2024

Forest Condition in Europe

The 2024 Assessment

ICP Forests Technical Report under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention)

ICP FORESTS

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ICP Forests Technical Report under the UNECE Convention on Long-range Transboundary Air Pollution (Air Convention)

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7

METEOROLOGICAL CONDITIONS IN EUROPEAN FORESTS IN 2022

Lothar Zimmermann, Stephan Raspe, Tim Schütt, Alexa Michel, Kai Schwärzel

Introduction

Weather and climate affect composition, structure, growth, health, and dynamics of forest ecosystems. Observing weather conditions and their seasonal variations on forest monitoring plots is therefore essential for identifying and interpreting trends in forest condition as well as their interactions with other stressors such as air pollution, diseases, or pests. Against this background, the ICP Forests Level II plots were equipped with meteorological measurement devices as early as the 1990s.

Meteorological monitoring at the Level II plots provides local, inside forest area information on the basic driving and influencing factors for forest ecosystems. The main objectives of the meteorological monitoring at the Level II plots are:

- to describe the meteorological conditions and changes at the Level II plots;
- to investigate the meteorological conditions as a basis for a better understanding of the state of forest ecosystems and their interrelationships;
- to identify and investigate stress indices and factors for trees on the plot like extreme weather conditions and events (e.g., frost, heat, droughts, storms, floods);
- to build up long time series that fulfil requirements of further analysis (statistics and modelling) of ecosystem responses under current and changing environmental conditions (e.g. water balance calculations, soil water availability for the stand, growth, nutrient cycling) as well as integrated evaluations in various aspects of the Level II plots (e. g. crown condition assessment, deposition, increment) (Raspe et al. 2020).

Temperature and precipitation patterns play a key role in climate change impacts on forests. This chapter, therefore, focuses on presenting and interpreting air temperature and precipitation data from 2022 in comparison with long-term mean values for different climatic regions in Europe. Meteorological stations were allocated to climatic regions according to the well-known Koeppen-Geiger climate classification scheme with the aim to aggregate values from Level II plots and show changes across European climatic regions. Details on the aggregation can be found in Zimmermann et al. (2023). The most frequent Koeppen climatic regions in Europe are (1) C-climates, which are temperate climates such as the CfB atlantic temperate (beech climate) or the warm to hot Mediterranean climate (Csb, Csa), and (2) D-climates, which are continental climates from the humid continental (Dfa, Dfb: oak climate) to the subarctic (Dfc: birch climate), and also to the Mediterranean-influenced warm-summer humid continental climate (Dsa) (Tab. 7-1, Fig. 7-1).

Table 7-1: Number of meteorological stations at Level II plots in different climatic regions in 2022. For criteria, please refer to Table 3 in Beck et al. 2018.

Code	Description of climate	Name	Stations
BSk	Arid, steppe, cold	Cold semi-arid climate	6
Cfa	Temperate, no dry season, hot summer	Humid subtropical climate	2
Cfb	Temperate, no dry season, warm summer	Temperate oceanic climate	18
Csa	Temperate, dry summer, hot summer	Hot-summer Mediterranean climate	4
Csb	Temperate, dry summer, warm summer	Warm-summer Mediterranean climate	2
Dfa	Cold, no dry season, hot summer	Hot-summer humid continental climate	1
Dfb	Cold, no dry season, warm summer	Warm-summer humid continental climate	103
Dfc	Cold, no dry season, cold summer	Subarctic climate	22
Dsb	Cold, dry summer, warm summer	Mediterranean-influenced warm-summer humid	1
		TOTAL	159

