Umwelt Bundes Amt
Für Mensch und Umwelt

Dessau, January 2007

Regional climate changes: Recent findings

WETTREG: A statistical regionalization model

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1. Introduction

1.1 Clear-cut targets in regard to climate change

Climate change is no longer a matter of a distant future; it is already taking place all over the world, in Europe and also in Germany. Thus, an increase in the number of extreme weather events such as heat spells and floods is observed. For example, the Elbe flood in 2002 caused material damage amounting to more than 9 thousand million Euros; 18 persons lost their lives. A comparison of historical and current photographs depicting glaciers in the Alps gives evidence of their drastic shrinking during recent decades. Although the unusually mild beginning of the new year in terms of temperatures cannot be directly attributed to climate change, it has made many people think about what we may perhaps have to experience more often in the future.

The international community of nations has reacted to the signs of climate change by adopting the United Nations Framework Convention on Climate Change already in 1992. This Convention stipulates, among other objectives, a stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Since then, too little has been done to achieve this aim. Current projections of future climatic development are alarming and show enormous risks to exist both for the national economies and the stability of ecosystems and thus for a sustainable development. In order to avoid at least the uncontrollable effects of climate change and to reduce the risk of sudden and irreversible climate changes, the rise in temperature needs to be permanently limited to a maximum of 2 °C as compared to pre-industrial levels. This aim can only be achieved if the trend in global greenhouse gas emissions is reversed within the next 10 – 15 years. Subsequently, mankind will have to reduce global greenhouse gas emissions to less than half the 1990 level by the middle of the 21^{st} century. Germany should actively continue playing its pioneering role in climate protection and aim to reduce its greenhouse gas emissions by 40 % against the 1990 level by 2020.

Science and policy-makers use climate models to evaluate possible future climate developments and thus, as a basis for the assessment of risks and opportunities posed by future climate changes as well as of the adaptive measures necessary in various sectors. Such models serve to study possible corridors of future climate development. They refer to a number of emission scenarios based, among other factors, on assumptions regarding future economic development and population growth. There are global climate models simulating the climate of the entire earth, and regional climate models producing data for defined regions. This background paper presents a regional climate model named WETTREG, which has been used to determine possible future climate changes in Germany. Statements are made as to possible regional consequences of climate change and to the regions that may be particularly affected, as well as to the types of consequences to be expected. The results produced by these WETTREG model runs are available in the form of a report (in German) plus background information (published on the UBA website).

1.2 The WETTREG model

At present, global climate models, i.e. models covering the entire earth, are able to provide data with a horizontal resolution of ca. 200 x 200 km. However, this resolution, which in terms of global models is regarded as very high, is insufficient for many purposes. Therefore, regionalization methods have been developed. There are, in principle, two different methods: dynamic and statistical. Examples include the REMO and the WETTREG model, which are both used by the UBA. Of these, REMO represents a dynamic and WETTREG, a statistical approach[1]

WETTREG was used to develop regional climate projections for Germany. WETTREG is based on data from meteorological stations and produces results for those stations for which also time series of measurements are available. Input data of the model include meteorological data from 282 climate stations and 1695 precipitation stations all over Germany.

The global climate simulations forming the basis for WETTREG were calculated by means of ECHAM5/MPI-OM, a global model which is run by the Max Planck Institute for Meteorology in Hamburg. The simulations were performed for the 2010 to 2100 period. The emissions scenarios A1B, A2 and B1 described in the Special Report on Emissions Scenarios (SRES) by the Intergovernmental Panel on Climate Change (IPCC) served as a basis for the calculations. The assumptions used in the scenarios A1B and B1, which are referred to in this background paper, are explained in Chapter 1.3 below (also cf. IPCC 2002, p. 30 – 31).

The simulation calculations made by means of WETTREG formed part of the research project ”Klimaauswirkungen und Anpassung in Deutschland – Phase 1: Erstellung regionaler Klimaszenarien für Deutschland“ (Climatic impacts and

[1] Dynamic methods simulate parameters for subregions of the global model region by means of a dynamic model with a higher resolution, using input data from the global model. Statistical methods are based on the assumption that global models are able to precisely describe the patterns of atmospheric circulation on the global scale. Most of these models identify statistical relationships between global scale patterns and/or weather situations, and the local consequences, with the relationships derived from the past or the present being applied to the projections of global models. The statistical model, WETTREG, used by the UBA does not establish the climate signal directly from the scenario calculations of the global climate model but through the causal chain of changing

adaptation in Germany – Phase 1: Generation of regional climate scenarios for Germany) and were carried out by Climate & Environment Consulting Potsdam GmbH.

1.3 Characterization of the SRES scenarios

A1B, referred to below as the higher-emissions scenario, is based on:

- A globally oriented development characterized by strong economic growth;
- Rapid introduction of new and more efficient technologies;
- Use of fossil and renewable energy sources;
- A growth of the global population that peaks in the middle of the 21st century and is followed by a decline;
- An increase in CO_2 emissions that peaks in the middle of the 21st century and is followed by a slight decline by 2100.

B1, referred to below as the lower-emissions scenario, is based on:

- A globally oriented development and the introduction of low-emission and resource-efficient technologies;
- Focus on socially and environmentally sustainable development, but without additional climate protection initiatives;
- A growth of global population that peaks in the middle of the 21st century and is followed by a decline;
- An increase in CO_2 emissions that peaks in the middle of the 21st century and is followed by a marked decline by 2100 (emission level in 2100 lower than assumed for A1B).

1.4 Interpretation of climate simulations

The results produced by the ECHAM5 global model at the Max Planck Institute for Meteorology in Hamburg and consequently, also those of the WETTREG regional model **cannot** be interpreted as forecasts. Rather, they have to be considered as climate scenarios or climate projections. Unlike forecasts, climate scenarios and projections merely describe possible future climate developments or corridors of climate development. Climate models are not capable of forecasting the climate for a defined period in the future. In addition, climate projections will by no means produce

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frequencies of weather situations in the day-to-day reality of the climate model characterized by high or low temperatures and low or high precipitation levels.

the absolute truth; rather, they may be changed when based on different assumptions or in the light of new findings.

The reasons why climate simulations cannot be interpreted as forecasts include the fact that for their calculations, climate models require comprehensive information on the future development of factors not yet known to a sufficient extent. Such factors having a decisive influence on the climate include, for example, solar radiation, the position of the Earth relative to the Sun, greenhouse gas emissions (which are highly dependent on economic development and global population growth) and the resulting concentrations in the atmosphere, volcanic activity or the condition of the Earth’s surface. For extended future periods these climatic factors are not sufficiently known in advance. Therefore, climate projections are not to be interpreted as forecasts of the future climate but serve to simulate different possible future climate developments (climate trends).

In addition, a detailed interpretation of the results from the WETTREG model should take into account the following: It is not possible to perform an evaluation for a defined year in the future, and it is not always useful to assess the findings made for a single meteorological station. To be adequately representative, spatial evaluations should preferentially refer to regions and temporal evaluations should refer to periods of time of at least a decade or even better, three decades.

2. Selected results produced by the WETTREG model

The presentation of results will refer to emissions scenarios A1B and B1. For better illustration, the statements below refer to A1B and B1 as the “**higher-emissions scenario**” and the “**lower-emissions scenario**”, respectively.

2.1 Temperature

The fundamental parameter chosen for the evaluation is average daily temperature. We will compare average daily temperatures of the 1961 – 1990 period, as obtained from WETTREG simulations based on the data from the ECHAM5 control run, with the average daily temperature in the 2071 – 2100 period simulated by means of WETTREG. Fig. 1 shows the control run. Figs. 2 and 3 illustrate the difference between the 2071 – 2100 period and the control runs for the higher-emissions scenario (A1B) and the lower-emissions scenario (B1).

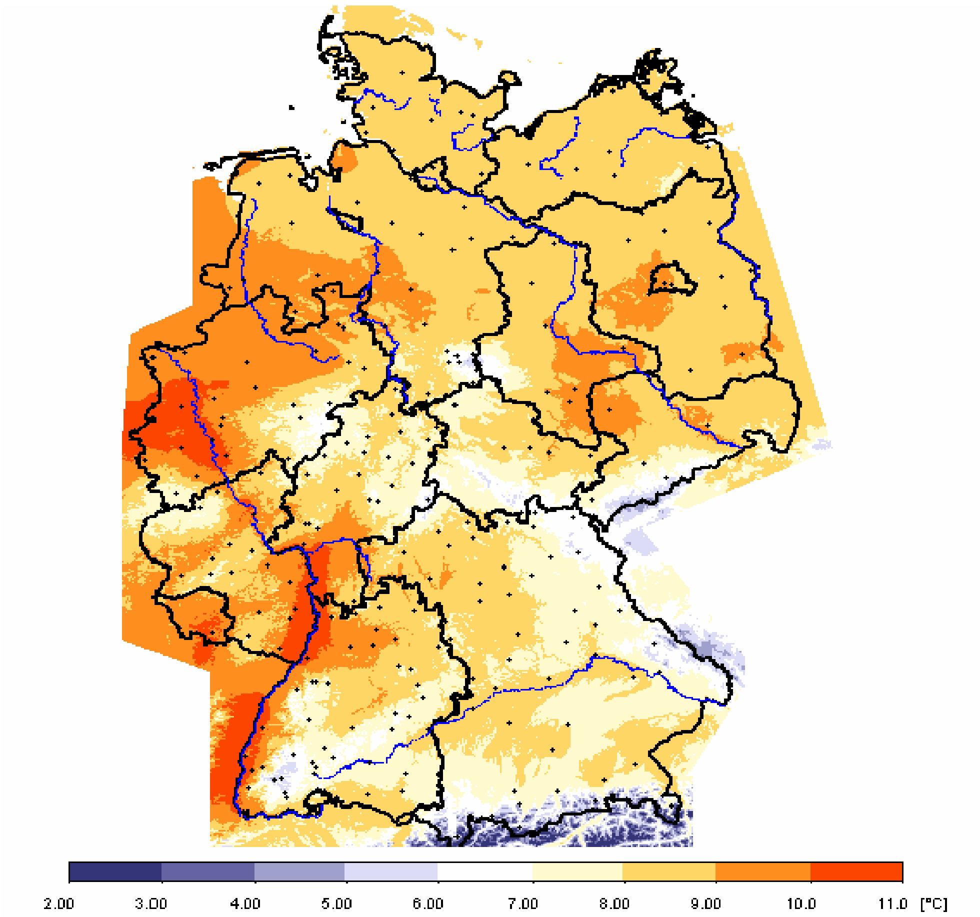

Fig. 1: Average daily temperature, averaged over the 1961 – 1990 period (ECHAM5 control run); Blue: Low temperature; Red: High temperature; Area average: 8.2°C; Black dots denote climate stations

