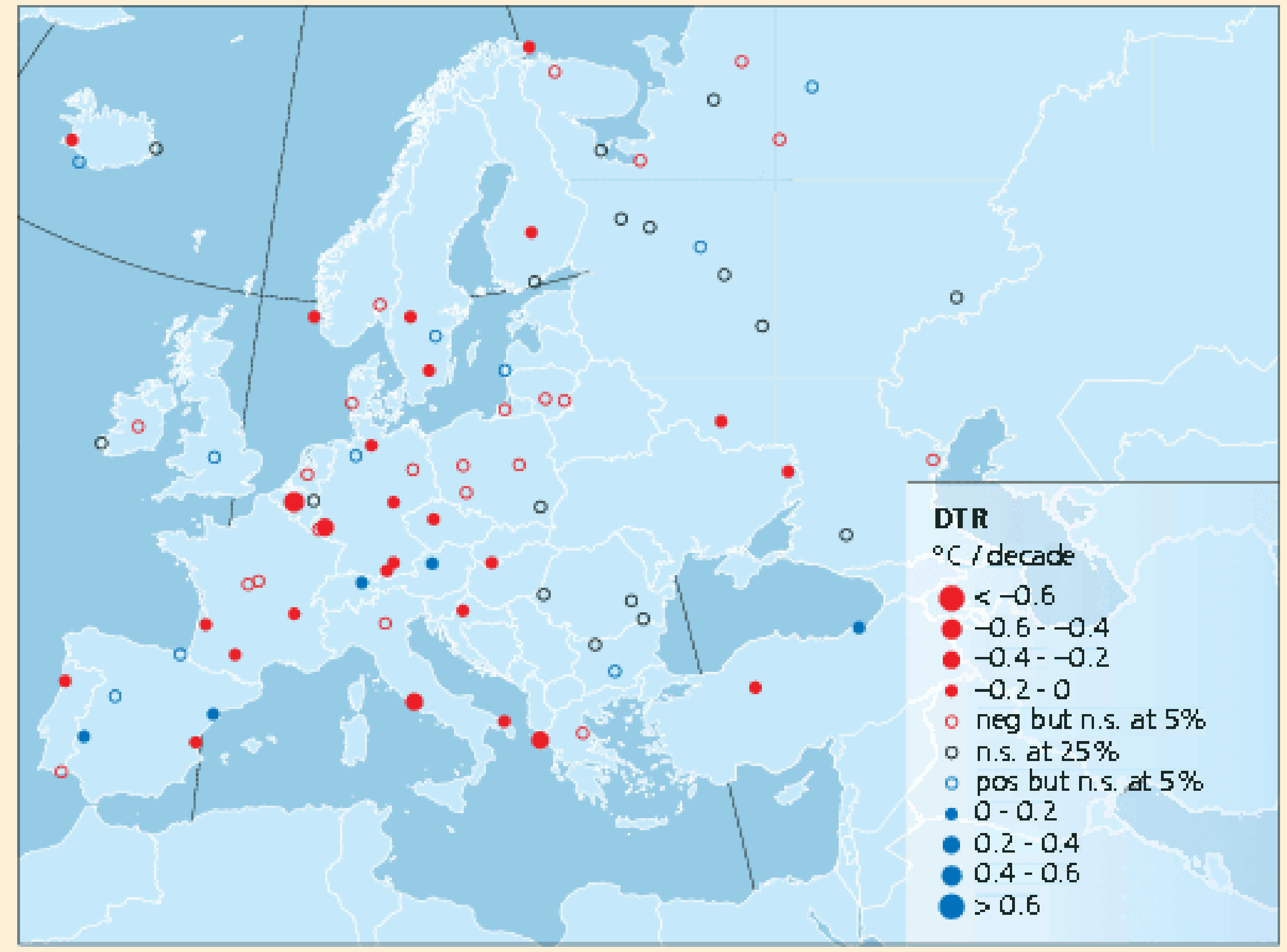
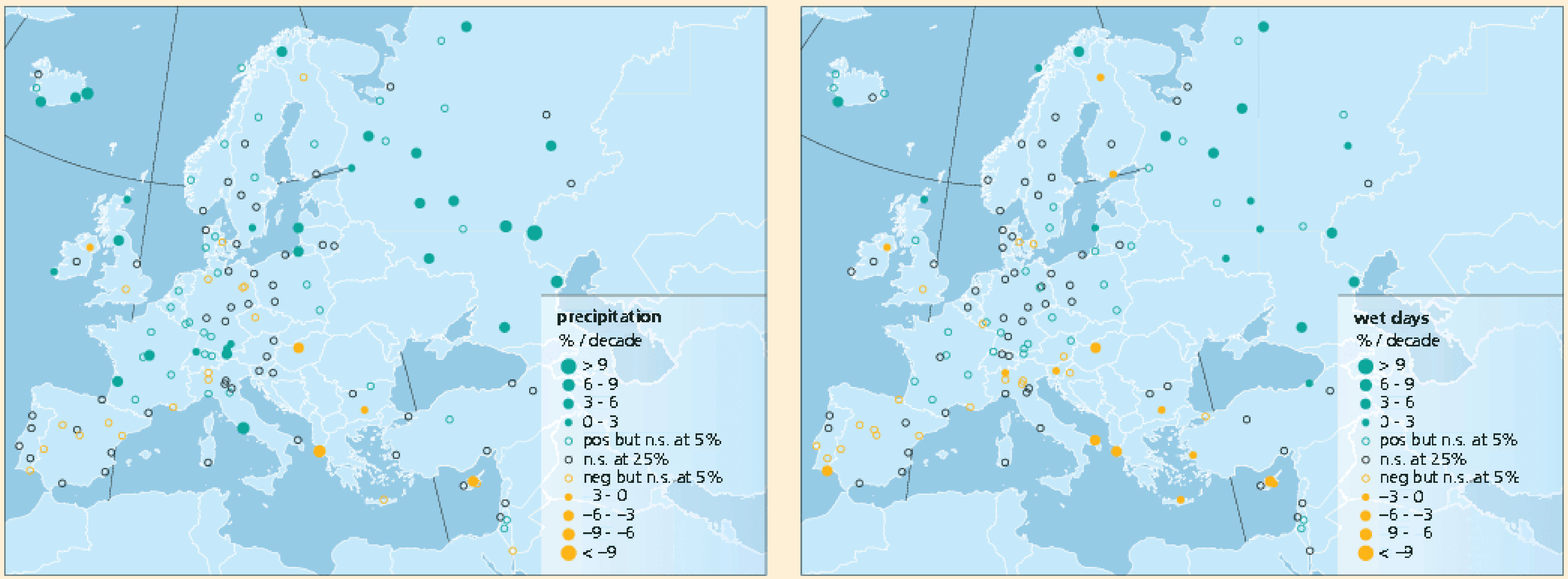


Figure 4.5 | *Trends in annual precipitation amount and number of wet days (≥ 1mm) in the 1946-1999 period.*



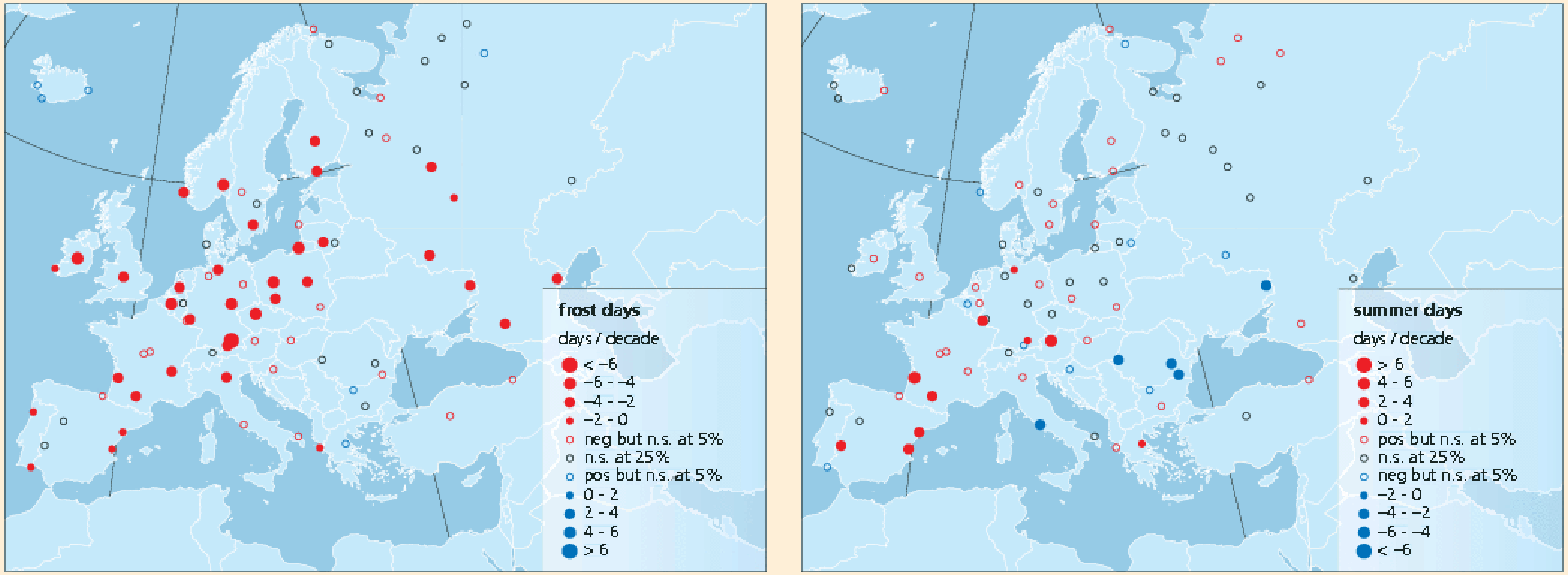


Figure 4.6 | *Trends in annual number of frost days (minimum temperature < 0°C) and summer days (maximum temperature > 25°C) in the 1946-1999 period.*

