StartClim2006

Climate Change and Health, Tourism, Energy

Final Report

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Die Österreichische Hagelversicherung

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Project Leader

Institute of Meteorology
Department of Water-Atmosphere-Environment
BOKU - University of Natural Resources and Applied Life Sciences, Vienna
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Contracting Parties

Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
Austrian Federal Ministry for Health, Family and Youth (formerly BMGF)
Austrian Ministry for Economics and Labour
Austrian Federal Ministry for Science and Research (formerly BMBWK)
Österreichische Nationalbank
Austrian Hail Insurance
Federal Environment Agency
Verbund AHP

Administrative Coordination
Federal Environment Agency

Vienna, July 2007

StartClim2006
„Climate Change and Health, Tourism and Energy“

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Vienna, July 2007

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Abstract

StartClim2006 covered a series of different topics: StartClim studies in the last few years have shown that fundamental changes in animal habitats related to climate change are to be expected. These changes will have consequences on human health as well as on agricultural crops. In StartClim2006 two studies addressed this topic: one analysed leishmaniosis and its transmitters, the other the increasing occurrence of white grubs in grassland. Changes in aerosol concentrations, especially particulate matter, in the context of climate change as studied in another subproject could also influence human health. The expected average future demand for heating and cooling impressively shows another aspect of climate change. Three subprojects analysed different aspects of the influence of climate change on summer tourism.

Sand flies and leishmania

Leishmaniae (genus *Leishmania* comprising several species/strains) are protozoan parasites which multiply intracellularly in various organs of many vertebrates including humans, thus causing serious diseases. About 12 million people are infected with *Leishmania* worldwide, at least 60,000 die of leishmaniosis every year. The occurrence of *Leishmania* is linked with the occurrence of sandflies (Phlebotominae) that take up the parasites during a blood meal and transmit them to another vertebrate host during the next blood meal. For a long time it was thought that in Europe sandflies only occur in Mediterranean countries (and sporadically in some regions with favourable climatic conditions in Western and Eastern extra-mediterranean parts of Europe). However, in recent years sandflies have been detected in several parts of central Europe, particularly in Germany; it cannot be excluded that some parts of these distributional patterns are due to warming of the climate. The aim of the project was to collect and characterise all known records of sandflies in central Europe on the basis of climatological parameters in order to identify those regions in Austria, in which the occurrence of sandflies might be possible or even probable and to assess the risk of an autochthonous transmission of *Leishmania* in Austria.

In central Europe and the adjacent extra-mediterranean regions six sandfly species have been reported so far (however, only four can be regarded as confirmed). A comparison of the climatological parameters of all locations has led to the conclusion that temperature is the determining parameter for occurrence. At present, the derived July and January temperature criteria are not constantly fulfilled for any of these species, however, an increase of the temperatures of less than 1°C would lead to conditions suitable for sandflies in many regions of Austria, in particular the Rhine valley, the Danube valley, the eastern parts of the province of Burgenland, and regions bordering Slovenia. Species that might be expected to have been or to become established in Austria are *Phlebotomus mascittii* in the west and *Ph. neglectus* (and *Ph. Perfiliewi*) in the east of Austria.

White grubs damage

In the Austrian cultivated grassland, mainly soil-dwelling grubs of the cockchafer (*Melolontha melolontha*), the june beetle (*Amphimallon solstitiale*) and the garden chafer (*Phyllopertha horticola*) are of interest.