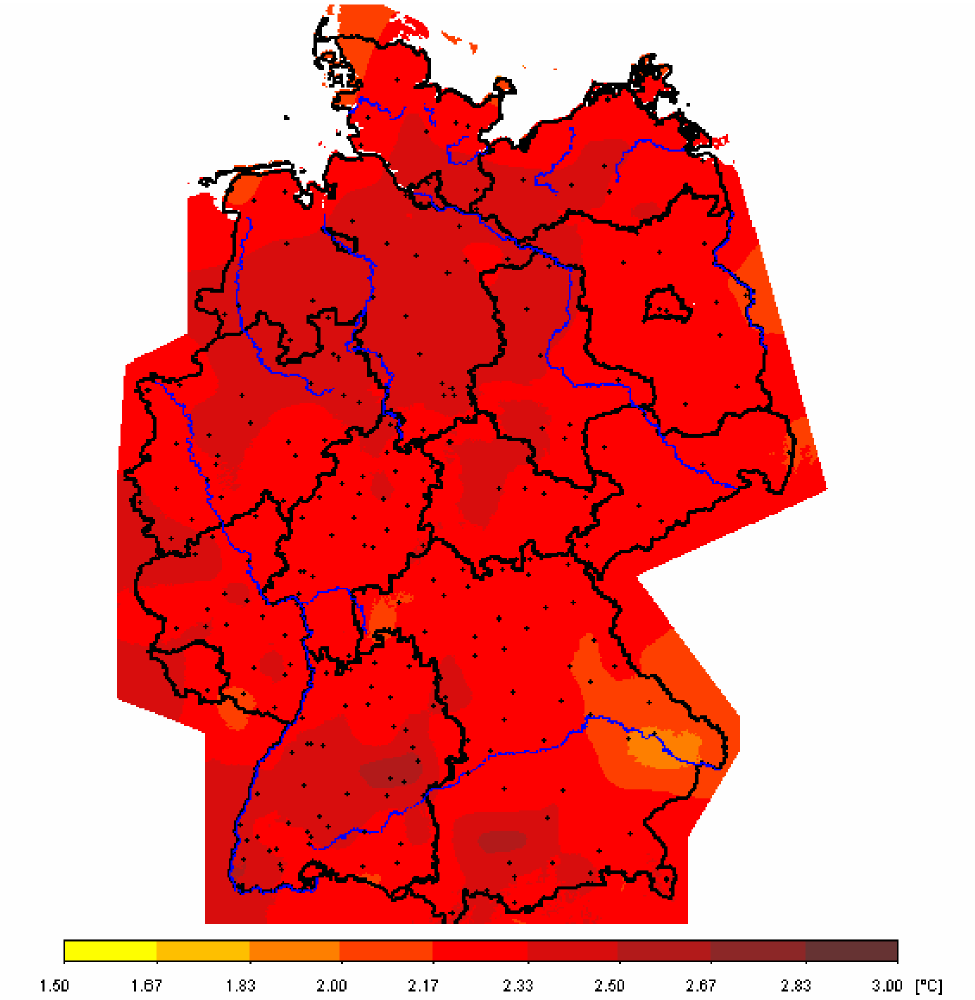

Fig. 2: Average daily temperature: Difference between the 2071 – 2100 period and the 1961 – 1990 period for the higher-emissions scenario (A1B); Yellow: Minor temperature rise by the end of the 21st century; Dark red: Major temperature rise by the end of the 21st century; Area average: 2.3°C

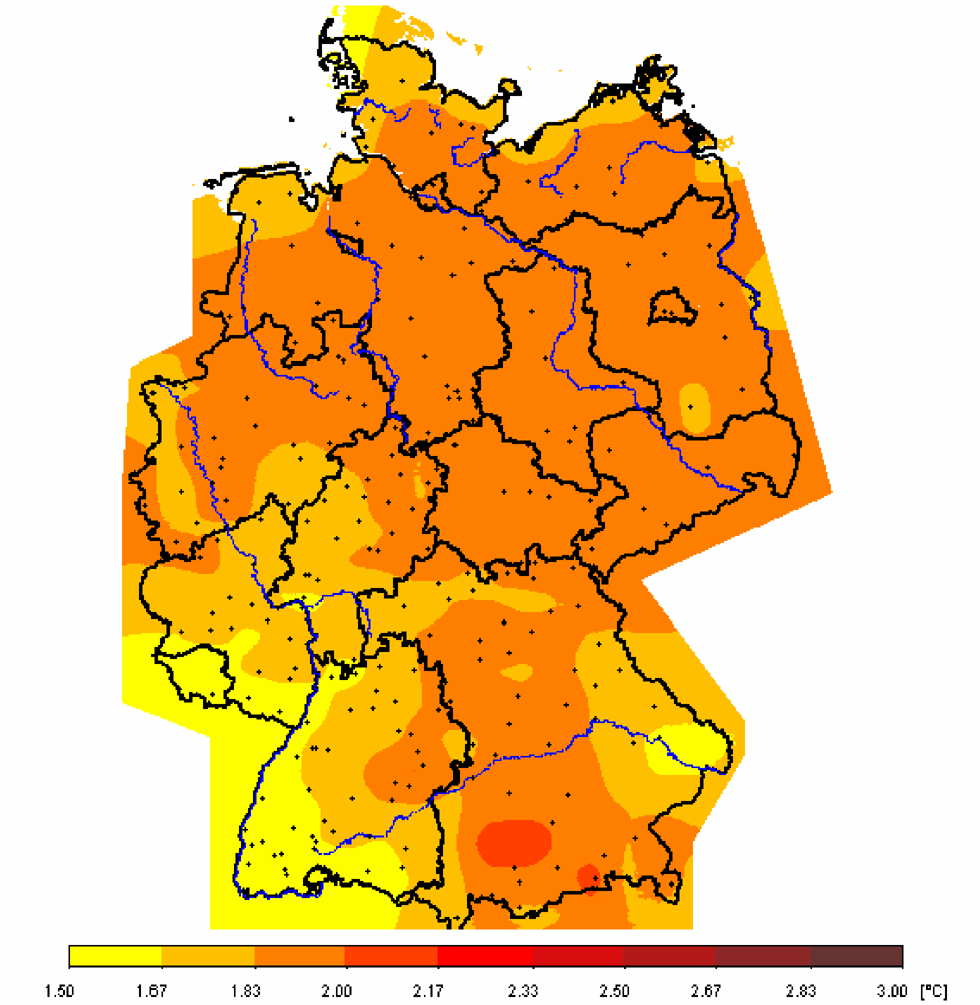

Fig. 3: Average daily temperature: Difference between the 2071 – 2100 period and the 1961 – 1990 period for the lower-emissions scenario (B1); Yellow: Minor temperature rise by the end of the 21st century; Dark red: Major temperature rise by the end of the 21st century; Area average: 1.8°C

The 1961 – 1990 control run (Fig. 1) shows relatively high temperatures in the Rhine and Mosel valleys and the Cologne basin reaching into south-western Lower Saxony. Also parts of Brandenburg, Saxony-Anhalt and Lower Saxony show relatively high temperature values. In contrast, lower temperature values are found in the mountainous regions.

Depending on the emissions scenarios, the WETTREG simulations for the three-decade period of 2071 – 2100 show the following patterns:

- Most pronounced warming in the entire north of Germany (except for the coastal regions) and in the foothills of the Alps;

- Comparatively minor regional warming in the coastal areas of the North and Baltic Seas, in the central low mountain ranges and in the eastern part of Bavaria;
- The mean temperature increase for the entire area of Germany was calculated at 2.3 °C for the higher-emissions scenario (A1B) and 1.8 °C for the lower-emissions scenario (B1).
- The simulated maximum and minimum warming is about 2.5 and 1.5 °C, respectively.
- In the south-west of Germany, simulation results obtained for the two emissions scenarios show the most pronounced differences in the entire simulation region; the higher-emissions scenario (A1B) results in a strong temperature rise, and the lower-emissions scenario (B1), in a minor temperature rise.

Figures 2 and 3 illustrate the clear differences between the results for the emissions scenarios A1B and B1.

2.2 Precipitation

Precipitation was also evaluated in a comparison of the 1961 – 1990 period (control run) with that of 2071 – 2100. Evaluation of precipitation has to take into account that modelling of this meteorological parameter is clearly less accurate than that of temperature. The parameter precipitation may vary extremely, which is why a representative evaluation should preferably use an average over a period of three decades.

The WETTREG simulations of precipitation show distinct – but opposite – trends for the summer and winter seasons with a net result of minor changes in annual precipitation. For this reason, and because of the importance of summertime precipitation for vegetation, a separate evaluation for summer and winter periods is meaningful.

2.2.1 Precipitation in summer

Fig. 4 shows the average summer precipitation in Germany by way of the WETTREG regionalization based on ECHAM5 control run data. Regions characterized by relatively low precipitation are found in the north-eastern and eastern parts of Germany and the Lower Rhine region, while high precipitation is seen mainly in the south-west, in the Alpine foothills and in the Alps. Validation of the WETTREG model showed that it slightly overestimates summer precipitation in the south-west and slightly underestimates summer precipitation in the north-west in the period of 1971 – 2000.