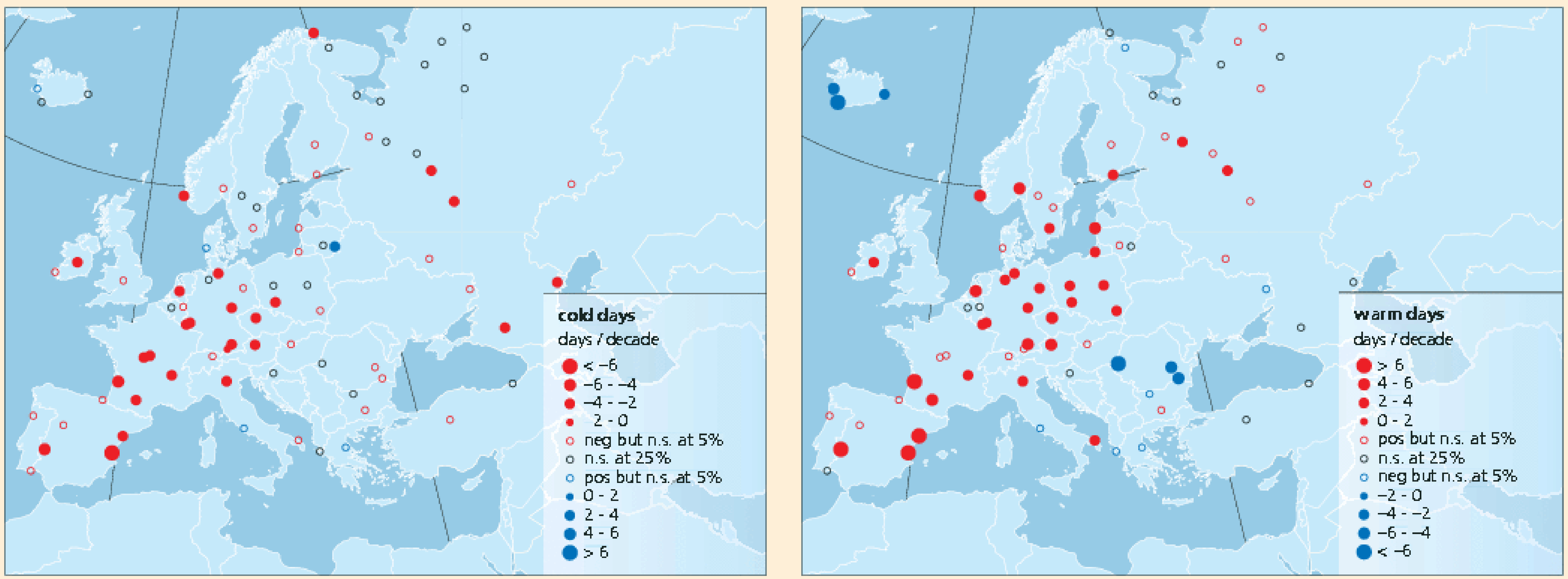


Figure 4.7 | *Trends in annual number of cold days and warm days in the 1946-1999 period. Cold days and warm days are defined as days with mean temperature crossing the seasonally varying 10th and 90th percentiles in the 1961-1990 baseline period.*

Figure 4.8 | *Schematic showing the effect on cold days and warm days for a 'symmetric' increase in the mean temperature (after IPCC, 2001; fig. 2.32a).*

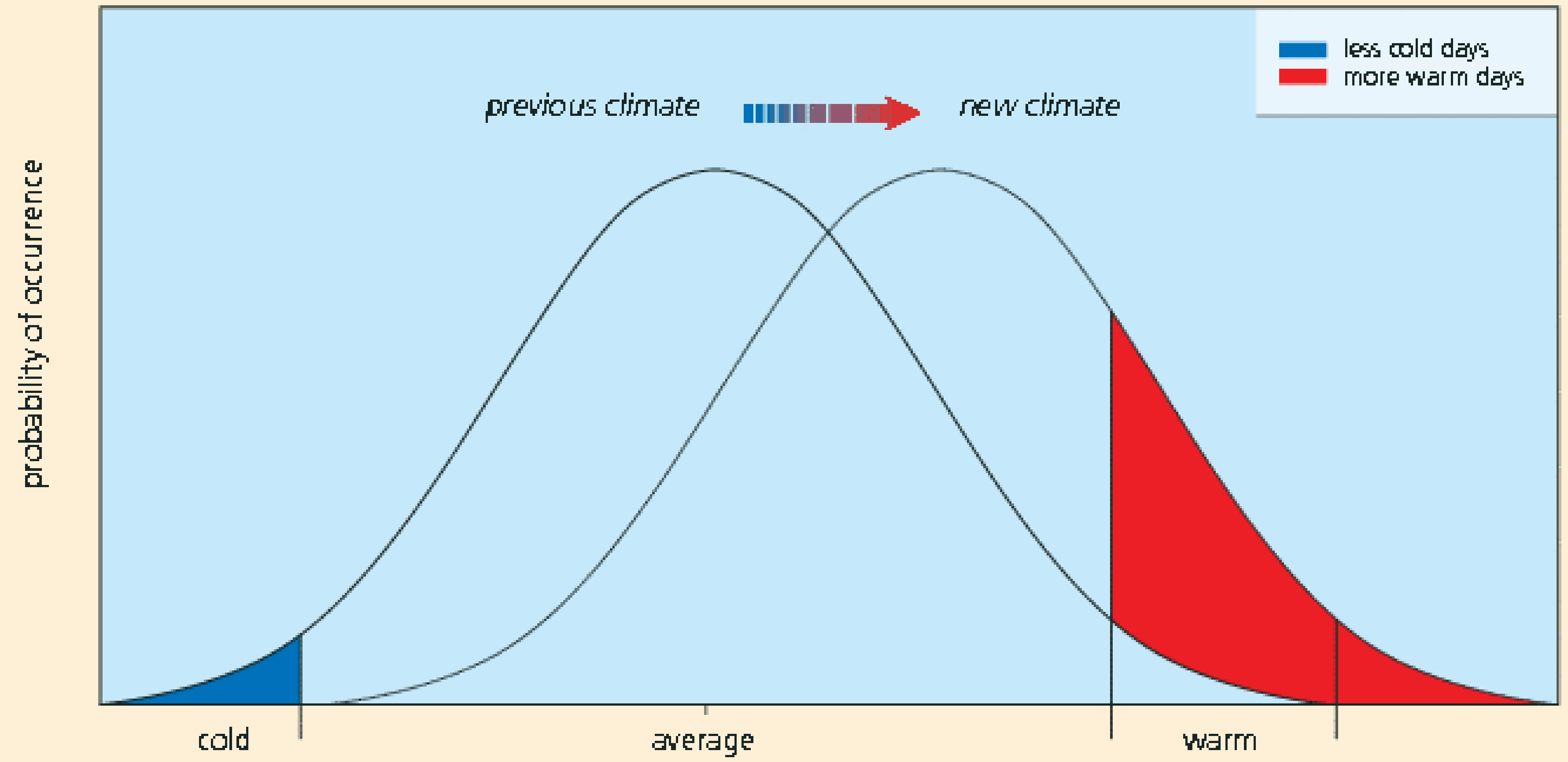
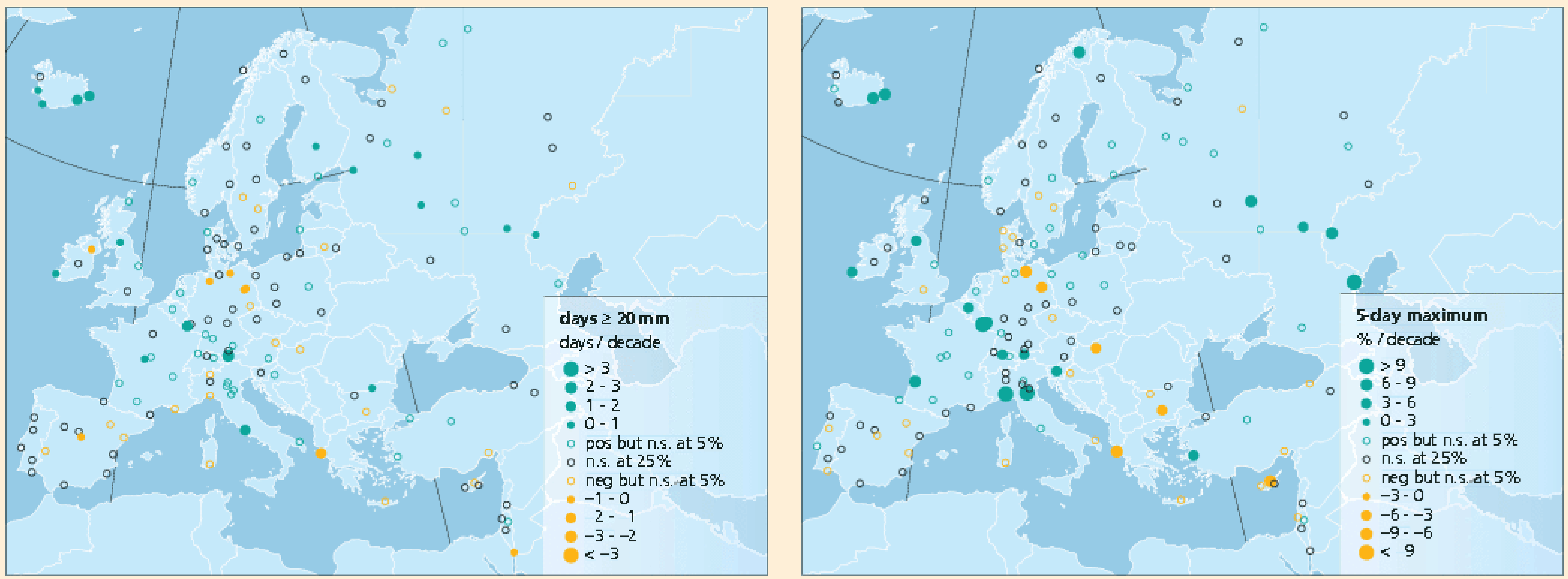
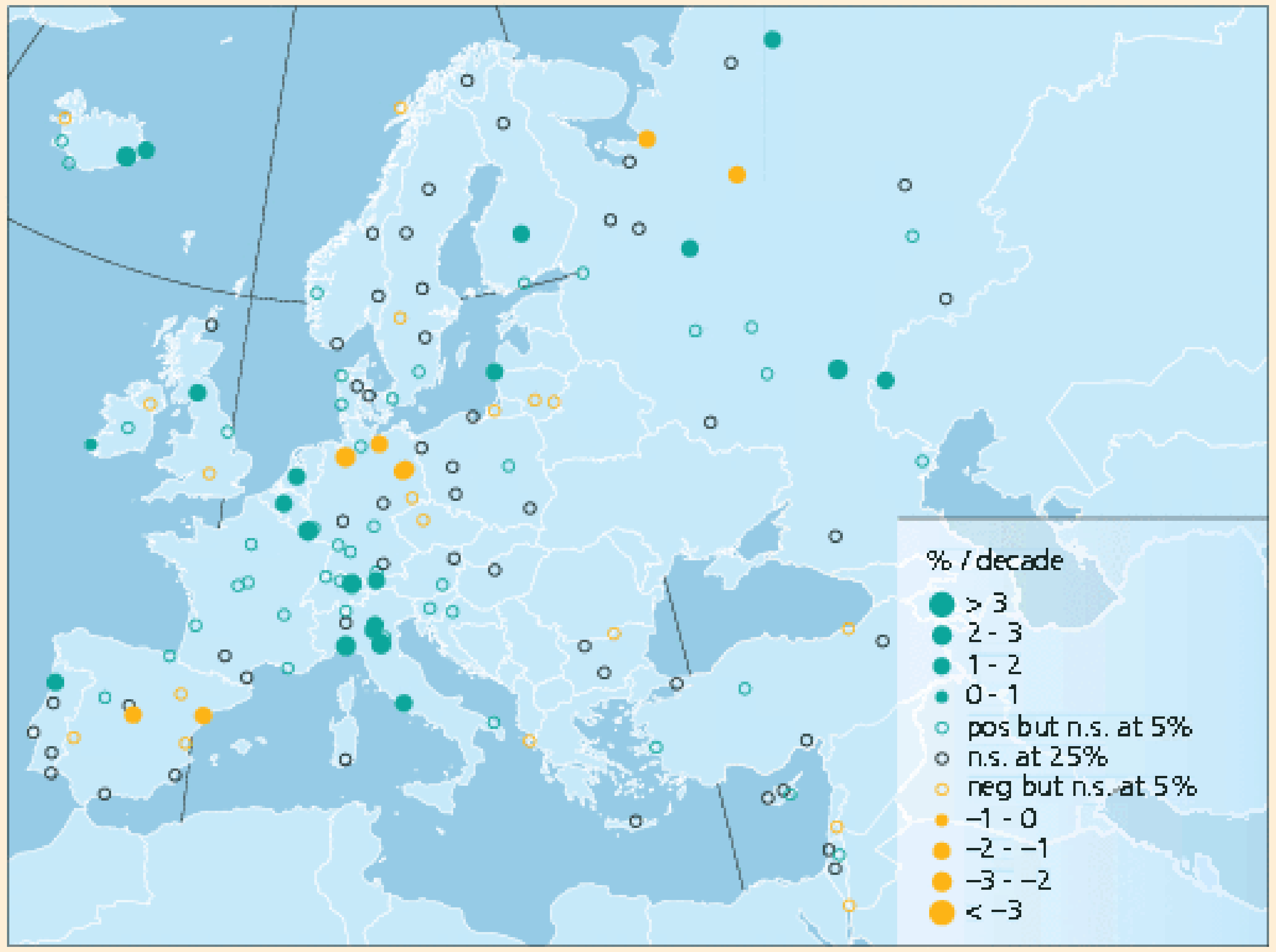