A total area of 14,800 hectares of damaged fields, mainly in cultivated grassland, was estimated in Austria based on interviews with plant protection consultants of the Agricultural Chambers and a questionnaire sent to 74 county agricultural chambers. From the year 2000 onwards, a steady increase of white grub damages occurred, with a climax in the year 2003 that is characterized by heat waves and drought. The infested fields extended along the main alpine ridge from Vorarlberg up to the alpine foreland. Furthermore, southern slopes of the Danube valley in Upper and Lower Austria were affected. The massive occurrence of white grubs is mainly due to the garden chafer that dominates in these regions and damages exposed southern slopes of grassland. From 2004 to 2006, the extent of damages decreased in Austria. It appears that the damaged areas were mainly situated in regions with strong

precipitation deficits. On-farm investigations performed in 2007 strengthen the hypothesis that drought and elevated soil temperatures might be the decisive factors for optimized development of grub populations and subsequent feeding damages. Drought can additionally increase the effects of grub damage by delaying the regeneration of the damaged sward. Strongly damaged sward on slopes can cause slipping of farm machines and thus endanger farm workers.

To develop and implement a grub warning service it is essential to further test the identified parameters for their effect on the beetles and grubs, respectively, and subsequently quantify them. The implementation of a reliable risk forecast system requires accurate knowledge of the distribution of grub species as well as their ecological demands, mainly concerning soil parameters.

Aerosols

Air pollutants and aerosols in particular pose a threat to health. Concentrations prevailing at present have a clear effect on the daily variation of health indicators like the daily mortality (due to cardiovascular and respiratory diseases), hospital admissions and respiratory symptoms. Atmospheric conditions have a strong influence on atmospheric pollution. In north-eastern Austria the highest concentrations of particulate matter are found in winter and most frequently in high pressure regimes, with low mixing height as a precondition.

From climate scenario calculations for the future it is predicted that periods of low mixing height, typical for winter, may become shorter and therefore particulate matter may be better diluted. However, at the same time changes in emissions (less need of energy for heating, more for cooling) due to climate change and reductions due to technical development have to be taken into account.

The interaction between meteorological conditions and air pollutants with respect to their effect on health is extremely complex and must be investigated in more detail.

Heating and cooling degree days and energy demand

Using high resolution climate scenarios for Austria (20X20 km grid) for the period 2041-50 the changes of the heating and cooling degree days were calculated in comparison to 1981-90 as the base period. This data was combined with a data set describing the Austrian buildings and their heating systems in order to calculate the total and usable energy demands of different types of buildings on a regional scale as well as for the whole country.