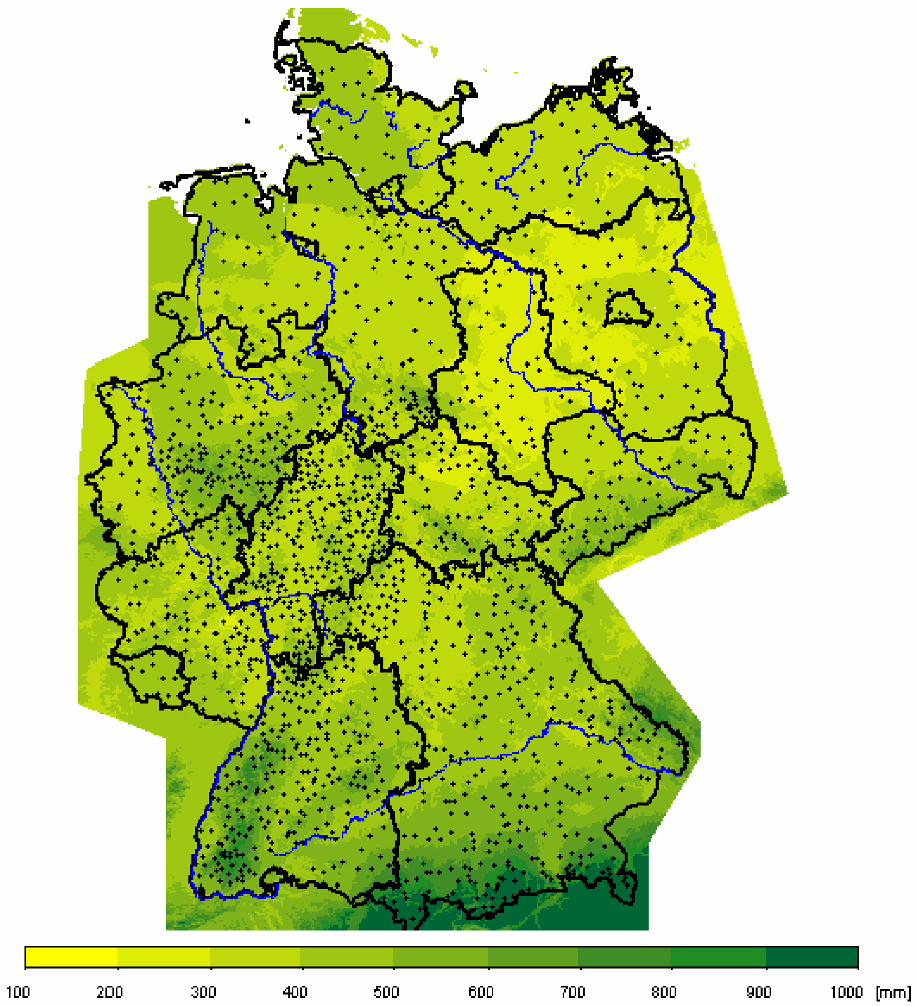

Fig. 4: Summertime precipitation, averaged over the 1961 – 1990 period (ECHAM5 control run); Yellow: Low summertime precipitation; Green: High summertime precipitation; Area average: 462.3 mm; Dots denote climate stations and precipitation stations

Figures 5 and 6 show the relative changes of summertime precipitation between the 2071 – 2100 period and the control run period of 1961-1990 for the higher-emissions scenario (A1B) and the lower-emissions scenario (B1). WETTREG simulates a clear decrease in average summer precipitation, of the order of 20%, by the end of the 21st century. The largest decrease appears in the north-eastern part of Germany. In the higher-emissions scenario, it amounts to more than 40 % in extensive areas of Western Pomerania. The lower-emissions scenario yields a lower decrease, amounting to about 25 % for Mecklenburg-Western Pomerania. Thus, the model projects a decrease in average summer precipitation for regions where precipitation was already relatively low in the control run.

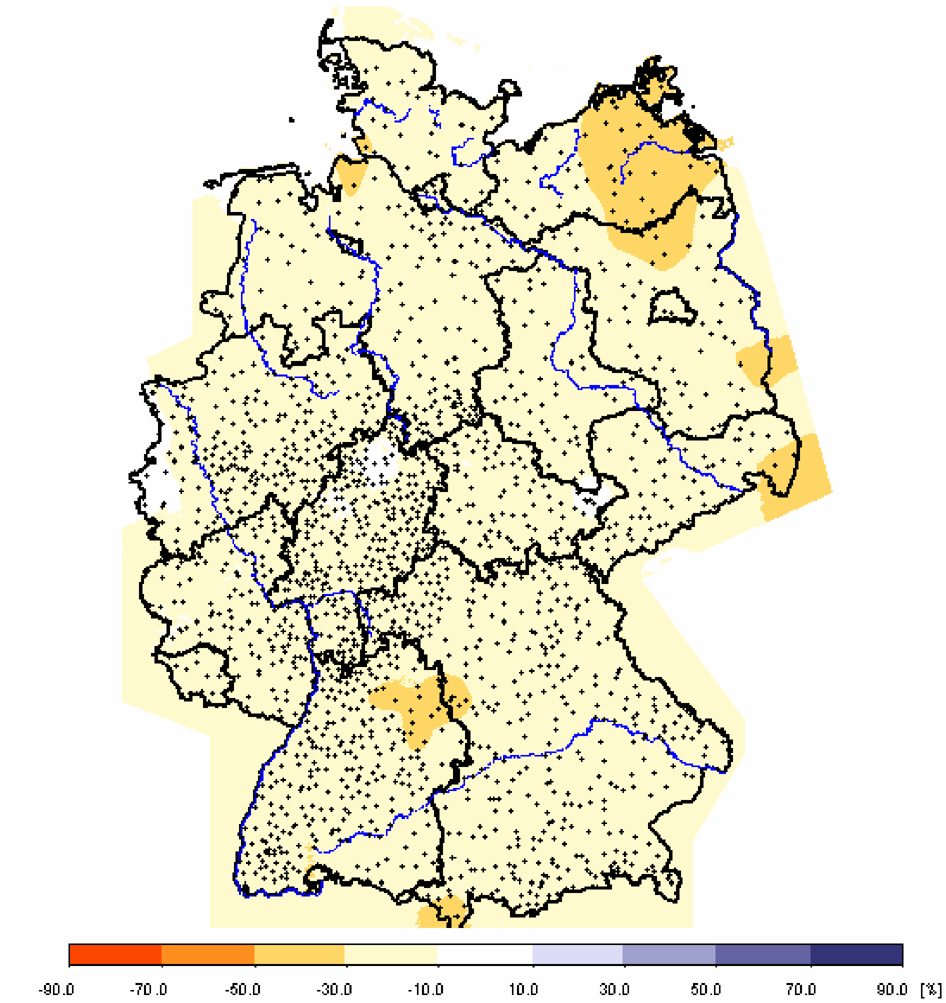

Fig. 5: Summertime precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the higher-emissions scenario (A1B); Red: Decrease in summertime precipitation by the end of the 21st century; Blue: Increase in summertime precipitation by the end of the 21st century; Area average: -22%

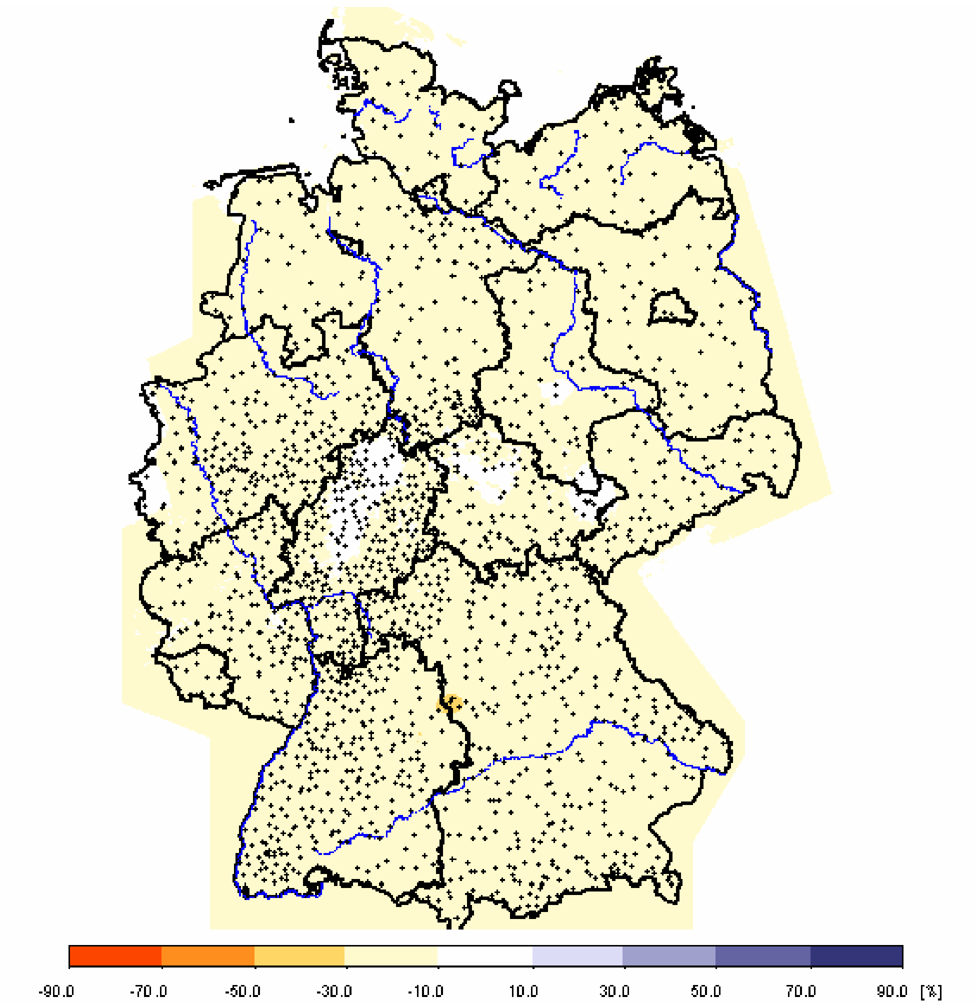

Fig. 6: Summertime precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the lower-emissions scenario (B1); Red: Decrease in summertime precipitation by the end of the 21st century; Blue: Increase in summertime precipitation by the end of the 21st century; Area average: -17.7 %

2.2.2 Precipitation in winter

Fig. 7 shows the average winter precipitation generated by WETTREG on the basis of the ECHAM5 control run (1961 – 1990). Higher average precipitation levels can be seen in the northern parts of the Harz Mountains, the Rhenish Slate Mountains (Rheinisches Schiefergebirge), the Thuringian Forest (Thüringer Wald), the Ore Mountains (Erzgebirge), the Spessart, the Oden Forest (Odenwald) and the Swabian Alb (Schwäbische Alb), as well as in the entire Black Forest (Schwarzwald) and in the Alpine region. Validation revealed that the WETTREG model slightly underestimates winter precipitation in the western parts of Germany and at the North Sea coast and slightly overestimates this parameter in the north-east.