Figure 4.9 | *Trends in annual number of days with precipitation amount ≥ 20 mm and in annual maximum 5-day precipitation amount in the 1946-1999 period.*





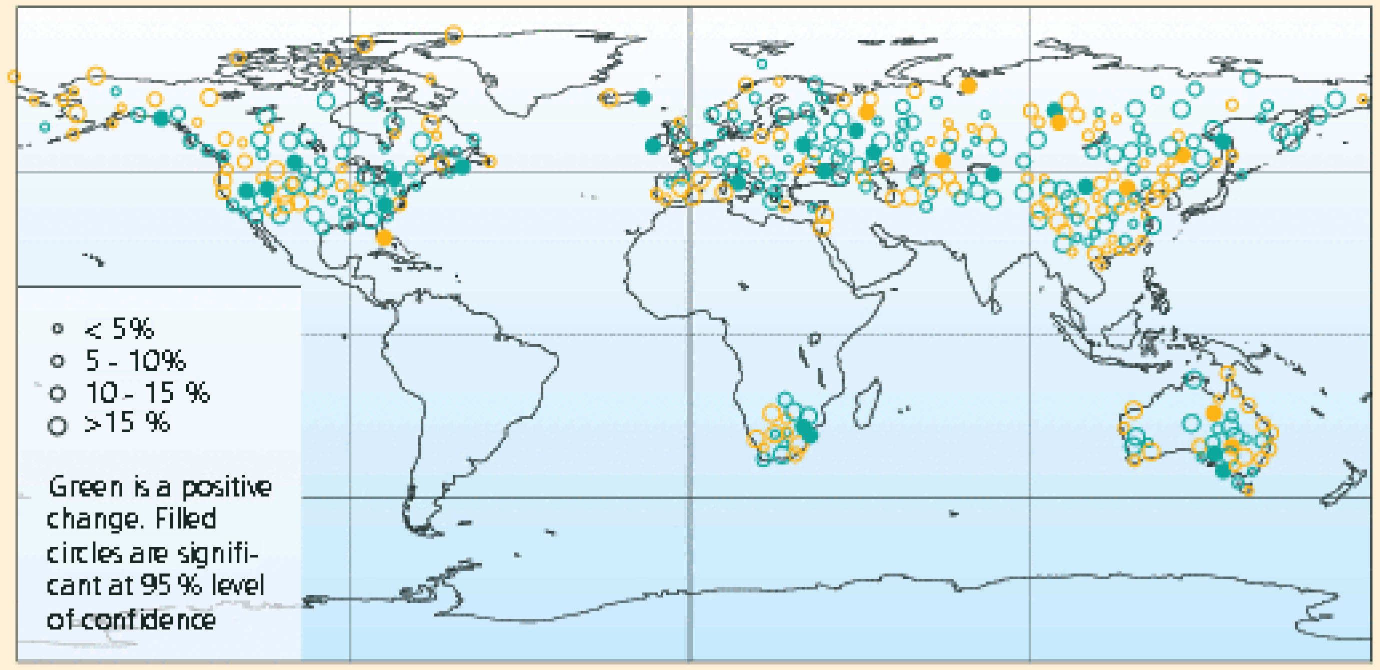


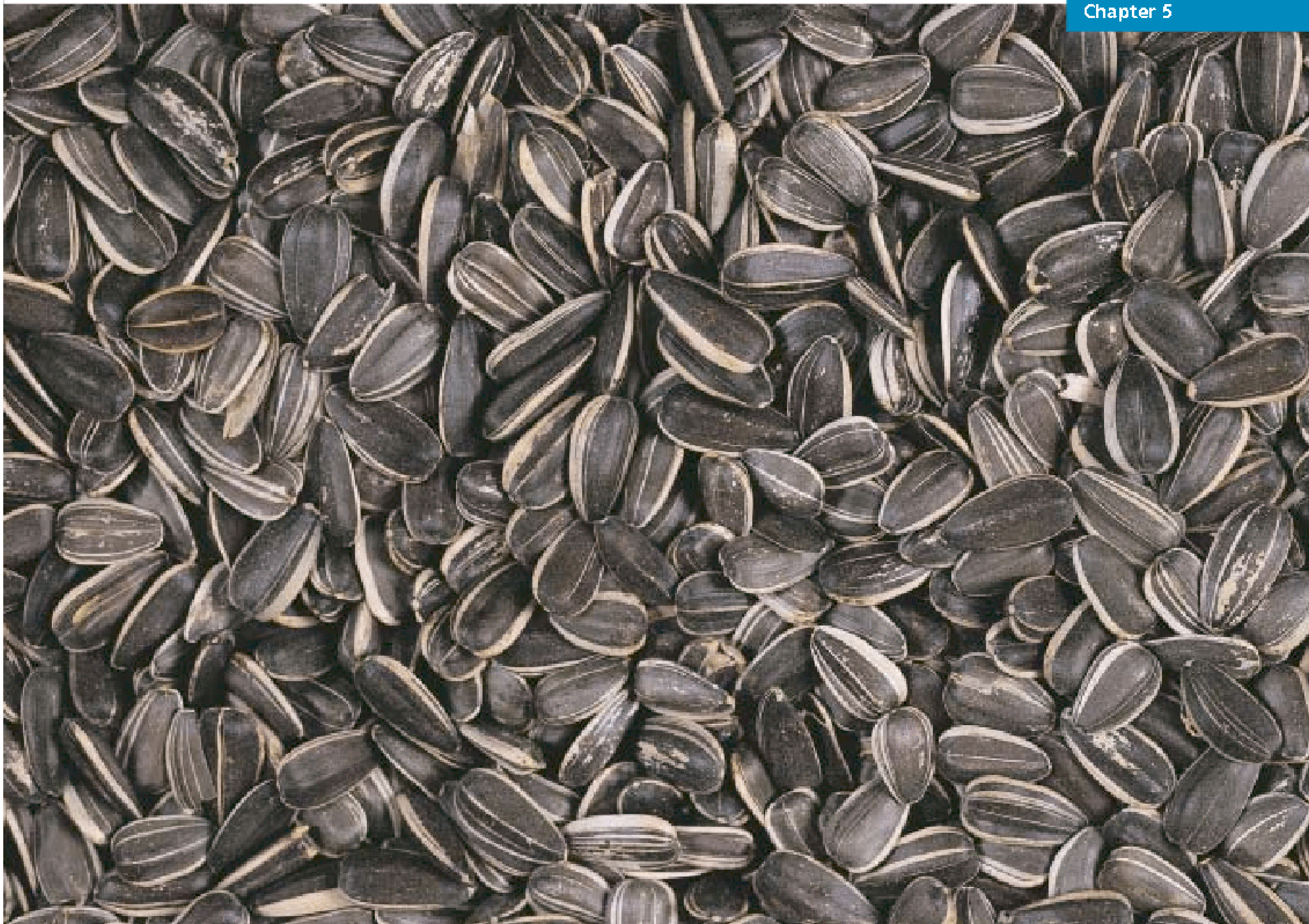
Figure 4.10 | *Trends in percentage of annual precipitation amount due to very wet days in Europe and world-wide in the 1946-1999 period. Very wet days are defined as days with precipitation above the 95th percentile at wet days in the 1961-1990 baseline period. World-wide trends are from Frich et al. (2002) and refer to the change (%) between two multi-decadal averages during the 2nd half of the 20th century.*

Daily values 1946-1999	Lowest values	station	country	date	Highest values	station	country	date
Minimum temperature	-56.0°C	Petsjora	Russia	9 Feb 1946	33.0°C	Elat	Israel	9 Aug 1998
	-53.9°C	Ust-Tzilma	Russia	6 Feb 1998	31.9°C	Larnaca	Cyprus	8 Aug 1998
	-53.6°C	Krasnoufimsk	Russia	1 Jan 1979	31.2°C	Turnu-Magurele	Romania	25 Jul 1987
	-52.2°C	Kojnas	Russia	9 Feb 1946	31.1°C	Arad	Romania	15 Aug 1952
	-51.2°C	Karasjok	Norway	28 Jan 1999	30.8°C	Buzau	Romania	20 Jul 1987
Maximum temperature	-51.7°C	Petsjora	Russia	28 Feb 1973	47.2°C	Elat	Israel	10 Jun 1966
	-49.4°C	Karasjok	Norway	28 Feb 1999	45.6°C	Adana	Turkey	24 Aug 1958
	-46.8°C	Kojnas	Russia	4 Jan 1985	45.2°C	Beja	Portugal	24 Jul 1995
	-44.8°C	Hoseda-Hard	Russia	31 Jan 1967	45.2°C	Larissa	Greece	19 Jul 1973
	-44.1°C	Sodankyla	Finland	28 Jan 1999	45.0°C	Nahal-Hazerim	Israel	21 May 1970
Precipitation amount					418 mm	Genoa	Italy	28 Sep 1992
					313 mm	Malaga-Aeropuerto	Spain	27 Sep 1957
					263 mm	Valencia	Spain	17 Nov 1956
					240 mm	Torrevieja	Spain	4 Sep 1989
					222 mm	Perpignan	France	12 Nov 1999

Table 4.1 | *Record highs and lows in the 1946-1999 period. Note that only one date is retained for each station series.*

Conclusions and outlook

Chapter 5



Conclusions

Trends in observed temperature and precipitation extremes could be studied Europe-wide because of joint efforts of 36 participants in developing a dataset of climatological time series with daily resolution for individual stations. A subset of these series was carefully selected for trend analysis, using a combination of statistical tests and metadata, to avoid biases introduced by inhomogeneities. Based on this subset the following conclusions were reached:

Mean temperature and total precipitation:

1 The warming observed between 1946 and 1999 is generally stronger at night-time than at day-time, leading to a decrease in the diurnal temperature range.

2 Positive trends in the annual precipitation amount and number of wet days between 1946 and 1999 are found at stations mainly in the north, whereas negative trends concentrate in the south.

Temperature and precipitation extremes:

3 At 45% of the stations the warming between 1946 and 1999 is associated with a significant decrease in the number of frost days, whereas no station shows significant increase. Trends in the number of summer days are less indicative of warming with only 12% increases and 6% decreases.

4 The Europe-averaged increase in warm days between 1946 and 1999 matches the decrease in cold days, i.e. 'symmetric' warming. For the two sub-periods (1946-1975 and 1976-1999), indications for asymmetric warming are found.

5 The dominant-warming trend between 1946 and 1999 was generally accompanied by a slight increase in wet extremes. However, there are large trend differences between nearby stations and only about 20% of the station trends are significant at the 5% level.

Box G *Climate Explorer*

To correlate the ECA data with a variety of other climate data, the KNMI Climate Explorer (http://climexp.knmi.nl) was recently extended with a daily data option. It contains the public daily ECA series and presents the user the possibility to generate derived monthly and yearly time series, such as the number of days with minimum temperature below zero or other indices used in this study.