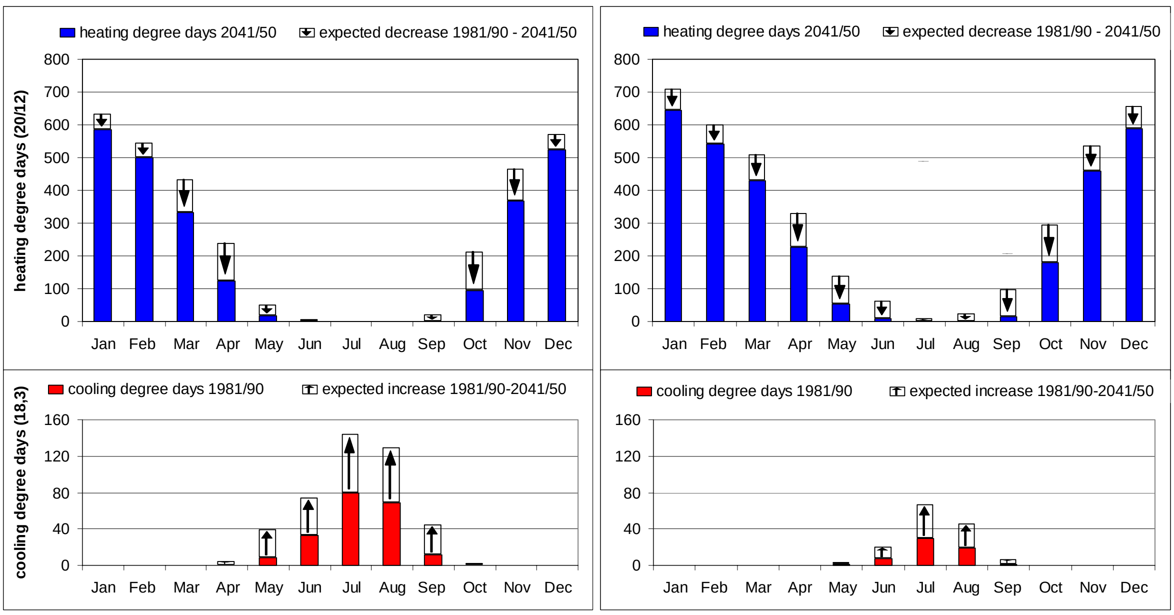


Fig: Heating and cooling degree days: Expected changes in Vienna, 200 m a.s.l., (left) and Lienz , 673 m a.s.l. (right)

The results show a climate-induced decrease of 20 per cent of the average demand for heating in the period 2041-2050 compared to the base period 1981-1990. This equals a decrease in final energy demand of 10,800 gigawatt hours (GWh) for the current Austrian building stock. This average decrease of space heating demand is larger in the cooler alpine regions. Cooling degree days increase, especially in the lowlands.

While in higher regions heating degree days drop by a ration of 1:5 (400m) to 1:20 (900m) per additional cooling degree day, this relationship is 1:4 at 300 meters, 1:3 at 200 meters, and only 1:2 at 100 meters. Climate change in the period 2041-50 can be described as a sea level shift in heating as well as cooling degree days of approximately 300 meters.

Summer tourism

Weather and climate as well as topographical and orographical conditions, vegetation and fauna play a prominent role in tourism and leisure facilities; they are limiting and controlling factors. Therefore climate change can have considerable consequences on winter as well as summer tourism in Austria. Additionally, a large number of other factors play a significant role for tourism: the weather conditions at home and the (weather) experience of the last holidays, the variety of possible activities, advertisement and prices. None of the three StartClim studies could take all the influencing factors into account. In one case the focus was set on the variability of weather and climate conditions of specific destination areas, in the other case the focus was on a subjective assessment of the climate sensitivity of diverse types of holidays; the third studied the influence of visual impressions of the landscape on tourism.

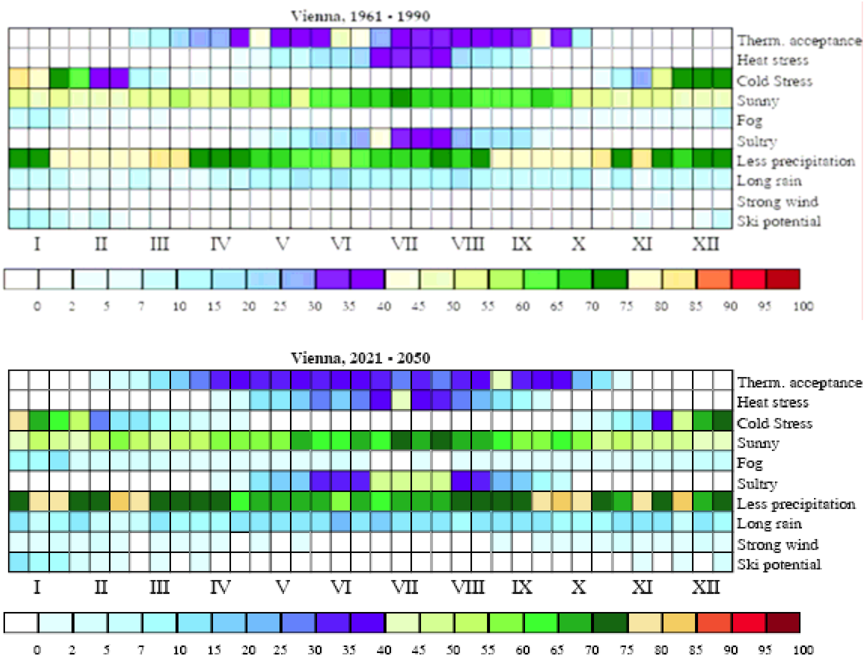


Fig: CTIS (Climate Tourism Information Scheme) –Diagram (in %) for Vienna visualising the percentage of days of each month when climate conditions are favourable for different parameters influencing summer tourism based on the A1B-climate scenario for the period 1961 – 1990 (above) and 2021 – 2050 (below).