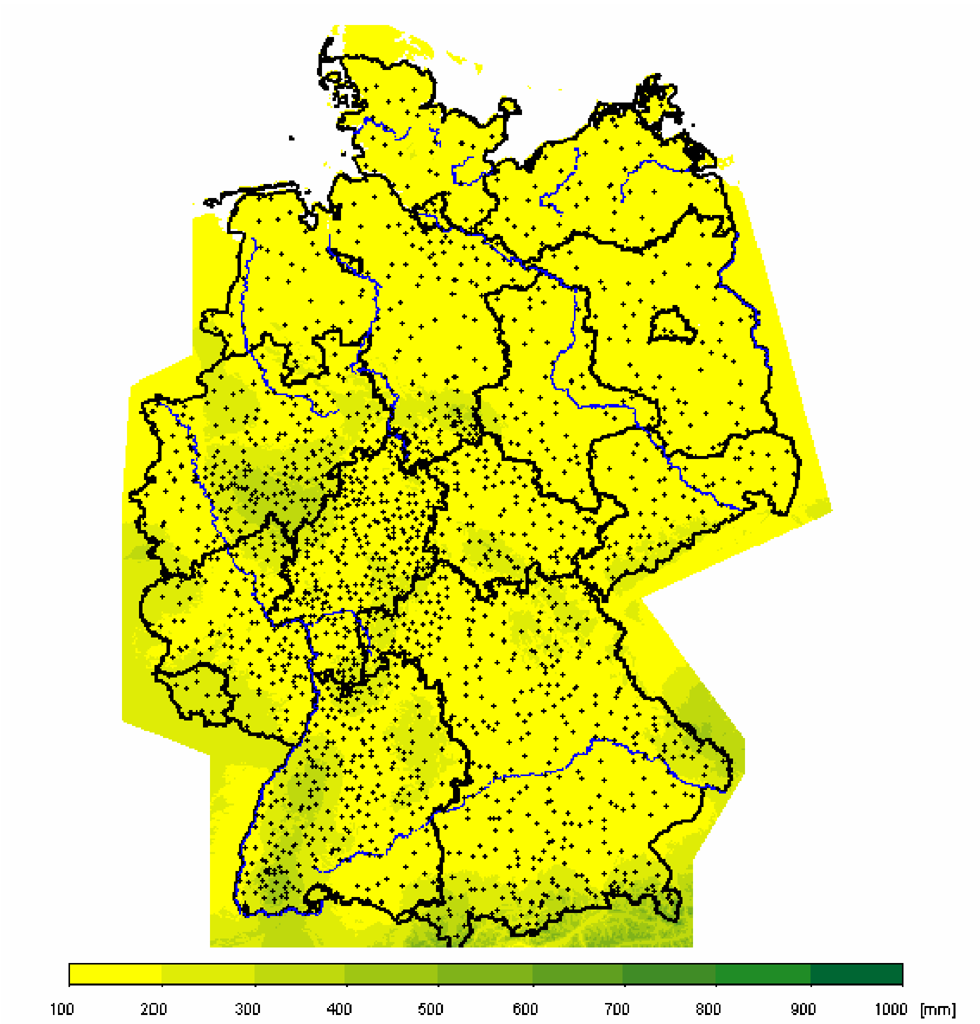

Fig. 7: Wintertime precipitation, averaged over the 1961 – 1990 period (ECHAM5 control run); Yellow: Low wintertime precipitation; Green: High wintertime precipitation; Area average: 192.4 mm

Simulation of the change of wintertime precipitation by the 2071 – 2100 period shows an average increase by 20 – 30 %, depending on the emission scenario (see Figs. 8 and 9; for reasons of comparability, the same range of values has been chosen for the graphical representations for summer and winter). For the higher-emissions scenario (A1B), the change signal is clearly more pronounced than that for the lower-emissions scenario (B1). Fig. 8 representing scenario A1B shows the highest increase in the western half of Germany, with particular emphasis on the Eifel and Hunsrück regions (by up to 80 %), the Oden Forest, Spessart and Rhön as well as Lower Franconia (Unterfranken), in some places by more than 70 %. An increase is also seen on the North Sea coast of Schleswig-Holstein and in the Danube valley. Relatively minor changes are projected for wintertime precipitation in the eastern parts of Germany, particularly in Brandenburg and Saxony, as well as in the Alpine region.

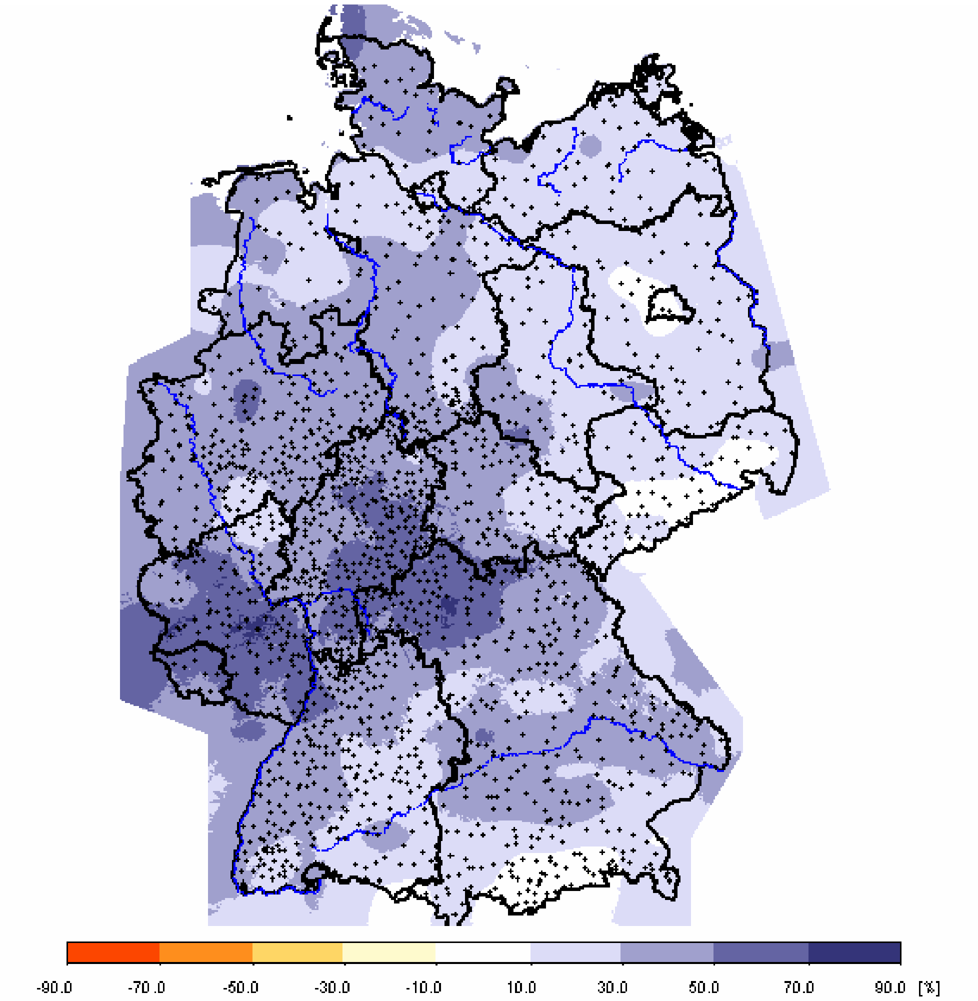

Fig. 8: Wintertime precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the higher-emissions scenario (A1B); Red: Decrease in wintertime precipitation by the end of the 21st century; Blue: Increase in wintertime precipitation by the end of the 21st century; Area average: 30.3%

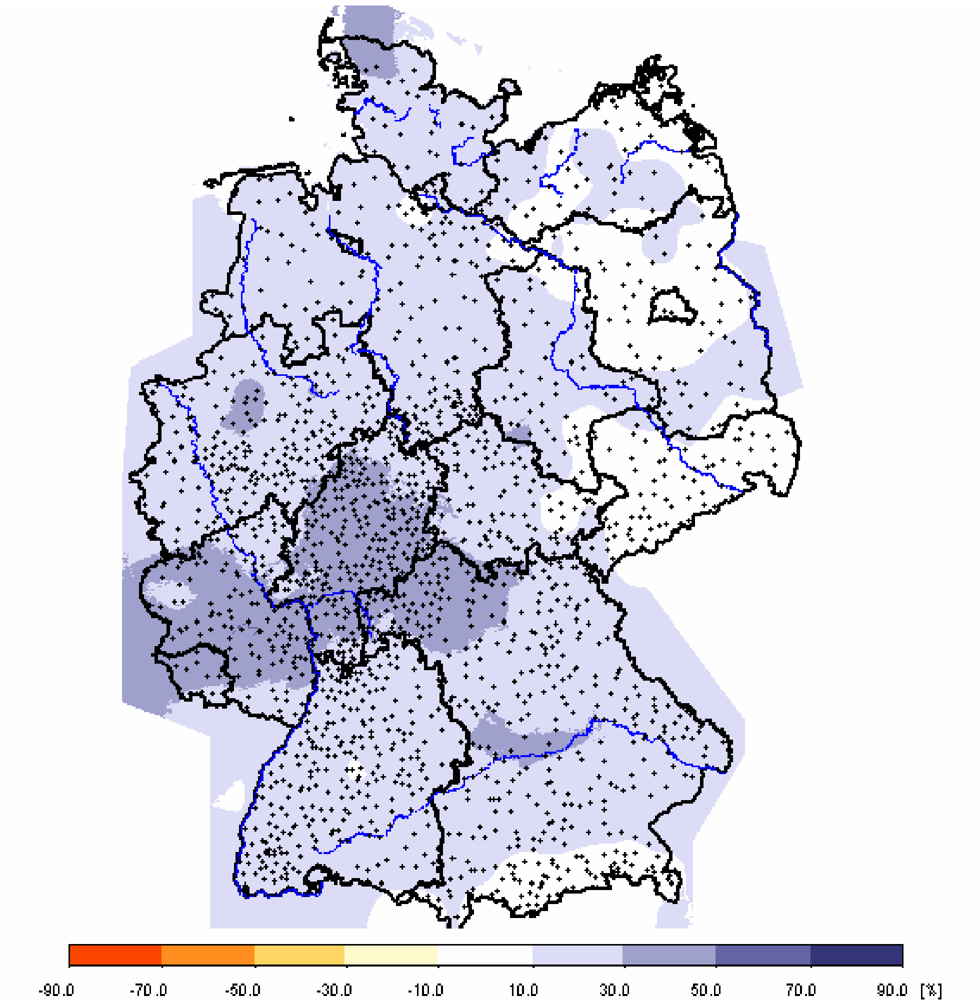

Fig. 9: Wintertime precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the lower-emissions scenario (B1); Red: Decrease in wintertime precipitation by the end of the 21st century; Blue: Increase in wintertime precipitation by the end of the 21st century; Area average: 19.0%

2.3 Results for selected regions and topographical areas in Germany

The Chapters below present WETTREG results for selected regions and topographical areas (for delimitations of topographical areas see Fig. 10) that have special characteristics or are projected to experience pronounced changes in atmospheric parameters.