The derived series can be correlated with data that is available at this website: climate indices (e.g. NAO, SOI, NINO3, global temperature) monthly station data (e.g. GHCN precipitation, temperature and pressure, RivDis river runoff) and analyzed fields (e.g. Hulme precipitation, Jones temperatures, TOMS ozone, NCEP snow cover, selected NCEP/NCAR and ERA reanalysis fields). Time series and fields can be added to the system by the user. At KNMI, the system has been used for different types of analysis, for instance to construct and verify seasonal forecasts and to investigate the patterns of climate change in Europe. The system is open to everyone and can be used freely.

Outlook

To consolidate the present European Climate Assessment we recommend:

- to build upon the unique co-operation, extend the data analysis and continue the series of climate assessments, issued periodically;
- to consider the participation of neighbouring countries in the Middle East and countries in North Africa;
- to extend the daily dataset and include meta-data information, e.g. results of homogeneity tests, station history and data quality flags;
- to broaden the daily dataset to other climatic elements, like atmospheric pressure, humidity, sunshine and cloudiness;
- to explore how the indices of extremes can be used by policymakers and for impact assessment;
- to study the relation between observed trends and atmospheric circulation, which is ruling the regional climate of Europe;
- to consider widening the scope and include the study of extremes in climate models.

Box H

Liaison with 'the impact community'

Through the EUMETNET working group on environment, a co-operation between ECA and the European Environment Agency (EEA) was established. EEA aims to support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy making agents and the public.

Determining the effectiveness of measures to mitigate or adapt to climate change requires continuous monitoring and assessment of climate change in Europe. Regarding climate change as a key environmental theme, EEA is identifying relevant state and impact indicators. These indicators should provide broader information on climate change and its impacts than currently available in the regular EEA indicator-based European state of the environment reports, like Signals2001 (see: http://reports.eea.eu.int/signals-2001).

The rationale for EEA is that policymakers need indicators to measure progress towards achieving the objectives that have been set for greenhouse gas emissions, global average temperature increase and carbon dioxide concentrations in the atmosphere. The indicators should provide early warning signals to policymakers. Such indicators have to reflect the actual climate trends for variables that are giving rise to public concern.

In particular the state indicators identified by EEA, that give a quantitative and qualitative description of the actual changes occurring in the climate, are similar to the indices used in ECA to study changes in climate extremes. ECA indices are therefore good candidates for inclusion in EEA indicator-based reports.

References

Dai, A., K.E. Trenberth and T.R. Karl, 1999. *Effects of clouds, soil moisture, precipitation and water vapor on diurnal temperature range.* J. Climate 12: 2452-2473.

Easterling, D.R., B. Horton, P.D. Jones, T.C. Peterson, T.R. Karl, D.E. Parker, M.J. Salinger, V. Razuvayev, N. Plummer, P. Jamason and C.K. Folland, 1997. *Maximum and minimum temperature trends for the globe.* Science 277: 364-367.

Frich, P., L.V. Alexander, P. Della-Marta, B. Gleason, M. Haylock, A.M.G. Klein Tank and T. Peterson, 2002. *Observed coherent changes in climatic extremes during 2nd half of the 20th century.* Climate Research 19: 193-212.

Heino, R., R. Brázdil, E. Forland, H. Tuomenvirta, H. Alexandersson, M. Beniston, C. Pfister, M. Rebetez, G. Rosenhagen, S. Rösner and J. Wibig, 1999. *Progress in the study of climatic extremes in northern and central Europe.* Climatic Change 42: 151-181.

Hulme, M., T.J. Osborn and T.C. Johns, 1998. *Precipitation sensitivity to global warming: Comparison of observations with HadCM2 simulations.* Geophys. Res. Letts. 25: 3379-3382.

IPCC, 2001. *Climate Change 2001: The Scientific Basis.* Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J van der Linden and D. Xiaosu (Eds.), Cambridge University Press, UK, pp944.

Jones, P.D., M. New, D.E. Parker, S. Martin and I.G. Rigor, 1999. *Surface air temperature and its changes over the past 150 years.* Reviews of Geophysics 37:173-199.