An analysis of meteorological and climatological parameters based on climate scenarios for 1961 - 2050 calculated by the Max-Planck-Institute for Meteorology in Hamburg shows that an extension of the pre- and post-tourism season and the period of thermal acceptability for recreation and leisure can be expected in Austria for the period 2021-50. This positive development is counteracted by a) an increase in the frequency and intensity of heat stress (PET-conditions), b) an increase of sultry days in areas below 1000 m in elevation and c) a slight increase of days with long rainfall events (RR > 5 mm), which cannot be compensated by the decrease of the number of days with light or no rain.

A special diagram (CTIS (Climate Tourism Information Scheme) -Diagram) visualises the percentage of days during each month when climate conditions are favourable for summer tourism and comparison of the diagrams for different periods indicates the expected changes.

Over night stays in Austrian summer tourism is attributed to the market segments: city tourism, congress tourism, spa/health tourism, holidays in climatic spas, lake tourism, Danube tourism, tourism in natural sanctuaries, tourism along the traditional wine routes, and countryside holidays or alpine/mountain tourism. Depending on different demands for “natural quality criteria”, such as landscape/nature and weather/climate, and different ranges of nature-consuming outdoor activities, each market segment is affected by climate changes to varying degrees.

A first subjective estimate based on long time expertise, of the effect of climate change on the market segments shows that mainly alpine tourism, lake tourism and Danube tourism could be affected by climate change scenarios as it is described by the research project “reclip:more”, whereas congress tourism, city tourism and health tourism are expected to be affected to a lesser extent. In contrast to winter tourism, positive effects were especially identified for the sensitive segments; lake tourism might profit the most. The two lake-region examples show that for a 2050 scenario the rise in temperature leads to an approximate 40% increase in “summer days”, to a more than doubling of “heat days” and a reduction of “cool days” by half. Furthermore, the bathing season/suitability would stretch over approximately four months and therefore would increase the profitability (utilised capacity) of summer tourism.