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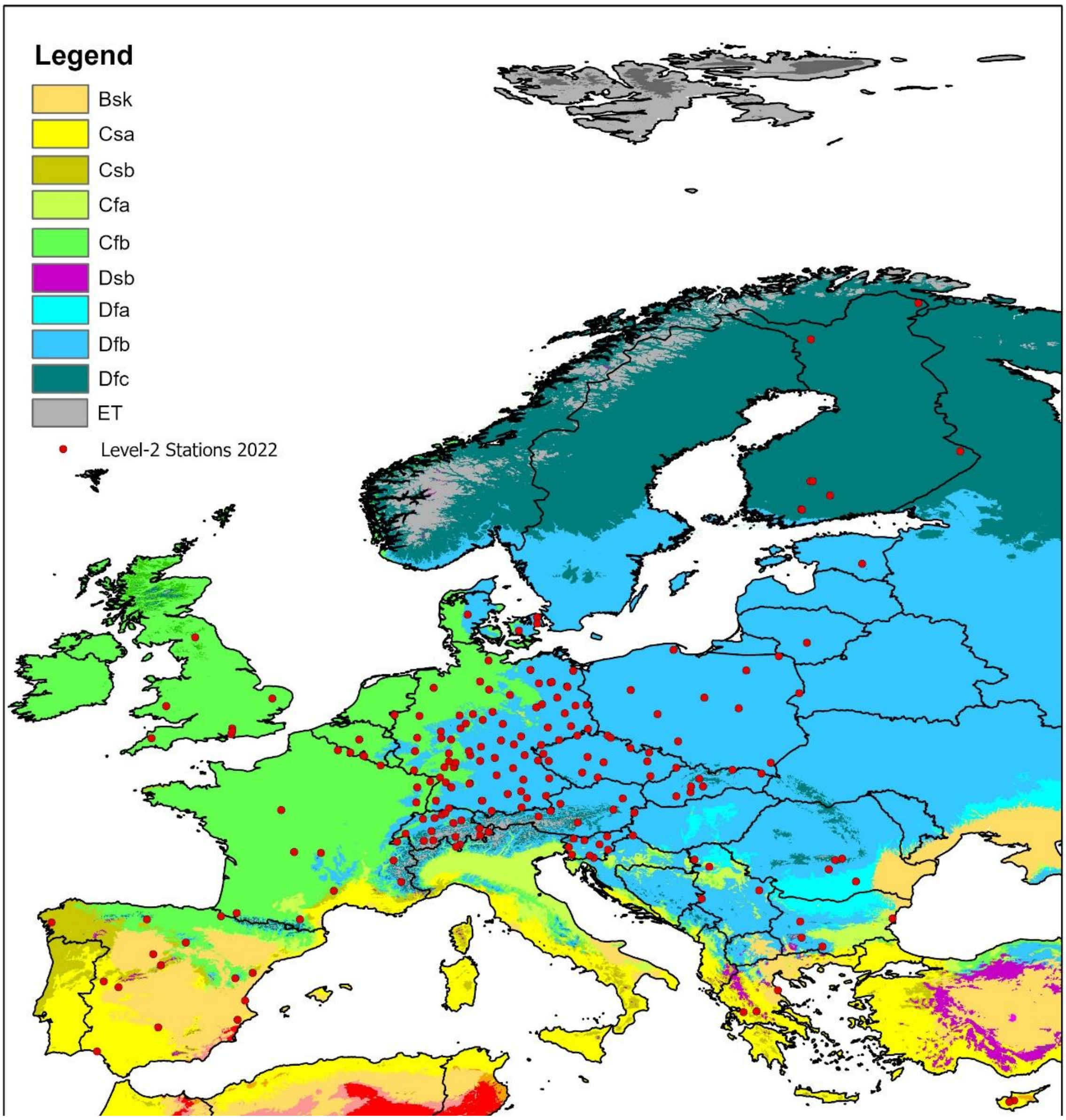

Figure 7-1: Map of Level II stations with gap-filled time series of meteorological data for 2022 and for different climatic regions (Table 7-1 acc. to Beck et al. 2018)

Climate and weather in Europe 2022

According to the European State of the Climate 2022 Report (Copernicus Climate Change Service (C3S) 2023), the year 2022 was the second warmest year on record in Europe (+ 0.9 °C to reference period 1991-2020). For many countries in southwestern Europe, the year was even the warmest since records began. But temperatures in northeastern Scandinavia were also above average (1991-2020). There were many more warm periods than cool periods in 2022. The year as a whole was as much as 10% drier than average.