Jones, P.D., T.J. Osborn, K.R. Briffa, C.K. Folland, E.B. Horton, L.V. Alexander, D.E. Parker and N.A. Rayner, 2001. *Adjusting for sampling density in grid box land and ocean surface temperature time series.* J. Geophys. Res. 106: 3371-3380.

Karl, T.R., R.W. Knight and B. Baker, 2000. *The record breaking global temperature of 1997 and 1998: evidence for an increase in the rate of global warming?* Geophys. Res. Lett. 27: 719-722.

Klein Tank, Albert M.G. and Janet B. Wijngaard, 2000. *European Climate Assessment.* In: Proceedings of the 3rd European Conference on Applied Climatology, 16-20 October 2000, Pisa, Italy.

Klein Tank, A.M.G., J.B. Wijngaard, G.P. Können, R. Böhm, G. Demarée, A. Gocheva, M. Mileta, S. Pashiardis, L. Hejkrlik, C. Kern-Hansen, R. Heino, P. Bessemoulin, G. Müller-Westmeier, M. Tzanakou, S. Szalai, T. Pálsdóttir, D. Fitzgerald, S. Rubin, M. Capaldo, M. Maugeri, A. Leitass, A. Bukantis, R. Aberfeld, A.F.V. van Engelen, E. Forland, M. Mietus, F. Coelho, C. Mares, V. Razuvaev, E. Nieplova, T. Cegnar, J. Antonio López, B. Dahlström, A. Moberg, W. Kirchhofer, A. Ceylan, O. Pachaliuk, L.V. Alexander and P. Petrovic, 2002. *Daily dataset of 20th-century surface air temperature and precipitation series for European Climate Assessment (ECA).* Int. J. of Climatol., in press.

Peterson, T.C., C. Folland, G. Gruza, W. Hogg, A. Mokssit and N. Plummer, 2001. *Report on the Activities of the Working Group on Climate Change Detection and Related Rapporteurs 1998-2001.* Report WCDMP-47, WMO-TD 1071, World Meteorological Organization, Geneva, Switzerland.

Schuurmans, C. H. Cattle, E. Choisnel, B. Dahlström, C. Gagaoudaki, A.M. Jorgensen, G. Müller-Westermeier and B. Orfilla, 1995. *Climate of Europe: Recent variation, present state and future prospects.* KNMI, De Bilt, the Netherlands, pp 72.

Wijngaard, J.B. and A.M.G. Klein Tank, 2001. *Homogeneity of the ECA temperature data.* In: S. Szalai (Ed.). Proceedings of the Third Seminar for Homogenization and Quality Control in Climatological Databases, Budapest, Hungary, 25-29 September 2000.

WMO, 2001. *Commission for Climatology,* thirteenth session 21-30 November 2001 Report WMO-No. 938, World Meteorological Organization, Geneva, Switzerland.

List of abbreviations

CCL	Commission for Climatology of WMO
CLIVAR	Research programme on CLImate VARiability and predictability
DNMI	Norwegian Meteorological Institute
DTR	Diurnal Temperature Range (maximum – minimum temperature)
DWD	German Weather Service
ECA	European Climate Assessment
ECD	European EUMETNET/ECSN Climate Dataset
ECSN	European Climate Support Network
EEA	European Environment Agency
ERA	European Centre for Medium-Range Weather Forecasts Re-Analysis project
EUMETNET	EUropean METeorological NETwork of NMS's
GCOS	Global Climate Observing System
GHCN	Global Historical Climatology Network
GSN	GCOS Surface Network
IPCC	Intergovernmental Panel on Climate Change
KNMI	Royal Netherlands Meteorological Institute
NAO	North Atlantic Oscillation
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NINO3	Index for sea surface temperature between 5°S-5°N and 90°W-150°W
NMS	National Meteorological Service
RivDis	Global River Discharge Database
SOI	Southern Oscillation Index
TOMS	Total Ozone Mapping Spectrometer
WMO	World Meteorological Organization

Appendix

The following list of station series gives a complete overview of the daily time series of temperature (minimum, mean and maximum) and precipitation amount studied in ECA. ECD: station series part of the European Climate Dataset (Box D). GSN: station series part of the GCOS Surface Network.

Country	series ID	station name	WMO number	ECD	GSN	latitude	longitude	elevation (m)	begin date min. temp	end date min. temp	begin date mean temp	end date mean temp	begin date max. temp	end date max. temp	begin date precip	end date precip
Austria	16402	Graz	11290	Y	N	+47:05:00	+15:27:00	366			19010101	19991231			19010101	19991231
Austria	11801	Innsbruck	11120	Y	N	+47:16:00	+11:24:00	577			19010101	19991231			19010101	19991231
Austria	5010	Kremsmuenster	11012	Y	Y	+48:03:00	+14:08:00	383	19010101	19981231	19010101	19981231	19010101	19981231		
Austria	6306	Salzburg	11150	Y	N	+47:48:00	+13:00:00	437			19010101	19991231			19010101	19991231
Austria	15410	Sonnblick	11146	Y	Y	+47:03:00	+12:57:00	3106			19010101	19991231			19010101	19991231
Austria	5901	Wien	11035	Y	N	+48:14:00	+16:21:00	199			19010101	19991231			19010101	19991231
Belgium	6447	Uccle	06447	Y	N	+50:48:00	+04:21:00	100	19010101	19991231			19010101	19991231	19010101	19991231
Bulgaria	3040	Kneja	15520	N	N	+43:30:00	+24:05:00	117	19310101	19961231	19310101	19961231	19310101	19961231	19310101	19961231
Bulgaria	15002	Obraszov-chiflik		N	N	+43:48:00	+26:02:00	157	19310101	19991231	19310101	19991231	19310101	19991231	19310101	19991231
Bulgaria	15001	Sadovo		N	N	+42:09:00	+24:57:00	155	19310101	19991231	19310101	19991231	19310101	19991231	19310101	19991231
Croatia	14236	Zagreb-gric	14236	Y	N	+45:49:01	+15:58:41	157	19010101	19971231	19010101	19971231	19010101	19971231	19010101	19971231
Cyprus	300	Amiandos		Y	N	+34:56:00	+32:55:00	1380	19860101	19981231			19860101	19981231	19161001	19981231
Cyprus	730	Larnaca		Y	N	+34:55:00	+33:38:00	3	19860101	19981231			19860101	19981231	19161001	19981231
Cyprus	390	Limassol		Y	N	+34:40:00	+33:03:00	5	19930601	19981231			19930601	19981231	19161001	19981231
Cyprus	640	Nicosia		Y	N	+35:10:00	+33:21:00	160	19860101	19981231			19860101	19981231	19161001	19981231
Cyprus	40	Polis		Y	N	+35:02:00	+32:26:00	20	19860101	19981231			19860101	19981231	19161001	19981231
Czech Republic	11515	Praha-klementinum	11515	Y	N	+50:05:27	+14:25:09	191	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Denmark	30370	Botanisk have		Y	N	+55:41:00	+12:35:00	6							19610101	19981231
Denmark	21430	Groenbaek		Y	N	+56:17:00	+09:37:00	25							19010101	19981231
Denmark	6193	Hammer odde fyr	06193	Y	N	+55:18:00	+14:47:00	11	19840101	19981231			19840101	19981231	19840101	19981231
Denmark	32020	Hammer odde fyr		Y	N	+55:18:00	+14:47:00	11	19710101	19870624			19710101	19870624	19610101	19870630
Denmark	6186	Koebenhavn-landbohoejskol	06186	Y	Y	+55:41:00	+12:32:00	9	19951201	19981231			19951201	19981231		
Denmark	30380	Koebenhavn-landbohoejskol		Y	Y	+55:41:00	+12:32:00	9	19010101	19970630			19010101	19970630	19010101	19961001
Denmark	30210	Meteorologisk institut		Y	N	+55:43:00	+12:34:00	8							19010101	19841231
Denmark	25140	Nordby		Y	N	+55:27:00	+08:24:00	4	19010101	19981231			19010101	19981231	19010101	19981231
Denmark	32030	Sandvig		Y	N	+55:17:00	+14:47:00	12	19010101	19701231			19010101	19701231	19010101	19701231
Denmark	27080	Tranebjerg		Y	N	+55:51:00	+10:36:00	11							19010101	19981231
Denmark	21100	Vestervig		Y	N	+56:46:00	+08:19:00	18	19010101	19981231			19010101	19981231	19010101	19981231
Finland	304	Helsinki	02978	Y	N	+60:10:00	+24:57:00	4	19510101	19991231	19510101	19991231	19510101	19991231	19510101	19991231
Finland	2401	Jyvaskyla	02935	Y	Y	+62:24:00	+25:41:00	137	19510101	19991231	19510101	19991231	19510101	19991231	19510101	19991231
Finland	7501	Sodankyla	02836	Y	Y	+67:22:00	+26:39:00	179	19080101	19991231	19990101	19991231	19080101	19991231	19080101	19991231
France	33281001	Bordeaux-merignac	07510	Y	N	+44:50:00	-00:42:00	49	19060101	19991231			19060101	19991231	19010101	19991231
France	18033001	Bourges	07255	Y	Y	+47:04:00	+02:22:00	161	19130101	19991231			19130101	19991231	19450301	19991231
France	36063001	Chateauroux	07354	Y	N	+46:52:00	+01:43:00	160	19010101	19991231			19010101	19991231	19010101	19991231
France	69029001	Lyon-bron		Y	N	+45:43:40	+04:56:20	172	19200901	19991231			19200901	19991231	19200901	19991231
France	13055001	Marseille		Y	Y	+43:18:30	+05:23:48	75	19010101	19991231			19010101	19991231	19010101	19991231
France	75114001	Paris-montsouris	07150	Y	N	+48:49:00	+02:20:00	75	19010101	19991231			19010101	19991231	19010101	19991231
France	66136001	Perpignan	07747	Y	N	+42:44:00	+02:52:00	43	19010101	19991231			19010101	19991231	19010101	19991231
France	31069001	Toulouse-blagnac	07630	Y	Y	+43:37:00	+01:23:00	152	19010101	19991231			19010101	19991231	19010101	19991231
Germany	4063	Bamberg	10675	Y	N	+49:53:00	+10:53:00	282	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	3319	Berlin	10389	Y	N	+52:27:00	+13:18:00	55	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	1474	Bremen	10224	Y	N	+53:03:00	+08:47:00	4	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	3244	Dresden-wahnsdorf	10486	Y	N	+51:07:00	+13:41:00	246	19170101	19991231	19170101	19991231	19170101	19991231	19170101	19991231
Germany	2641	Frankfurt	10637	Y	N	+50:07:00	+08:40:00	103	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	3218	Halle	10466	Y	N	+51:29:00	+11:59:00	104	19010101	19901231	19010101	19901231	19010101	19901231	19010101	19901230
Germany	3865	Hamburg-bergedorf		Y	N	+53:29:00	+10:15:00	35	19120101	19620930	19120101	19620930	19120101	19620930	19120101	19620930