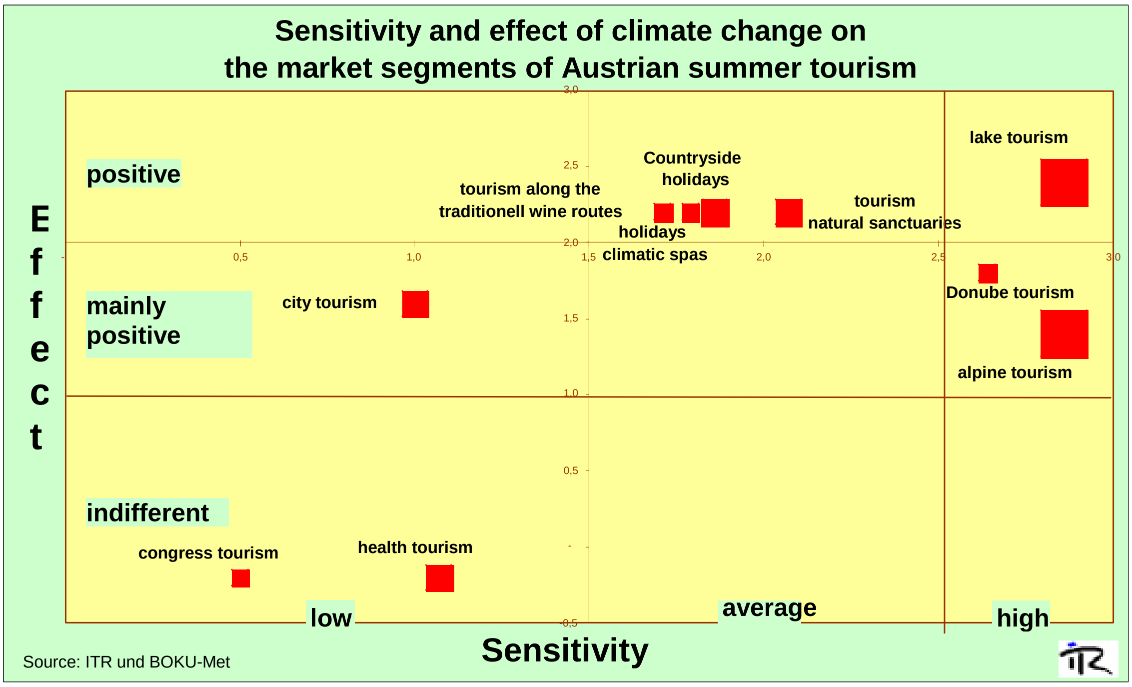


Fig: First Assessment of the sensitivity and effect of climate change on the market segments of Austrian summer tourism. The characteristic positions of the individual market segments within this portfolio analysis result from the average scores of the evaluated dimensions “sensitivity” (0.6 to 2.86) and “effect of climate change” (-0.2 to 2.4). Different sizes of the portfolio squares result from derived threshold values of the sensitivity and effect stages. The three different sizes of market segments reflect their diverse importance and the number of over night stays of the individual respectively.

A completely different approach was selected for the project “see-vision” that analysed the effects of climate change on the perception and behaviour of visitors to Lake Neusiedl in Burgenland, Austria. Visitors were surveyed in a questionnaire, which also contained a discrete choice experiment with varying water levels depicted visually. This method is particularly well suited to explore demand and visitor reaction to currently non-existent scenarios.

The choice experiment revealed divergent preferences between weekend visitors and vacationers. Weekend visitors are mostly interested in the various sports activities and associated infrastructure (i.e. swimming in the lake and a pool), while longer term vacationers are attracted mostly by landscape related attributes of water level and nature experiences; for them, cultural and wine experiences are the most important additional attractions.

The results show that the effect of water levels also depends on the type of landscape (i.e. shoreline with reeds, open shoreline, artificial beach with gravel). Visitors who are interested in nature react more strongly to water level changes.

The responses provide the following insights regarding methods of adaptation:

- Most long-term vacationers were not affected by limited swimming opportunities in the lake, as long as the image conveys a natural environment. Therefore, limited swimming opportunities can be compensated with pools. Day- and weekend visitors react differently; they are less content with the compensation of swimming in the lake with the availability of pools.
- Significant potential for adaptation was shown by long-term visitors, as they consider the natural environment, as well as cultural events and wine events as the most important product components, which can partly compensate for losses in recreation opportunities due to low water levels.
- The infrastructure for upscale sports activities such as horseback riding and golf are only of importance for a small segment of users, and are considered to be insignificant by the large majority of visitors.
- The hypothesis that more information about the natural environment of the lake and the natural fluctuations of water level increases the acceptance of water level fluctuations was not confirmed.

MEDEA (meteorological extreme event data information system for the eastern alpine region)

The data base MEDEA (meteorological extreme event data information system for the eastern alpine region) was further refined in StartClim2006 and will be filled with StartClim data in a next step. MEDEA shall serve as an archive for data created within StartClim projects in years to come. It will also allow integrated analyses of diverse data.

1 The Research Programme StartClim

The climate research programme StartClim was implemented in 2002 following extensive floods in Austria based on an initiative of the Austrian Federal Minister of Environment. StartClim developed into a research programme for new topics concerning climate and climate change, analysed from different points of view and by different scientific disciplines. Results achieved so far demonstrate that substantial research work on climate, climate change and its impacts in Austria is essential. The large numbers of approximately 80 Austrian scientists and more than 30 Austrian institutions participating in StartClim show that the required know-how is available in Austria and is still growing.