In winter, precipitation varied between regions, with wetter-than-average conditions in northern and eastern Europe and drier-than-average conditions in southwestern Europe. Spring was drier than average across most areas. May was the driest month with 21–28% less precipitation than average. In March and May, daily maximum temperatures were up to 8°C above average. The summer in 2022 was definitely the warmest since 1950 (+1.4 °C above 1991–2020 average) even surpassing the previous warmest summer 2021. In southwestern and western areas, up to 30% more warm days occurred than average, highlighting the frequency of high temperature extremes in line with a changing climate. During summer large parts of Europe were affected by exceptional heatwaves, and in western Europe the highest temperatures were around 10°C above the typical summer maximum temperatures. In July, air temperatures in the UK reached 40°C for the first time on record.

Summer and spring in 2022 were drier than average across most areas, which can be attributed to periods of drought. Driest anomalies were found in Germany, Spain, and the UK. Central

European countries experienced a prolonged drought. High temperatures and dry conditions contributed to the spread and intensification of wildfires, with the second largest burnt area on record, with very large fires in south-eastern Europe and the Mediterranean region. September was the wettest month with 13–21% more precipitation. October was the warmest on record and December started cold but turned exceptionally warm towards the end of the year. In northern Europe a cold wave was registered in December.

Materials and methods

Meteorological data was available for 2022 from 159 ICP Forests Level II sites for generating this report. Details on the meteorological measurements, the equipment used, the quality standards, and the procedures for closing gaps in the ICP Forests program can be found in Zimmermann et al. (2023) and in Raspe et al. (2013). In this chapter, we only present air temperature and precipitation data in 2022 and compare it with their long-term average (1990–2022).

Results

Air temperature

Deviations of annual mean air temperature

The year 2022 was generally warmer than the long-term average (Fig. 7-2). The largest positive deviations were observed primarily in the UK, Germany, Switzerland, France, Spain, and Serbia, while the deviation was somewhat smaller in Finland, the Baltic states, Poland, Slovakia, Slovenia, and Romania.

Deviation of mean air temperature in the vegetation period

During the vegetation period, it was warmer than the long-term average in most parts of Europe (Fig. 7-3). Many Level II plots in Spain, France, Switzerland, and western Germany recorded mean temperatures that were more than +1.5 °C warmer than normal. In Denmark, eastern Germany, Austria, Poland, Czechia, Slovakia, Slovenia, and Romania, the positive deviation was smaller, with few plots even showing almost no change. Interestingly, the Finnish, Polish, and Romanian stations also showed positive anomalies, while their deviations from the annual temperatures were moderate (Figs. 7-2, 7-3).

Annual mean air temperature in different climatic regions

To complement the picture of annual mean air temperature at specific Level II plots during the year 2022, averages for Level II plots in different climatic regions were calculated. Figure 7-4 shows that in almost all climate zones, the air temperature in 2022 on Level II plots was at least 1 °C higher than the long-term average. Exceptions are the subarctic (Dfc) and hot-summer Mediterranean (Csa) zones with slighter increases.

Temperature stress indicators

The health and vitality of forests is more strongly influenced by extreme temperatures than by average conditions. In this respect, heat and frost events are of particular interest.

Heat

In 2022, maximum air temperatures during the vegetation period at Level II plots from the British Isles to Belgium, the Netherlands, Germany, and Poland were between 36 °C and 40 °C. Maximum temperatures of more than 40° C were observed in Spain, Slovenia, Serbia, and Greece (Fig. 7-5).

Another indicator of the risk of heat stress in forests is the number of hot days with a maximum temperature of 30 °C and more. A significant increase in the number of days with temperatures above 30 °C was observed in climatic regions that were also exposed to such high temperatures in the past (Fig. 7-6). For the majority of Level II plots in the cold semi-arid climate (BSk), the humid subtropical climate (Cfa), the temperate oceanic climate (Cfb), the Mediterranean climates (Csa and Csb), and the humid continental climates (Dfa and Dfb), there was a significant increase in extremely hot days compared to the long-term average (Fig.7-6) and almost twice as many hot days were counted in some climate zones (e.g., Cfb or Csb) in 2022. A slightly lower – but still remarkable – increase in hot days of around 30% and more was observed in other climate zones such as the humid subtropical (Cfa) or the humid continental climate zones Dfa, Dfb).