Country	series ID	station name	WMO number	ECD	GSN	latitude	longitude	elevation (m)	begin date min. temp	end date min. temp	begin date mean temp	end date mean temp	begin date max. temp	end date max. temp	begin date precip	end date precip
Germany	1459	Hamburg-fuhlsbuettel	10147	Y	Y	+53:33:00	+09:58:00	26	19010101	19991231			19010101	19991231	19010101	19991231
Germany	4161	Hohenpeissenberg	10962	Y	Y	+47:48:00	+11:01:00	977	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	4204	Jena-sternwarte		Y	N	+50:56:00	+11:35:00	155	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	2288	Kaiserslautern		Y	N	+49:27:00	+07:47:00	248	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	2698	Karlsruhe	10727	Y	N	+49:01:00	+08:23:00	114	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	4199	Muenchen	10865	Y	N	+48:10:00	+11:30:00	515	19010101	19990331	19010101	19990331	19010101	19990331	19010101	19990331
Germany	1153	Muenster		Y	N	+51:58:00	+07:36:00	63	19010101	19911231	19010101	19911231	19010101	19911231	19010101	19911231
Germany	3342	Potsdam	10379	Y	N	+52:23:00	+13:04:00	81	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	3038	Schwerin	10162	Y	N	+53:39:00	+11:23:00	59	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	2716	Stuttgart	10738	Y	N	+48:43:00	+09:13:00	401	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Germany	2277	Trier	10609	Y	N	+49:45:00	+06:39:00	144	19070501	19990131	19070501	19990131	19070501	19990131	19070501	19990131
Germany	4155	Zugspitze	10961	Y	N	+47:25:00	+10:59:00	2960	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Greece	641	Corfu	16641	Y	N	+39:37:00	+19:55:00	4	19550101	19981231	19550101	19971231	19550101	19981231	19550101	19971231
Greece	716	Hellinikon	16716	Y	N	+37:54:00	+23:45:00	15	19550101	19981231	19550101	19981231	19550101	19981231	19550101	19981231
Greece	754	Heraklion	16754	Y	N	+35:20:00	+25:11:00	39	19550101	19981231	19550101	19980831	19550101	19981231	19550101	19980831
Greece	648	Larissa	16648	Y	N	+39:39:00	+22:27:00	74	19550101	19981231	19550101	19971231	19550101	19981231	19550101	19971231
Greece	734	Methoni	16734	Y	Y	+36:50:00	+21:42:00	52	19560101	19981231	19560101	19971231	19560101	19981231	19560101	19971231
Hungary	12843	Budapest	12843	N	N	+47:31:00	+19:02:00	118			19010101	19981231			19010101	19981231
Iceland	620	Dalatangi	04097	Y	N	+65:16:00	-13:35:00	9	19510921	19990531	19510101	19990531	19510101	19990531	19510101	19990531
Iceland	1	Reykjavik	04030	Y	N	+64:08:00	-21:54:00	52	19510101	19990831	19510101	19990831	19510101	19990831	19510101	19990831
Iceland	178	Stykkisholmur	04013	Y	Y	+65:05:00	-22:44:00	8	19510101	19990731	19510101	19990731	19510101	19990731	19510101	19990731
Iceland	675	Teigarhorn	04092	Y	Y	+64:41:00	-15:14:21	14	19510101	19990731	19510101	19990731	19510101	19990731	19510101	19990731
Iceland	815	Vestmannaeyjar	04048	Y	Y	+63:24:00	-20:17:00	118	19510101	19990630	19510101	19990630	19510101	19990630	19510101	19990630
Ireland	965	Birr	03965	Y	N	+53:05:25	-07:53:25	70	19541001	19991231	19541001	19991231	19541001	19991231	19541001	19991231
Ireland	969	Dublin-phoenix-park	03969	Y	N	+53:21:50	-06:20:50	68	19010101	19801231	19010101	19801231	19010101	19801231	19010101	19801231
Ireland	980	Malin Head	03980	Y	Y	+55:22:20	-07:20:20	20	19550501	19991231	19550501	19991231	19550501	19991231	19570101	19991231
Ireland	953	Valentia-observatory	03953	Y	Y	+51:56:23	-10:14:40	9	19391001	19991231	19391001	19991231	19391001	19991231	19410101	19991231
Israel	251690	Beer-sheva		Y	N	+31:15:00	+34:48:00	280							19211031	19990408
Israel	9972	Elat		Y	Y	+29:33:00	+34:57:00	20	19640101	19991130			19640101	19991130	19491218	19990228
Israel	4640	Har-kenaan		Y	N	+32:58:00	+35:30:00	934	19640901	19991130			19640901	19991130	19391030	19990413
Israel	6771	Jerusalem		Y	N	+31:46:00	+35:13:00	815	19640101	19991231			19640101	19991231	19081116	19990408
Israel	7847	Nahal-hazerim		Y	N	+31:16:00	+34:43:00	195	19670301	19991231			19670301	19991231		
Israel	2011	Tel Aviv		Y	N	+32:06:00	+34:46:00	4	19640101	19991130			19640101	19991130	19391030	19990408
Italy	111	Bologna		N	N	+44:29:00	+11:15:00	60	19010101	19991231			19010101	19991231	19010101	19981231
Italy	320	Brindisi	16320	Y	N	+40:38:00	+17:56:00	10	19510101	19981231			19510101	19981231	19510101	19981231
Italy	560	Cagliari	16560	Y	N	+39:14:00	+09:03:00	2	19510101	19981231			19510101	19981231	19510101	19981231
Italy	222	Ferrara		N	N	+44:49:00	+11:30:00	15							19010101	19961231
Italy	333	Genoa		N	N	+44:24:00	+09:00:00	53							19010101	19961231
Italy	444	Mantova		N	N	+45:09:00	+10:45:00	20							19010101	19971231
Italy	555	Milan		N	N	+45:28:00	+09:00:00	122							19010101	19981231
Italy	239	Roma-ciampino	16239	Y	N	+41:47:00	+12:35:00	105	19510101	19981231			19510101	19981231	19510101	19981231
Italy	90	Verona-villafranca	16090	Y	N	+45:23:00	+10:52:00	68	19510101	19981231			19510101	19981231	19510101	19981231
Latvia	26348	Gulbene	26348	N	N	+57:08:00	+26:43:00	141	19231001	19991231	19231001	19991231	19231001	19991231	19240101	19991231
Latvia	26406	Liepaja	26406	N	Y	+56:29:00	+21:01:00	4	19010101	19991231	19010101	19991231	19220401	19991231	19010101	19991231
Lithuania	26629	Kaunas	26629	Y	N	+54:53:00	+23:50:00	75	19010101	19990831	19010101	19990831	19220501	19990831	19010101	19990831
Lithuania	26509	Klaipeda	26509	Y	N	+55:44:00	+21:04:00	6	19290102	19990831	19290102	19990831	19290102	19990831	19230801	19990831