StartClim is financed by a donor consortium presently consisting of eight institutions. In a coordinating group the donors together with the scientific project leader develop the topics of research. An international advisory board reviews project applications and final reports. The administrative tasks are carried out by the Austrian Federal Environment Agency. The scientific responsibility lies with the Institute of Meteorology, Department of Water-Atmosphere-Environment, BOKU - University of Natural Resources and Applied Life Sciences Vienna.

New topics initiated in StartClim cannot be studied in depth within StartClim due to limited funding. StartClim research projects are therefore intended to subsequently be carried farther in the framework of normal research funding or as studies commissioned by interested stakeholders.

Working on new topics gives young researchers the opportunity to start their research work within the frame of StartClim.

Finally, StartClim jointly offers added value to donors financing the programme. Each donor profits from the joint administration and quality control. Furthermore synergies between projects and institutions have proven very useful.

1.1 StartClim2006

The main topics of StartClim2006 were effects of climate change on health, tourism and energy.

StartClim analyses of the last few years showed that fundamental changes in animal and plant habitats relating to climate change are to be expected. Those changes will have consequences on human health as well as on agricultural crops. In StartClim2006, two analyses addressed those topics: one analysed leishmaniosis and its transmitters, the other an increasing occurrence of white grubs in grassland. Another subproject dealing with human health analysed aerosols, especially particulate matter in the context of climate change. One project studied the changes in average demand for heating and cooling. Three subprojects analysed different aspects of the influence of climate change on summer tourism.

The data base MEDEA was extended and improved in StartClim2006, which will be documented in a separate report.

1.2 Structure of this report

The StartClim2006 report consists of an overview of the results in both German and English along with (separately bound) documentation in German in which the individual projects are described in detail by the respective project teams. All reports are published as a CD as well. A short summary will be published as a brochure. All reports and documents about StartClim2006 will be made available for download at http://www.austroclim.at/startclim/, the StartClim webpage.

1.3 Organisational aspects of StartClim2006

The organisational structure of StartClim2006 was similar to that of former StartClim phases. StartClim2006 consists of seven subprojects that encompass 33 people from 12 different institutions, representing far more than the 40 months of scientific work calculated in the project proposals. The breakdown of participating scientists reveals 13 female contributors and 15 contributors less than 35 years of age.

In order to promote scientific exchange between the individual subprojects, two workshops were held with members of the scientific board participating. All scientists were invited to present the results of their ongoing work and to discuss linkages between the subprojects.

The information and data exchange within the StartClim community was again supported by the FTP server and the StartClim webpage (http://www.austroclim.at/startclim/) at the Institute for Meteorology of the BOKU University of Natural Resources and Applied Life Sciences, Vienna.

As in the years before, Mag^{a}. Ingeborg Schwarzl provided support and help in administrative matters to the scientific co-ordinator and to scientists involved in the subprojects.

2 Climate Change, Health and Energy

2.1 StartClim2006.B: Risk profile for the autochthonous occurrence of Leishmania infections in Austria

Leishmaniae (genus *Leishmania* of the family Trypanosomatidae [Euglenozoa: Kinetoplastida]) are Protozoa (and thus unicellular eukaryotic microorganisms) that circulate between sandflies (Diptera: Psychodidae: Phlebotominae) on one hand, and the many vertebrate species on which the sandflies suck blood, on the other hand. In the vertebrate hosts they are intracellular parasites, they multiply in various organs and, depending on the location, may lead to various and sometimes also very serious diseases. Humans, too, may become infected and may develop a life-threatening disease. It is estimated that about 12 million people are infected with *Leishmania* world-wide and that at least 60,000 people die of a leishmaniosis every year.

The natural occurrence of *Leishmania* is linked with the occurrence of sandflies. So far about 800 species of Phlebotominae have been described, of which at least 23 occur in Europe, and most of them are confirmed or suspected vectors of *Leishmania*. For a long time the general opinion was that sandflies only occur in the Mediterranean countries of Europe and sporadically in some areas of Western as well as Eastern Europe with climatically favourable conditions. In recent years, however, cases of human leishmaniosis were increasingly found in various extra-mediterranean parts of Europe in which an infestation in a Mediterranean country as well as a non-vector infection could (largely) be excluded. Finally, the occurrence of sandflies has been detected in central Europe, particularly in Germany. It is possible that there are – at least in part – causal connections with climatic changes.