Late frost

Late frost occurs when the minimum daily temperature falls below 0 °C after the start of the vegetation period. This can cause damage to young shoots or blossoms on trees, especially shortly after bud burst. The number of frost days in the growing season can therefore be seen as an indicator of late frost stress.

In 2022, most Level II plots in the continental climate zones (Dfx), showed a significant decrease in late frost events compared to the long-term average by more than 50 to 100%, indicating the very warm weather in 2022. Fewer frost days were usually also observed in the climate stations in the temperate climate zones (Csx, Cfb). The Level II plots in the humid subtropical climate (Cfa) were an exception to this general trend, with almost four times the number of frost days compared to the long-term average (Fig. 7-7).

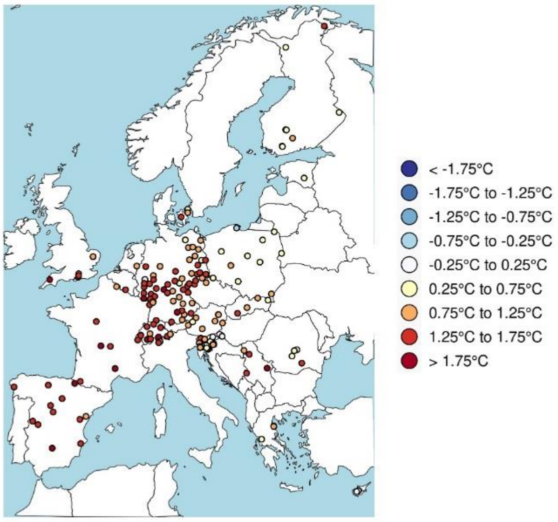

Figure 7-2: Deviation of annual air temperature (in °C) in 2022 from the long-term average (1990–2022) on Level II plots. Spanish data originate from a measurement height of 7 m.

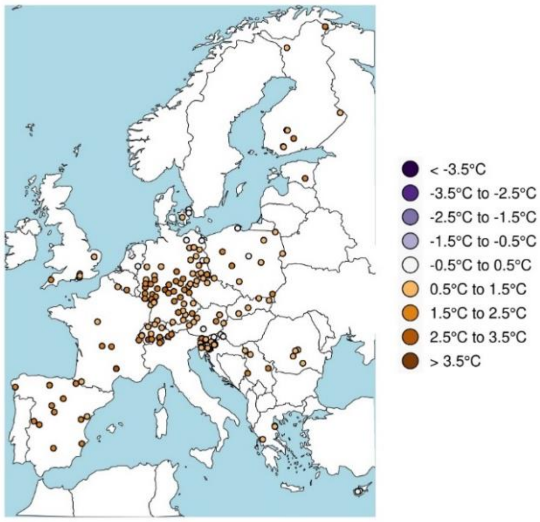

Figure 7-3: Deviation of mean air temperature in the vegetation period in 2022 from the long-term average (1990–2022) (in °C) on Level II plots. Spanish data originate from a measurement height of 7 m.

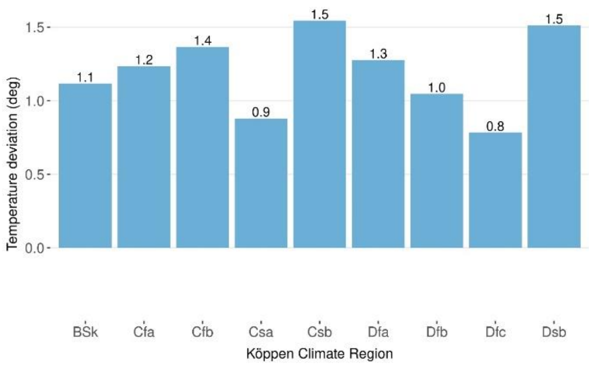

Figure 7-4: Deviation (in °C) of annual mean air temperature in 2022 from the long-term average (1990–2022) on Level II plots in different Koeppen climatic regions. For explanation of acronyms and for number of Level II plots in each climatic region, please refer to Tab. 7-1 and Fig. 7-1.