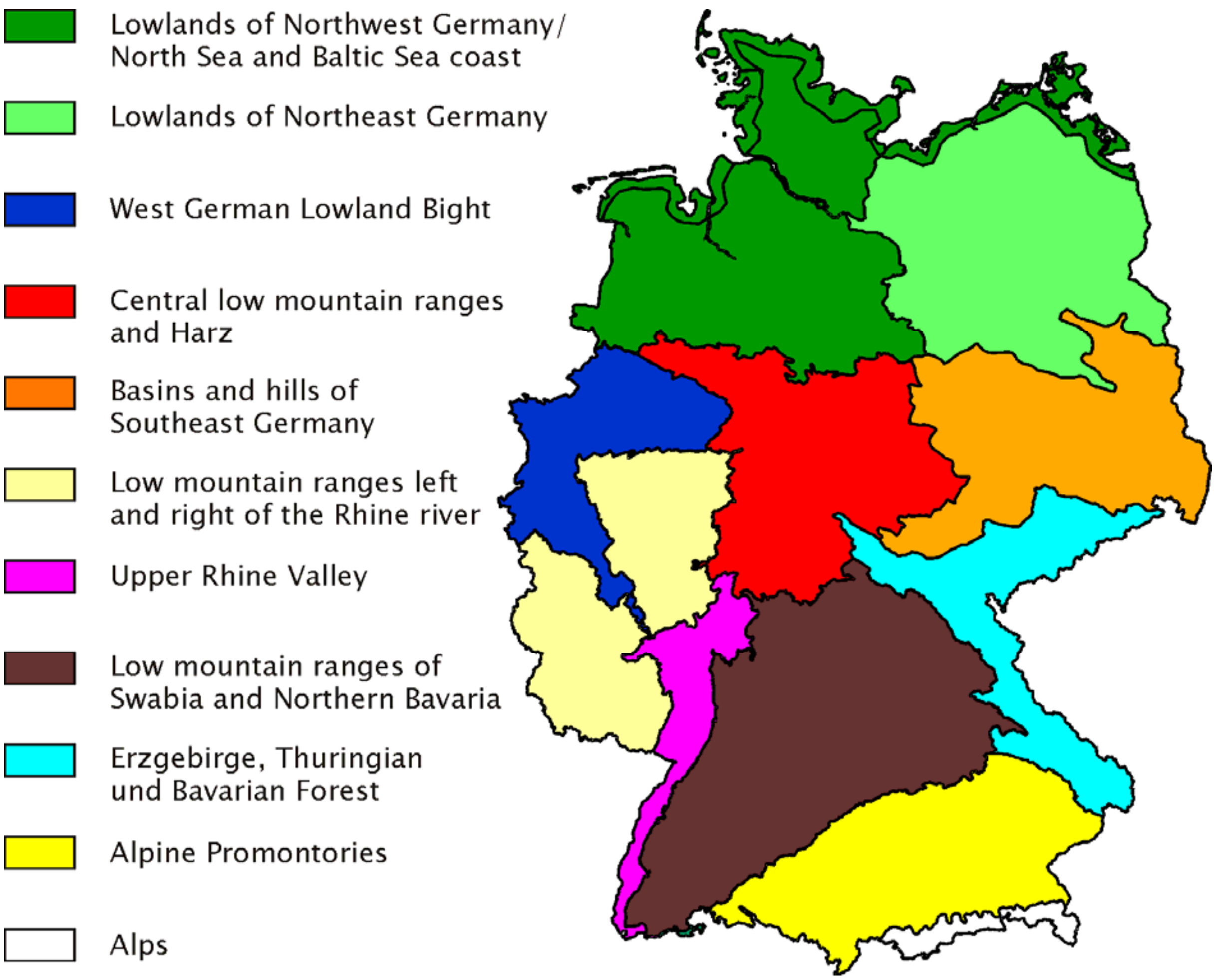

Fig. 10: Topographical areas in Germany

This evaluation for topographical areas also includes threshold days. Threshold days are defined as days when air temperature values are lower or higher than defined threshold values. The definitions of threshold days are listed in Table 1.

Threshold day	**Definition**
Ice day	Maximum temperature ≤ 0°C
Frost day	Minimum temperature ≤ 0°C
Summer day	Maximum temperature ≥ 25°C
Hot day	Maximum temperature ≥ 30°C
Tropical night	Minimum temperature ≥ 20°C

Table 1: Definitions of threshold days

2.3.1 The coasts of the North and Baltic Seas (Nord- und Ostseeküste)

The coastal regions were simulated to experience a comparatively low rise in temperature by the end of the 21st century. Reasons for this include the proximity to the sea and the relatively balanced and moderate character of the coastal climate. Also, threshold days show a lower absolute frequency at the coastal stations than in other regions. A striking finding is that the changes of the frequencies of characteristic days in the 2091-2100 decade against the 1981-1990 decade are nevertheless more pronounced in these regions than in other topographical areas. Fig. 11 shows the threshold days calculated for the Arkona station on the Baltic Sea coast in the higher-emissions scenario (A1B).

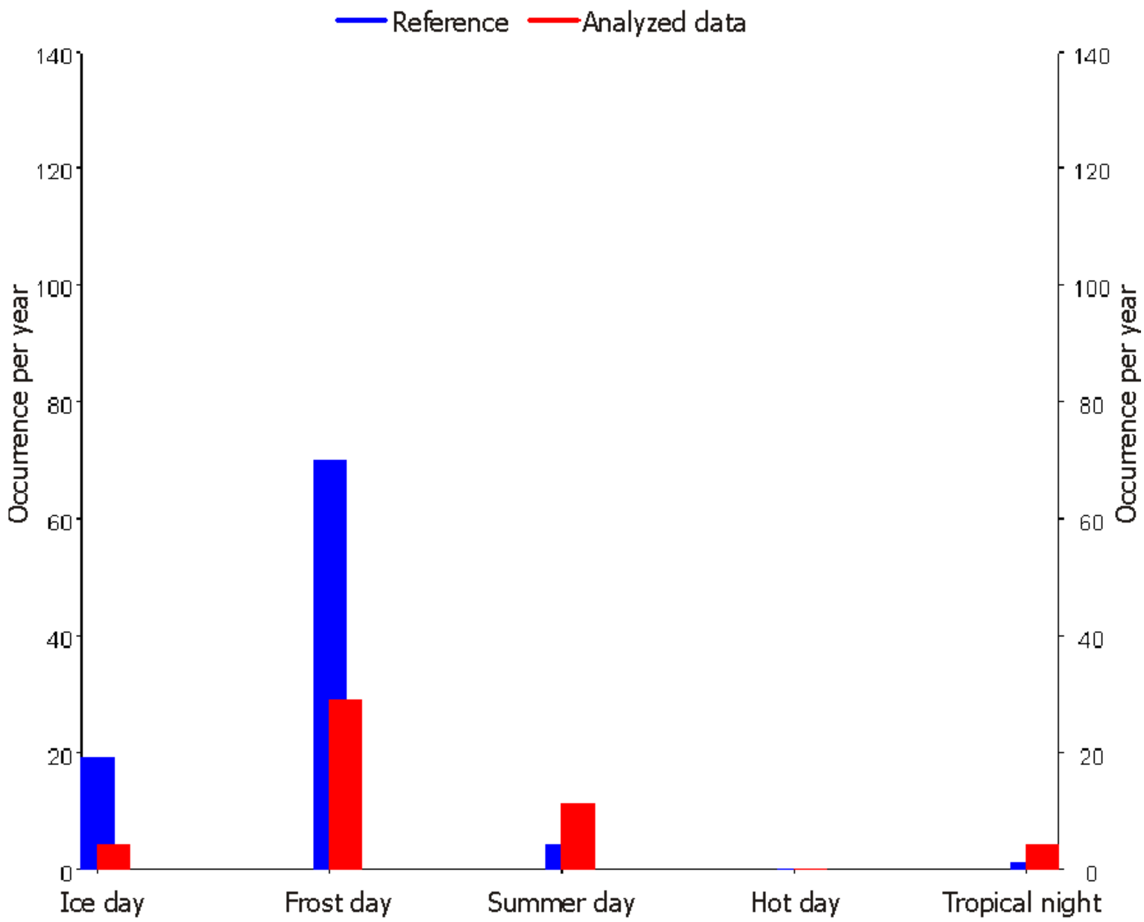

Fig. 11: Threshold days in the 1981 – 1990 decade (blue bars) and in the 2091 – 2100 decade (red bars) at the Arkona station in the higher-emissions scenario (A1B). The figure shows a strong decrease in the number of ice and frost days and a strong increase in the number of summer days and tropical nights by the end of the 21st century.

The figure representing the data for the Arkona station shows a decrease in the number of frost days to less than 50 % and a more than two-fold increase in the number of summer days. The simulation shows hot days to remain a rare occurrence by the end of the 21st century. However, for the number of tropical nights, more than a doubling can be expected.

With regard to precipitation in the 2071- 2100 period, calculations for the North Sea coast show an above-average increase in winter by up to 50 % (higher-emissions scenario A1B) and those for the Baltic Sea coast in Western Pomerania, a particularly strong decrease in summer, as illustrated by Figs. 8 and 5 (see above).