Country	series ID	station name	WMO number	ECD	GSN	latitude	longitude	elevation (m)	begin date min. temp	end date min. temp	begin date mean temp	end date mean temp	begin date max. temp	end date max. temp	begin date precip	end date precip
Lithuania	26730	Vilnius	26730	Y	N	+54:38:00	+25:17:00	189	19010101	19981231	19010101	19981231	19010101	19981231	19010101	19990831
Luxembourg	6590	Luxembourg-airport	06590	Y	N	+49:37:00	+06:13:00	376	19470101	19991231	19470101	19991231	19470101	19991231	19470101	19991231
Netherlands	6745	Axel		Y	N	+51:16:35	+03:54:38	2							19050101	19951231
Netherlands	260	De Bilt	06260	Y	Y	+52:06:00	+05:11:00	2	19010101	19991231	19010101	19991231	19010101	19991231		
Netherlands	6550	De Bilt		Y	N	+52:05:53	+05:10:40	2							19510101	19991231
Netherlands	235	De Kooy/Den Helder	06235	Y	N	+52:55:00	+04:47:00	0	19060101	19991231	19060101	19991231	19060101	19991231		
Netherlands	280	Elde/Groningen	06280	Y	N	+53:08:00	+06:35:00	4	19060301	19991231	19060301	19991231	19060301	19991231		
Netherlands	6139	Groningen		Y	N	+53:11:08	+06:36:12	1							19010101	19991231
Netherlands	6222	Hoorn		Y	N	+52:39:06	+05:02:49	-1							19010101	19991231
Netherlands	380	Maastricht/Beek	06380	Y	N	+50:55:00	+05:47:00	114	19060101	19991231	19060101	19991231	19060101	19991231		
Netherlands	6542	Putten		Y	N	+52:15:12	+05:37:51	14							19010101	19991231
Netherlands	6961	Roermond		Y	N	+51:10:55	+05:58:06	20							19010101	19991231
Netherlands	310	Vlissingen	06310	Y	N	+51:27:00	+03:36:00	8	19060101	19991231	19060101	19991231	19060101	19991231		
Norway	86850	Barkestad		Y	N	+68:49:00	+14:48:00	3							19010101	19991231
Norway	50540	Bergen-florida	01317	Y	N	+60:23:00	+05:20:00	12	19850101	19991231	19850101	19991231	19850101	19991231		
Norway	50550	Bergen-fredriksberg	01317	Y	N	+60:24:00	+05:19:00	41	19380101	19850228	19380101	19850228	19380101	19850228		
Norway	99710	Bjoernoeya	01028	Y	Y	+74:31:00	+19:01:00	16	19380101	19991231	19380101	19991231	19390630	19991231	19210101	19991231
Norway	80700	Glomfjord	01113	Y	N	+66:49:00	+13:59:00	39	19570101	19991231	19570101	19991231	19570101	19991231		
Norway	99950	Jan Mayen	01001	Y	Y	+70:56:00	-08:40:00	10	19560101	19991231	19560101	19991231	19560101	19991231		
Norway	97250	Karasjok	01065	Y	N	+69:28:00	+25:31:00	129	19570101	19991231	19570101	19991231	19570101	19991231		
Norway	16740	Kjoeremsgrende	01235	Y	N	+62:06:00	+09:03:00	626	19570101	19991231	19570101	19991231	19570101	19991231		
Norway	68330	Lien i selbu	01272	Y	N	+63:13:00	+11:07:00	255							19010101	19991231
Norway	39220	Mestad	01449	Y	N	+58:13:00	+07:53:00	151							19010101	19991231
Norway	47020	Nedstrand	01404	Y	N	+59:21:00	+05:48:00	55							19570101	19991231
Norway	5350	Nord Odal		Y	N	+60:23:00	+11:34:00	147							19010101	19991231
Norway	39100	Oksoey fyr	01448	Y	N	+58:04:00	+08:03:00	9	19510101	19991231	19510101	19991231	19510101	19991231		
Norway	18700	Oslo-blindern	01492	Y	N	+59:57:00	+10:43:00	94	19380101	19991231	19380101	19991231	19380101	19991231		
Norway	50350	Samnanger		Y	N	+60:28:00	+05:54:00	370							19010101	19991231
Norway	93300	Suolovuopmi		Y	N	+69:35:00	+23:32:00	374							19080101	19991231
Norway	47300	Utsira fyr	01403	Y	Y	+59:18:00	+04:53:00	55	19510101	19991231	19510101	19991231	19510101	19991231		
Norway	98550	Vardoe	01098	Y	Y	+70:22:00	+31:05:00	14	19510101	19991231	19510101	19991231	19510101	19991231		
Poland	295	Bialystok	12295	N	N	+53:06:00	+23:10:00	148	19630410	19981231	19630410	19981231	19630410	19981231	19630410	19981231
Poland	135	Hel	12135	N	N	+54:36:00	+18:49:00	1	19510701	19971231	19510701	19971231	19510701	19971231	19510101	19971231
Poland	330	Poznan	12330	N	N	+52:25:00	+16:50:00	86	19510101	19981231	19510101	19981231	19510101	19981231	19510101	19981231
Poland	580	Rzeszow-jasionka	12580	N	N	+50:06:00	+22:03:00	200	19520101	19981231	19520101	19981231	19520101	19981231	19520101	19981231
Poland	205	Szczecin	12205	N	N	+53:24:00	+14:37:00	1	19510101	19971231	19510101	19971231	19510101	19971231	19510101	19971231
Poland	375	Warszawa	12375	N	N	+52:09:00	+20:59:00	106	19510101	19981231	19510101	19981231	19510101	19981231	19510101	19981231
Poland	424	Wroclaw	12424	N	N	+51:10:00	+16:53:00	120	19510101	19981231	19510101	19981231	19510101	19981231	19510101	19981231
Portugal	562	Beja	08562	Y	N	+38:01:00	-07:52:00	246	19580101	19991231			19580101	19991231	19410101	19991231
Portugal	575	Braganca	08575	Y	N	+41:48:00	-06:44:00	690	19410101	19991231			19410101	19991231	19450101	19991231
Portugal	549	Coimbra	08549	Y	N	+40:12:00	-08:25:00	141	19010101	19941231			19010101	19941231	19410101	19941231
Portugal	535	Lisboa-geofisica	08535	Y	Y	+38:43:00	-09:09:00	77	19010101	19991231			19010101	19991231	19410101	19991231
Portugal	546	Porto	08546	Y	N	+41:08:00	-08:36:00	93	19410101	19991231			19410101	19991231	19410101	19991231
Portugal	282	Tavira	08282	Y	N	+37:07:00	-07:39:00	25	19410101	19941231			19410101	19941231	19410101	19941231
Romania	15	Arad	15200	Y	N	+46:08:00	+21:21:00	117	19010101	19931130			19010101	19931130		
Romania	2	Baia-mare	15014	Y	N	+47:40:00	+23:30:00	216	19010101	19931130			19210301	19931130		

Country	series ID	station name	WMO number	ECD	GSN	latitude	longitude	elevation (m)	begin date min. temp	end date min. temp	begin date mean temp	end date mean temp	begin date max. temp	end date max. temp	begin date precip	end date precip
Romania	35	Bucuresti	15420	Y	N	+44:31:00	+26:05:00	90	19290101	19931130			19290101	19931130		
Romania	29	Buzau	15350	Y	N	+45:08:00	+26:51:00	97	19010101	19931130			19010101	19931130		
Romania	38	Calarasi	15460	Y	N	+44:12:00	+27:20:00	19	19010101	19931130			19010101	19931130		
Romania	9	Cluj Napoca	15120	Y	N	+46:47:00	+23:34:00	410	19220501	19931130			19210301	19931130		
Romania	34	Drobeta-turnu-severin	15410	Y	N	+44:38:00	+22:38:00	77	19010101	19931130			19010101	19931130		
Romania	27	Tg Jiu	15340	Y	N	+45:02:00	+23:16:00	203	19010101	19931130			19010101	19931130		
Romania	41	Turnu Magurele	15490	Y	N	+43:45:00	+24:53:00	31	19010101	19931130			19010101	19931130		
Romania	20	Vf Omul	15280	Y	Y	+45:27:00	+25:27:00	2504	19280101	19931130			19280601	19931130		
Russia	34391	Aleksandrow	34391	Y	Y	+50:09:00	+48:33:00	25	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990819
Russia	22550	Archangelsk	22550	Y	Y	+64:30:00	+40:44:00	8	19010101	19990831	19010101	19990831	19130101	19990831	19010101	19990830
Russia	37031	Armavir	37031	Y	N	+44:59:00	+41:07:00	159	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990829
Russia	34880	Astrakan	34880	Y	N	+46:17:00	+48:03:00	-23	19010101	19990831	19010101	19990831	19010101	19990831	19010101	19990827
Russia	27648	Elatma	27648	Y	Y	+54:57:00	+41:46:00	136	19010101	19990831	19010101	19990831	19160401	19990831	19010101	19990831
Russia	23219	Hoseda Hard	23219	Y	N	+67:05:00	+59:23:00	84	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990831
Russia	28411	Izevsk	28411	Y	N	+56:50:00	+53:27:00	159	19580101	19990831	19580101	19990831	19580101	19990831	19580101	19990831
Russia	26702	Kaliningrad	26702	Y	N	+54:43:00	+20:33:00	21	19470101	19990831	19470101	19990831	19470101	19990831	19470101	19990831
Russia	22217	Kandalaksa	22217	Y	Y	+67:09:00	+32:21:00	25	19120901	19990831	19120901	19990831	19121001	19990831	19120901	19990825
Russia	22522	Kem	22522	Y	Y	+64:59:00	+34:48:00	8	19161201	19990831	19161201	19990831	19161201	19990831	19161201	19990829
Russia	34009	Koersk	34009	Y	N	+51:46:00	+36:10:00	247	19010101	19990831	19010101	19990831	19120101	19990831	19010101	19990831
Russia	22583	Kojnas	22583	Y	Y	+64:45:00	+47:39:00	64	19120901	19990831	19120901	19990831	19150101	19990831	19120901	19990830
Russia	27333	Kostroma	27333	Y	N	+57:44:00	+40:47:00	126	19250101	19990831	19250101	19990831	19250101	19990831	19250101	19990830
Russia	22887	Kotlas	22887	Y	N	+61:14:00	+46:43:00	56	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990831
Russia	28434	Krasnoufimsk	28434	Y	N	+56:39:00	+57:47:00	206	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990831
Russia	26063	Leningrad	26063	Y	Y	+59:58:00	+30:18:00	6	19010101	19990831	19010101	19990831	19010101	19990831	19010101	19990830
Russia	22113	Moermansk	22113	Y	N	+68:58:00	+33:03:00	51	19360112	19990831	19360101	19990831	19360112	19990831	19360112	19990828
Russia	27612	Moskou	27612	Y	Y	+55:50:00	+37:37:00	156	19480601	19990831	19480601	19990831	19481211	19990831	19480601	19990830
Russia	23205	Narjan Mar	23205	Y	N	+67:38:00	+53:02:00	12	19261114	19990831	19261114	19990831	19261114	19990831	19261114	19990831
Russia	28722	Oefa	28722	Y	N	+54:43:00	+55:50:00	104	19010101	19990831	19010101	19990831	19140101	19990831	19010101	19990831
Russia	22641	Onega	22641	Y	N	+63:54:00	+38:07:00	13	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990830
Russia	35121	Orenburg	35121	Y	N	+51:41:00	+55:06:00	117	19010101	19990831	19010101	19990831	19150801	19990831	19010101	19990831
Russia	27823	Paveletz	27823	Y	N	+53:47:00	+39:15:00	209	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990831
Russia	22820	Petrozawodsk	22820	Y	N	+61:49:00	+34:16:00	110	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990829
Russia	23418	Petsjora	23418	Y	N	+65:07:00	+57:06:00	59	19430901	19990831	19430901	19990831	19430901	19990831	19430901	19990831
Russia	26258	Pskow	26258	Y	N	+57:49:00	+28:25:00	45	19360101	19990830	19360101	19990830	19360101	19990830	19360101	19990829
Russia	34172	Saratow	34172	Y	N	+51:34:00	+46:02:00	156	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990831
Russia	26781	Smolensk	26781	Y	Y	+54:45:00	+32:04:00	239	19440801	19990831	19440101	19990831	19440801	19990831	19440122	19990831
Russia	22802	Sortavala	22802	Y	Y	+61:43:00	+30:43:00	19	19450101	19990831	19450101	19990831	19450101	19990831	19450101	19990830
Russia	23804	Syktywar	23804	Y	N	+61:43:00	+50:50:00	119	19010101	19990831	19010101	19990831	19130601	19990831	19010101	19990831
Russia	27947	Tambov	27947	Y	N	+52:48:00	+41:20:00	128	19360101	19990831	19360101	19990831	19360101	19990831	19360101	19990831
Russia	23711	Troitzko	23711	Y	N	+62:42:00	+56:12:00	139	19010101	19990831	19010101	19990831	19140908	19990831	19010101	19990831
Russia	23405	Ust Tzilma	23405	Y	N	+65:26:00	+52:16:00	68	19010101	19990831	19010101	19990831	19130101	19990831	19010101	19990830
Russia	26477	Velikie Lukie	26477	Y	N	+56:21:00	+30:37:00	106	19010101	19990831	19010101	19990831	19010101	19990831	19010101	19990830
Russia	22837	Vytegra	22837	Y	Y	+61:01:00	+36:27:00	56	19011101	19990831	19011101	19990831	19100401	19990831	19011201	19990829
Russia	27037	Wologda	27037	Y	N	+59:19:00	+39:55:00	130	19381101	19990831	19381101	19990831	19381101	19990831	19381101	19990830
Slovakia	11858	Hurbanovo	11858	Y	N	+47:52:38	+18:11:64	115	19480101	19991231	19480101	19991231	19480101	19991231		
Slovenia	192	Ljubljana-bezigrad	14015	Y	N	+46:03:56	+14:31:02	299			19490101	19981231			19490101	19981231