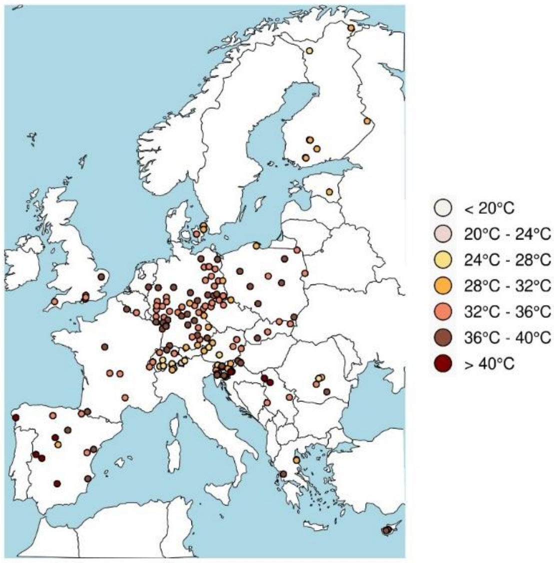

Figure 7-5: Maximum air temperature (°C) in the vegetation period in 2022 on Level II plots. Spanish data originate from a measurement height of 7 m.

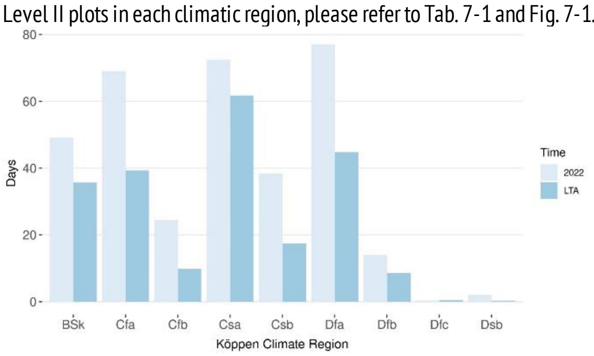

Figure 7-6: Number of hot days (Tmax ≥ 30 °C) in 2022 and long-term annual average (LTA, 1990–2020) on Level II plots in different Koeppen climatic regions. For explanation of acronyms and for number of stations in each climatic region, please refer to Tab. 7-1 and Fig. 7-1.

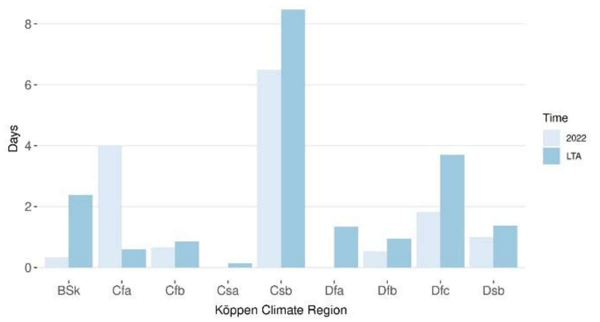

Figure 7-7: Number of late frost days (Tmin in vegetation period < 0°C) in 2022 and long-term annual average (1990–2022) on Level II plots in different Koeppen climatic regions. For explanation of acronyms and for number of stations in each climatic region, please refer to Tab. 7-1 and Fig. 7-1.

Precipitation

Deviation in annual precipitation

In general, 2022 was significantly drier than normal across Europe (Fig. 7-8) with a reduction in annual precipitation by -15 to -45% on average. In Germany and Czechia, quite a few stations show no change or even a slight increase in precipitation, which also applies to a number of stations in Austria, Spain, northeastern Poland, and Finland. In the UK, all but one Level II plot in the south show decreasing precipitation while in Spain precipitation was either increasing or decreasing. In France and south-eastern Europe, annual precipitation decreased on all Level II plots.

For the majority of Level II plots in continental climates (Dfx) as well as in the more oceanic (Cfa) and Mediterranean climates (Csx), precipitation was significantly drier than normal. Plots in the Mediterranean-influenced warm-summer humid continental climate (Dsb), the temperate oceanic climate, and the cold semi-arid climate (BSk) had wetter conditions than normal (Fig. 7-9).