2.3.2 The lowlands of Northeast Germany

The prominent change in the north-east German lowlands concerns the precipitation signal.

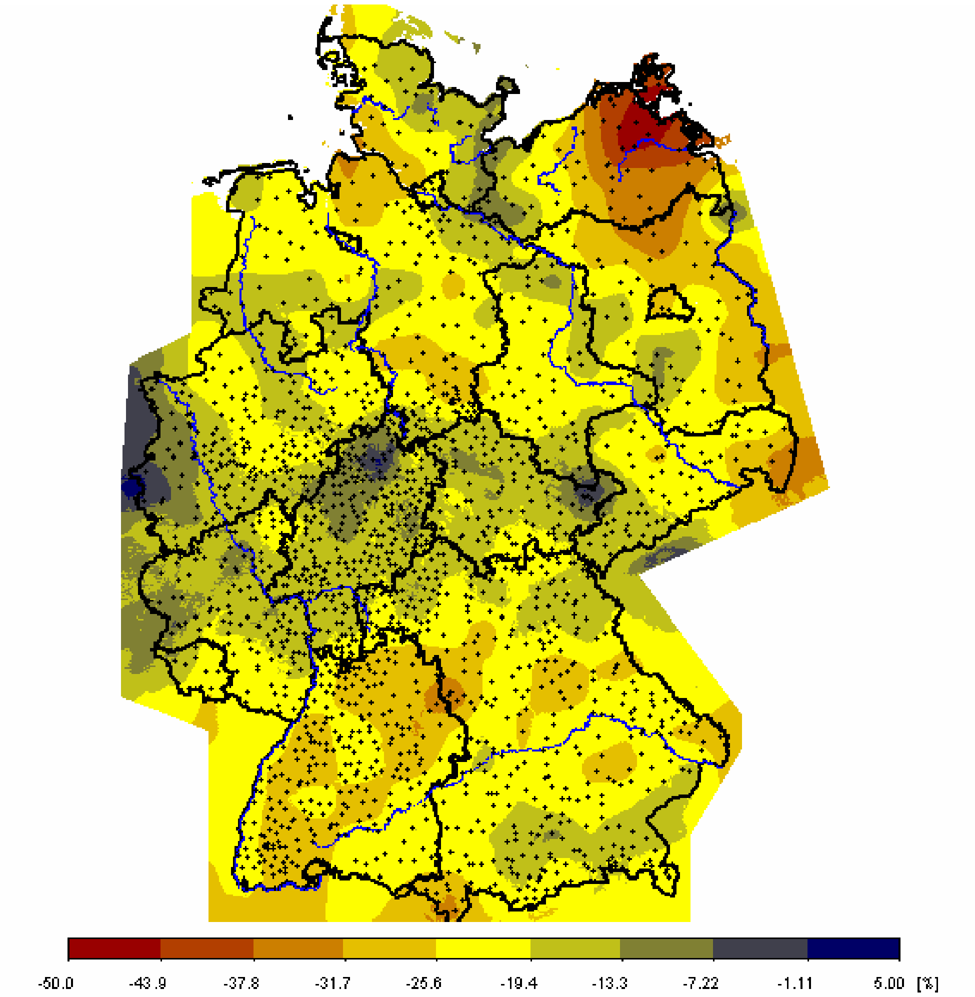

Fig. 12: Summer precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the higher-emissions scenario (A1B); Red: Decrease in summertime precipitation by the end of the 21st century; Dark blue: Increase in summertime precipitation by the end of the 21st century; Area average: -22 % (as in Fig. 5, but with a modified range of values for clearer illustration of changes)

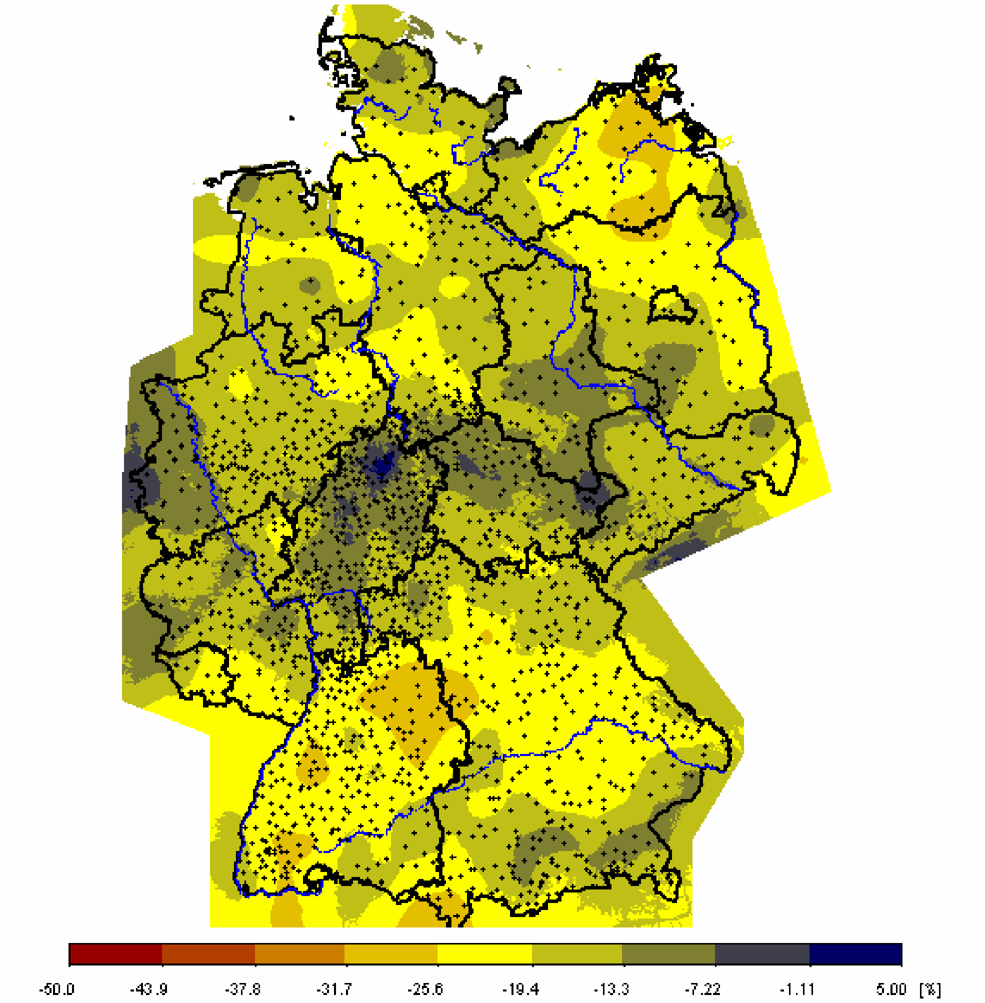

Fig. 13: Summer precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the lower-emissions scenario (B1); Red: Decrease in summertime precipitation by the end of the 21st century, Dark blue: Increase in summertime precipitation by the end of the 21st century; Area average: -17.7% (as in Fig. 6, but with a different range of values for clearer illustration of changes)

Evaluation of average summer precipitation by the end of the 21st century shows this region to see the highest decrease in all of Germany, as compared to the control run (1961 – 1990). In the higher-emissions scenario (A1B), precipitation falls by almost 50 %, while the lower-emissions scenario (B1) shows a decrease of about 30 % (see Figs. 12 and 13; for an improved visualisation of the changes, the range of values chosen is different from that in Figs. 5 and 6). In addition, the increase in winter precipitation is below average, amounting to 20 % in the higher-emissions scenario and to 10 % in the lower-emissions scenario.

Already under current conditions, i.e. at the baseline of the model calculations, average precipitation levels in the north-east German lowlands are low. If the WETTREG projections were to become reality, this would mean that the situation in this region becomes increasingly critical.

2.3.3 The central low mountain ranges and Harz Mountains

According to the WETTREG projections for the 2071 – 2100 period, the climate in the region around the central low mountain ranges and Harz Mountains, which is cooler than that of other parts of Germany, will retain its characteristics. In this region, the number of frost days shows less pronounced changes than in lower regions. However, WETTREG simulations show that the number of summer days is expected to double or increase even stronger, which represents a more pronounced change compared to lower regions.

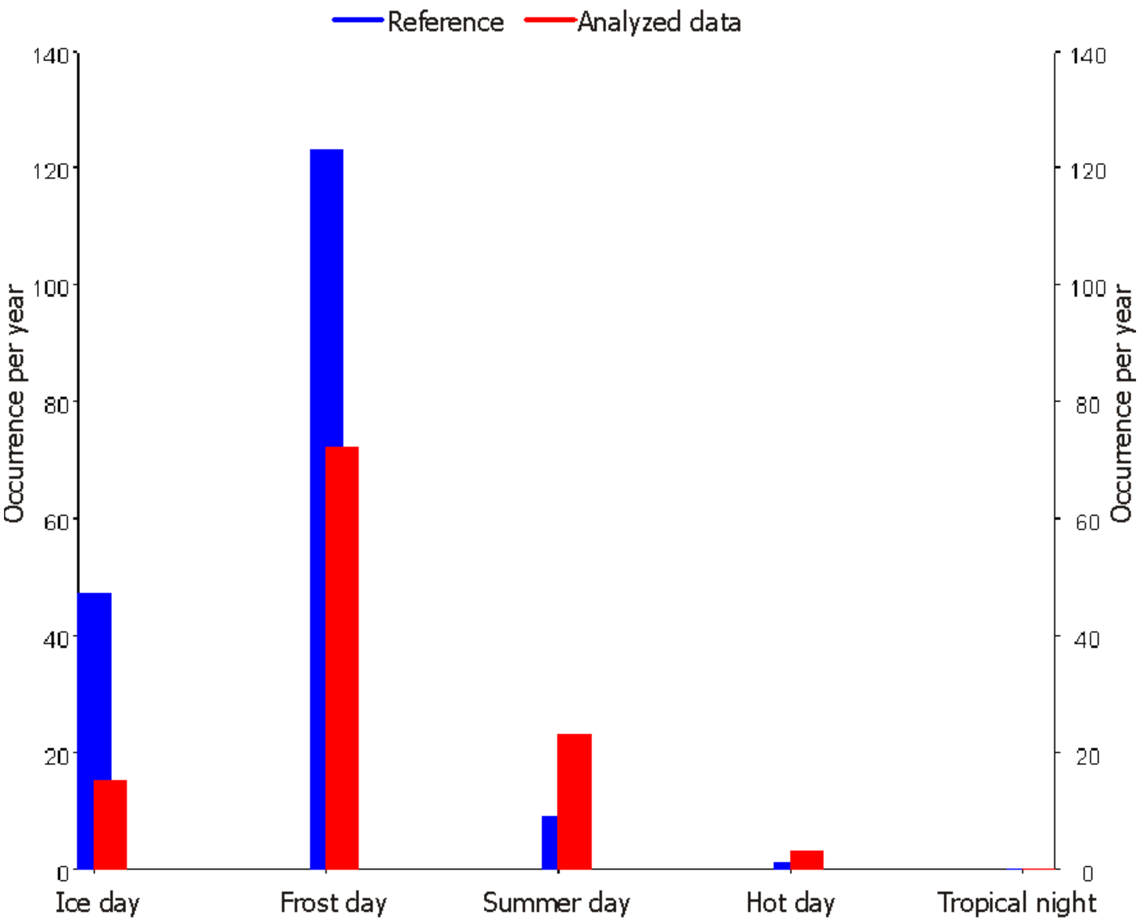

Fig. 14: Threshold days in the 1981 – 1990 decade (blue bars) and in the 2091 – 2100 decade (red bars) for the station of Braunlage in the Harz Mountains, based on the higher-emissions scenario (A1B). The graphical representation shows a decrease in the number of ice and frost days and an increase in the number of summer days, hot days and tropical nights by the end of the 21st century.