Country	series ID	station name	WMO number	ECD	GSN	latitude	longitude	elevation (m)	begin date min. temp	end date min. temp	begin date mean temp	end date mean temp	begin date max. temp	end date max. temp	begin date precip	end date precip
Spain	4452	Badajoz Talavera	08330	Y	N	+38:53:00	-06:49:45	185	19550101	19991231			19550101	19991231	19550101	19991231
Spain	3195	Madrid	08220	Y	N	+40:24:40	-03:40:41	667							19510101	19991231
Spain	6155	Malaga-aeropuerto	08482	Y	N	+36:40:00	-04:29:17	7	19420501	19991231			19420501	19991231	19420501	19991231
Spain	2462	Navacerrada	08215	Y	Y	+40:46:50	-04:00:37	1890	19460101	19991231			19460101	19991231	19460101	19991231
Spain	2867	Salamanca	08202	Y	Y	+40:56:50	-05:29:41	790	19510101	19991231			19510101	19991231	19510101	19991231
Spain	1024	San Sebastian	08027	Y	Y	+43:18:24	-02:02:22	259	19290101	19991231			19290101	19991231	19290101	19991231
Spain	7038	Torrevieja	08433	Y	N	+37:58:38	-00:42:39	1	19270101	19991231	19270101	19991231	19270101	19991231	19270101	19991231
Spain	9981	Tortosa	08238	Y	N	+40:49:14	+00:29:29	48	19100101	19991231			19100101	19991231	19100101	19991231
Spain	8416	Valencia	08285	Y	N	+39:28:48	-00:22:52	11	19350101	19991231			19350101	19991231	19380101	19991231
Spain	9434	Zaragoza-aeropuerto	08160	Y	N	+41:39:43	-01:00:29	247	19510101	19991231			19510101	19991231	19510101	19991231
Sweden	10537	Falun	02433	Y	N	+60:37:00	+15:37:00	160	19180101	19820531			19180101	19820531	19180101	19990930
Sweden	10537002	Falun	02433	Y	N	+60:37:00	+15:37:00	160	19820601	19991001			19820601	19991001		
Sweden	9322	Karlstad	02418	Y	Y	+59:21:00	+13:28:00	46	19180101	19991001			19180101	19991001	19180101	19971231
Sweden	8525	Linkoping-malmslatt		Y	N	+58:24:00	+15:32:00	93	19310101	19991011			19310101	19991011	19310101	19991011
Sweden	13411	Oestersund	02226	Y	Y	+63:11:00	+14:29:00	376	19180101	19991001			19180101	19991001	19180101	19991001
Sweden	15772	Stensele		Y	N	+65:04:00	+17:09:00	325	19180101	19990920			19180101	19990920	19180101	19990920
Sweden	240002	Stockholm	02485	N	N	+59:21:00	+18:03:00	44			19010101	19991231				
Sweden	6452	Vaexjoe	02640	Y	N	+56:52:00	+14:48:00	166	19180101	19990927			19180101	19990927	19180101	19990927
Switzerland	1940	Basel-binningen	06601	Y	N	+47:33:00	+07:35:00	316	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Switzerland	8440	Geneve-cointrin	06700	Y	N	+46:15:00	+06:08:00	420	19620101	19991231	19620101	19991231	19620101	19991231	19620201	19991231
Switzerland	8390	Geneve-observatoire		Y	N	+46:12:00	+06:09:00	405	19010101	19661130	19010101	19661130	19010101	19661130	19010101	19661130
Switzerland	9480	Lugano	06770	Y	N	+46:00:00	+08:58:00	273	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Switzerland	2220	Saentis	06680	Y	Y	+47:15:00	+09:21:00	2490	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Switzerland	3700	Zuerich-sma	06660	Y	N	+47:23:00	+08:34:00	556	19010101	19991231	19010101	19991231	19010101	19991231	19010101	19991231
Turkey	17351	Adana	17351	N	N	+36:59:00	+35:21:00	27	19300101	19991231	19300101	19991231	19300101	19991231	19300101	19991231
Turkey	17130	Ankara	17130	N	N	+39:58:00	+32:52:00	891	19300101	19991231	19300101	19991231	19300101	19991231	19300101	19991231
Turkey	17096	Erzurum	17096	N	N	+39:55:00	+41:16:00	1758	19300101	19991231	19300101	19991231	19300101	19991231	19300101	19991231
Turkey	17062	Istanbul	17062	N	Y	+40:58:00	+29:05:00	33	19300101	19991231	19300101	19991231	19300101	19991231	19300101	19991231
Turkey	17220	Izmir	17220	N	N	+38:24:00	+27:05:00	29	19380101	19991231	19380101	19991231	19380101	19991231	19380101	19991231
Turkey	17037	Trabzon	17037	N	N	+41:00:00	+39:43:00	38	19300101	19991231	19300101	19991231	19300101	19991231	19300101	19991231
Ukraine	177	Feodosia	33976	Y	N	+45:02:00	+35:23:00	22	19010101	19951231	19010101	19951231	19010101	19951231	19010101	19951230
Ukraine	32	Kyiv	33345	Y	N	+50:24:00	+30:32:00	166	19010101	19961231	19010101	19961231	19010101	19961231	19010101	19961231
Ukraine	83	Lugansk	34523	Y	N	+48:34:00	+39:15:00	59	19010101	19961231	19050101	19961231	19050101	19961231	19010101	19961231
Ukraine	153	Nikolaev	31369	Y	N	+46:58:00	+31:59:00	49	19010101	19951230	19010101	19951229	19010101	19951229	19010101	19951230
Ukraine	57	Poltava	28786	Y	N	+49:36:00	+34:33:00	160	19010101	19961231	19010101	19961231	19010101	19961231	19010101	19961231
United Kingdom	947811	Armagh		Y	N	+54:21:00	-06:39:00	62							19310101	19991231
United Kingdom	0	Central England (CET)		Y	N	+52:25:00	-01:50:00	0	19010101	19991231			19010101	19991231		
United Kingdom	610122	Eskdalemuir	03162	Y	Y	+55:19:00	-03:12:00	242							19310101	19991231
United Kingdom	44841	Hull		Y	N	+53:46:00	-00:22:00	2							19310101	19991231
United Kingdom	256225	Oxford		Y	N	+51:46:00	-01:16:00	63							19310101	19991231
United Kingdom	770765	Wick	03075	Y	N	+58:27:00	-03:05:00	36							19310101	19991231
Yugoslavia	13274	Beograd	13274	Y	N	+44:48:00	+20:28:00	132	19580101	19991231	19580101	19991231	19580101	19991231	19580101	19991231
Yugoslavia	13388	Nis	13388	Y	N	+43:20:00	+21:54:00	202	19580101	19991231	19580101	19991231	19580101	19991231	19580101	19991231

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