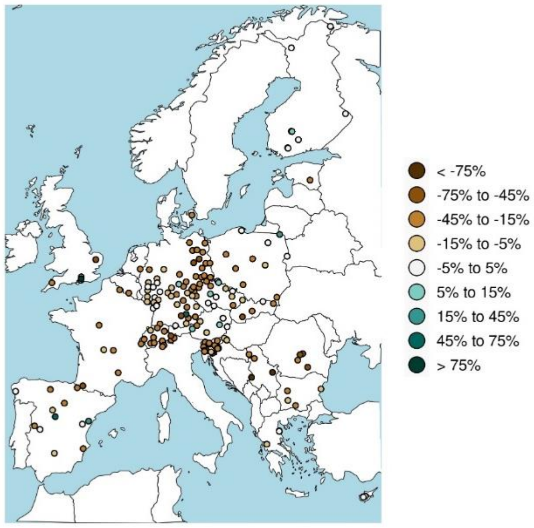

Figure 7-8: Deviation (in %) of the total annual precipitation in 2022 from the long-term yearly average (1990–2022) on Level II plots.

Precipitation in the vegetation period

The amount of precipitation during the growing season is of particular importance for the water supply of forests. With regard to the deviation of the amount of precipitation in the vegetation period from the long-term average, the majority of Level II plots in Europe showed a significant decrease, with the exception of a few individual stations in Czechia, north-eastern Poland, southern Germany, and Austria, which recorded an increase due to heavy rainfall events (Fig. 7-10). The decrease was extremely high in south-eastern Europe and in Spain but also at individual stations in southern England and eastern Germany. Even in the Swiss Alps, the majority of stations showed negative deviations. Exceptions were single stations in Cyprus, Greece, and Spain where, in contrast, a clear positive deviation was found.

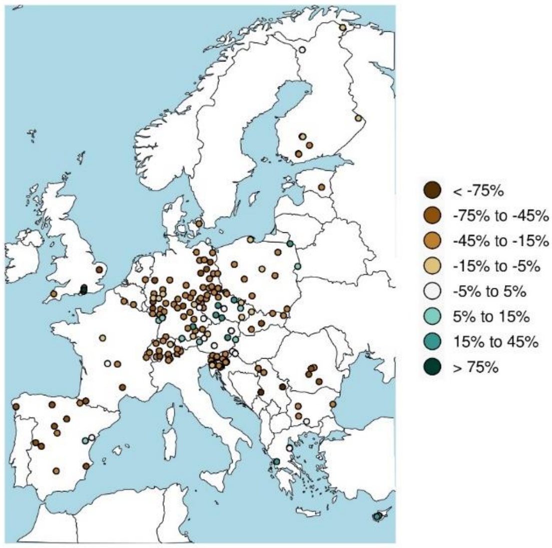

Figure 7-10: Deviation (in %) of the precipitation in the vegetation period in 2022 from the long-term average (1990–2022) on Level II plots.

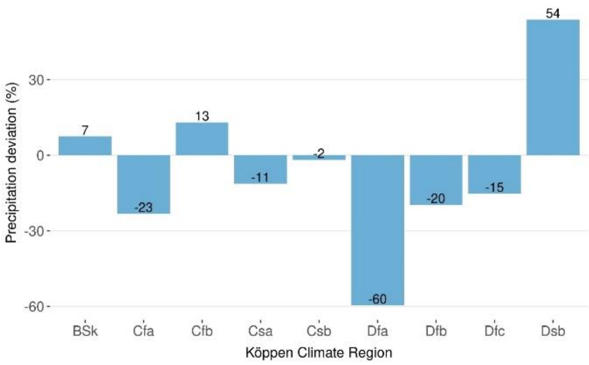

Figure 7-9: Deviation (in %) from the long-term average of the annual precipitation on Level II plots in different Koeppen climatic regions. For explanation of acronyms and for number of stations in each climatic region, please refer to Table 7-1 and Figure 7-1.

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