It should be noted that in the Harz Mountains, hot days and tropical nights are also simulated for high-level stations, which is not typical under current climatic conditions (see Fig. 14).

Presently, the precipitation level in this region is higher than in regions of lower altitude. Projections illustrate an above-average decrease in summertime precipitation levels in the Harz and adjacent areas, while almost unchanged precipitation levels are computed for the northern part of Hesse and even an increase in summertime precipitation, for the Kassel area (see Fig. 12, covering a modified range of values compared with Fig. 5). Wintertime precipitation levels are characterized by an above-average increase (see Fig. 15 covering a modified range of levels when compared with Fig. 8), with the strongest increase (up to 60 % according to the higher-emissions scenario A1B) simulated for the region situated between the Rothaar Mountains and the Vogelsberg region.

2.3.4 The low mountain ranges left and right of the Rhine

The low mountain ranges left and right of the Rhine are worth mentioning mainly because of their projected precipitation levels. The higher-emissions scenario A1B shows the strongest increase in average winter precipitation in all of Germany by the end of the 21st century, amounting to up to 80 % in the Hunsrück region (see Fig. 15). Increases exceeding 50 % can also be found in extended areas of the mountain ranges left of the Rhine. For the regions between the Taunus Mountains to the Sauerland, wintertime precipitation has been found to increase by no more than 20 – 30 %. Summertime precipitation is shown to decrease by 15 %, which is below the average. Hence, a shift towards a generally more humid climate will result also with regard to the annual precipitation projected for the lower mountain ranges left of the Rhine.

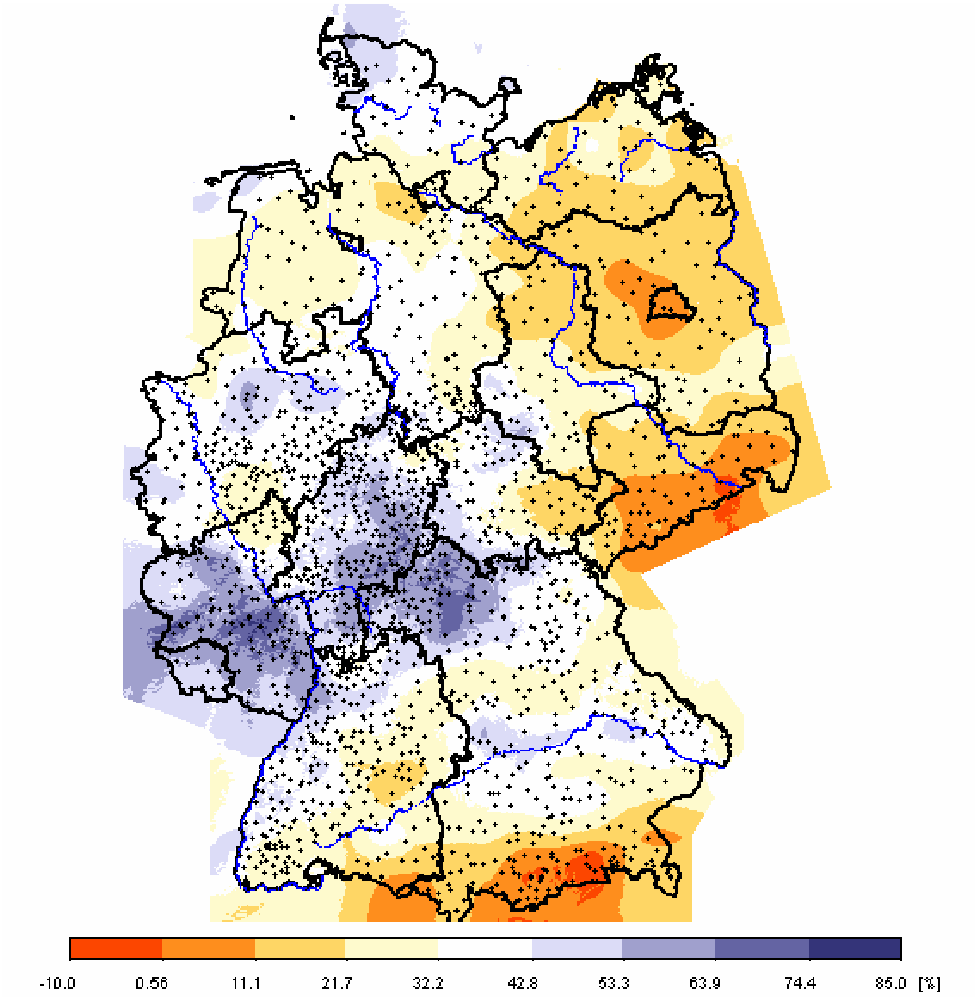

Fig. 15: Wintertime precipitation; relative change between the 2071 – 2100 period and the 1961 – 1990 period for the higher-emissions scenario (A1B); Dark red: Decrease in wintertime precipitation by the end of the 21st century; Orange to dark blue: Increase in wintertime precipitation by the end of the 21st century; Area average: 30.3% (as in Fig. 8, but with a modified range of values for clearer illustration of changes)

2.3.5 The Upper Rhine Valley

This region, which is warm under the current climate conditions, shows an average increase in temperatures by the end of the 21st century in the WETTREG projections for the higher-emissions scenario A1B. However, the lower-emissions scenario B1 has resulted in a less pronounced warming. There is hardly any other region where the difference between these two emission scenarios is as pronounced as in the region of the Upper Rhine Valley.

The warm climate prevailing in the Upper Rhine Valley is exemplified, among other factors, by the number of tropical nights projected. These are observed noticeably more often at a number of stations than in other regions in the control run of the 1981 – 1990 period, and in the projections for the 2091 – 2100 period, their frequency rises to average annual figures exceeding 10 in a number of places. Fig. 16 illustrates the threshold days for the city of Freiburg in the Breisgau region.

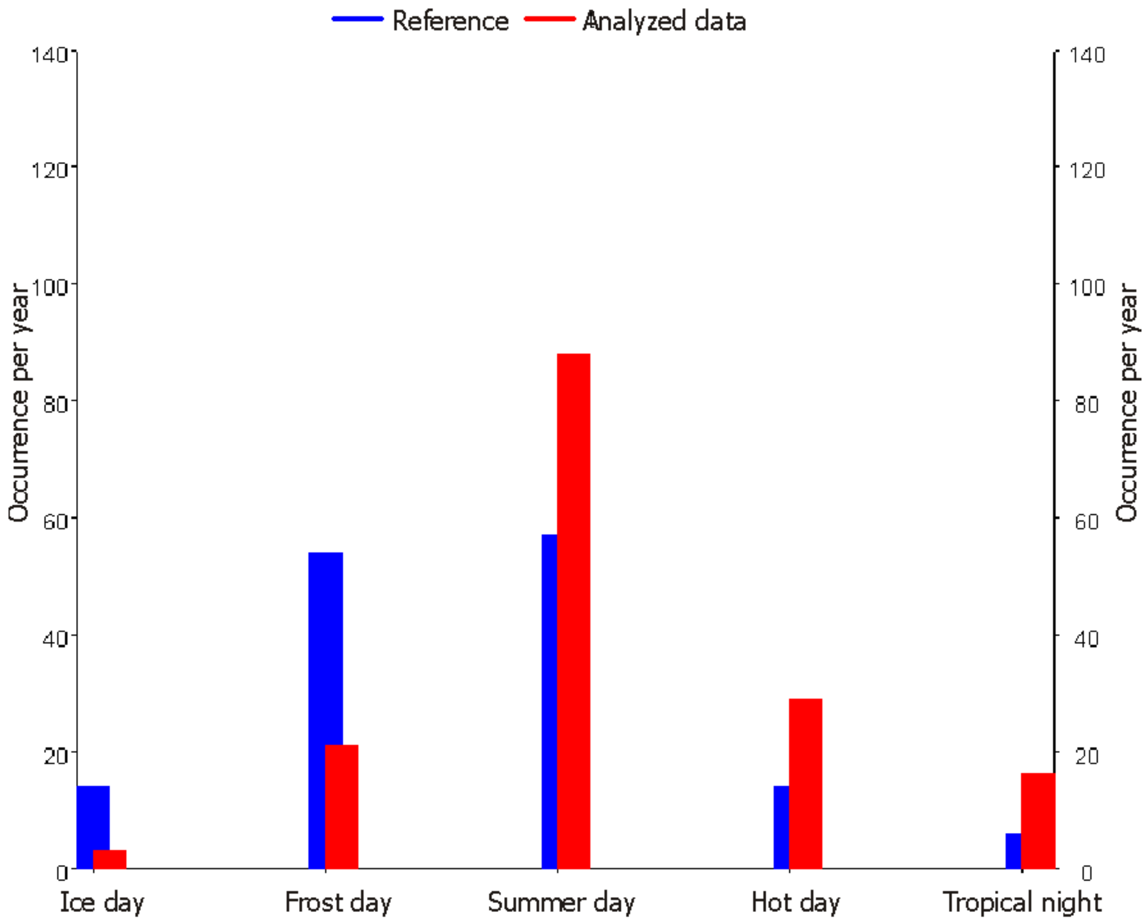

Fig. 16: Threshold days in the 1981 – 1990 decade (blue bars) and in the 2091 – 2100 decade (red bars) for the station of Freiburg/Breisgau , based on the higher-emissions scenario (A1B). The graphical representation exemplifies a decrease in the number of ice and frost days and an increase in the number of summer days, hot days and tropical nights by the end of the 21st century.

Fig. 17 shows the number of days with a maximum temperature above 30°C for the higher-emissions scenario A1B as well as the duration of periods of consecutive days characterized by summertime maximum temperatures above 30°C (heat waves) for the station of Heidelberg. The duration of periods with temperatures exceeding the 30 °C level is shown on the x-axis. The frequency of this event in the respective decade is shown on the y-axis. Again, two decades are compared, i.e. 1981 - 1990 against 2091- 2100.

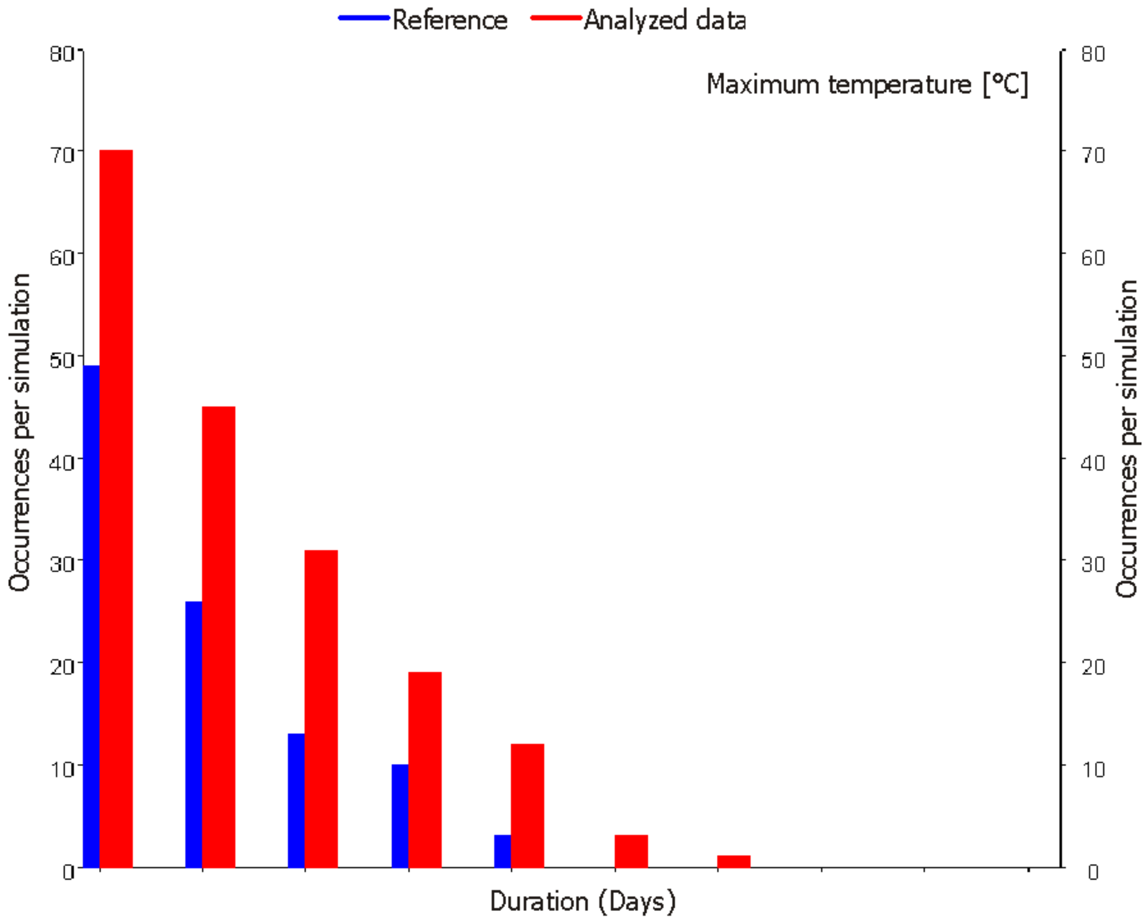

Fig. 17: Graphical representation of the duration of periods characterized by maximum temperatures above 30 °C; 1981 – 1990 decade (blue bars) and 2091 – 2100 decade (red bars) for the station of Heidelberg and the higher-emissions scenario (A1B). The diagram illustrates the increase in frequency and in addition, also in the duration of heat waves simulated for the end of the 21st century.

Fig. 17 for the station of Heidelberg shows for example that in the 1981 – 1990 period, the event of maximum temperatures exceeding 30°C on two consecutive days was observed about 25 times, while for the 2091 - 2100 period, this event has been determined to occur about 45 times. Moreover, the diagram shows that heat waves are more often simulated for the end of the 21st century (see length of the red bars) and that in addition, longer heat waves are expected to occur (see red bars for periods of 6 and 7 days duration). The increase in the number of tropical nights and heat waves is particularly important when it comes to medical implications such as an elevated risk of cardiovascular disease.

2.3.6 The Alps

At present, the Alps are characterized by a cool and high-precipitation climate. For the end of the 21st century, WETTREG simulations for the higher-emissions scenario A1B have resulted in a temperature rise by 2.3°C corresponding to the German average, and for the lower-emissions scenario B1, in a temperature rise by 2°C (German average for B1: 1.8°C). It should be noted that the decrease in the number of ice and frost days established for the Alps is particularly low compared with that for other regions. Fig. 18 shows the characteristic days for the station of Garmisch-Partenkirchen giving evidence of a decrease in the number of frost days by ca. 30 %, while other regions show a typical decrease by 50 % or more. Below-average values are also seen for the increase in the number of summer days and hot days.

The calculated decrease in average summer precipitation by the end of the 21st century is 20 %, as for other regions. A distinct result is that obtained for wintertime precipitation, for which the simulation established a very minor increase only, and in many places, even a decrease by up to 5 %. (See also Fig. 15).

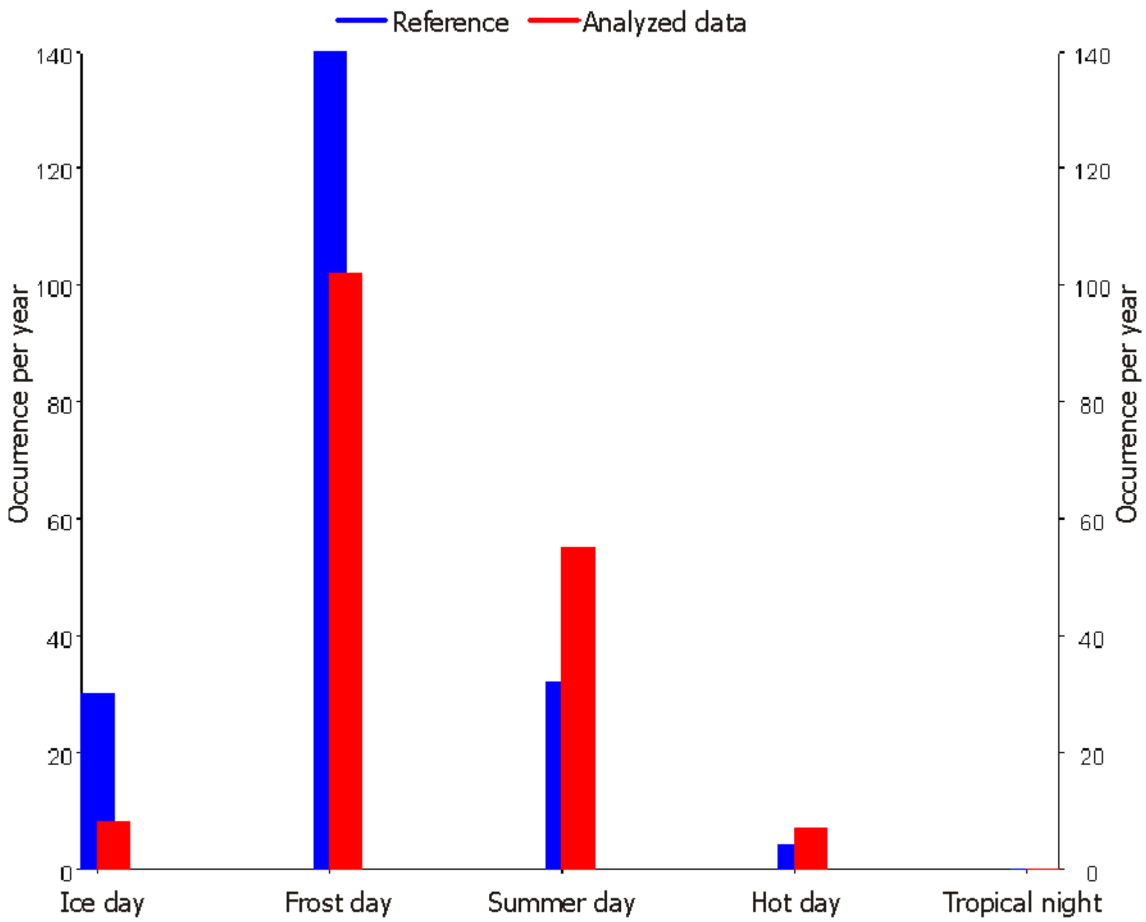

Fig. 18: Threshold days in the 1981 – 1990 decade (blue bars) and in the 2091 – 2100 decade (red bars) for the station of Garmisch-Partenkirchen, based on the higher-emissions scenario (A1B). The graphical representation exemplifies that both the decrease in the number of frost days and the increase in the number of summer days and hot days by the end of the 21st century are less pronounced than those simulated for other regions.

3. References

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For more detailed information on the WETTREG model and results obtained with these models, please consult:

http://www.smul.sachsen.de/de/wu/klimaschutz/index_1163.html

http://www.hlug.de/medien/luft/inklim/berichte_II_wandel.htm