There can be no doubt that those areas in central Europe where sandflies occur – at least presently – are very small and of focal character. With respect to the fact that visceral leishmaniosis (a form of the disease in which inner organs are afflicted) is a very grave disease, which may become increasingly established in central Europe, it appears important, if not imperative, to localize such potential foci on the basis of establishing the determining climatic parameters. So far, there are no records of sandflies in Austria.

The aim of this project was to collect the exact data of all records of sandflies in central Europe and the adjacent extra-mediterranean areas and compare their climatic parameters in order to detect those areas in Austria in which sandflies might occur. Moreover, the geographic and epidemiological data of all described autochthonous or possibly autochthonous cases of leishmaniosis in central Europe should be identified and correlated with climate data. Finally, separate maps should be provided – for each sandfly species which principally and for biogeographical reasons might be taken into consideration as possibly occurring in Austria – and those regions in which the necessary climatic criteria would be fulfilled, should be indicated.

First, a list of all published or otherwise available records of sandflies of central Europe (and adjacent regions) arranged according to species and countries was provided. Subsequently the exact geographical data correlating the single records were identified, and based on these data a climatological profile of each location, including all available parameters, was established. Profiles of the single locations were compared, and for each of the six sandfly species the limiting climatic parameters were found. Using the climate data available for Austria, attempts were made to determine where and under which conditions an occurrence of sandflies would principally appear to be possible. Finally, these data were compiled in risk maps.

In central Europe, adult sandflies are active from July to September. They are markedly stenotopic (i.e. confined to extremely small areas) and show a radius of activity of only few hundred meters. Hibernation takes place in the 4th larval instar. Almost all central European records of sandflies are from human dwellings or the near vicinity, mainly from cellars, stables, barns or sheds.

The evaluation of all available records of sandflies in central Europe has revealed that six species have been reported so far: *Phlebotomus mascittii* (Belgium, Southwest Germany, France, Switzerland), *Ph. perniciosus* (Germany, England, Northern Italy, Switzerland), *Ph. neglectus* (Italy, Hungary), *Ph. papatasi* (France, Italy, Switzerland, Hungary), *Ph. perfiliewi* (Italy, Hungary), *Sergentomyia minuta* (Switzerland, Italy). From these, the records of *Ph. perfiliewi* and of *Ph. papatasi* are – at least largely – probably based on incorrect identifications. *S. minuta* is a parasite of reptiles and does not transmit *Leishmania* to humans. Thus, three species of medical relevance (*Ph. mascittii*, *Ph. perniciosus*, *and Ph. neglectus*) remain undoubted elements of the central European fauna. While these species show a remarkable tolerance with respect to precipitation and humidity, their occurrence appears to be determined by the temperatures during summer on one hand and during winter on the other hand. The spectra of temperature tolerance of the six species are, however, different. Only three of the six species listed above (including *Ph. perfiliewi*) have been found in locations in which the climatic profiles are similar to those of certain regions in Austria, namely *Ph. mascittii*, *Ph. neglectus*, and *Ph. perfiliewi*. For *Ph. mascittii*, an indispensable average July temperature of at least 18°C and an average January temperature of at least 0°C was found. For both, *Ph. neglectus*, and *Ph. perfiliewi*, the lower limits of monthly mean temperature were 20.7°C in July and -2°C in January, respectively.

While the necessary July temperature for the occurrence of *Ph. mascittii* is fulfilled in large parts of the Austrian lowlands, the tolerated January temperature is not constantly reached. However, in the case of an increase of temperature of less than 1°C, sufficient conditions for *Ph. mascittii* would be reached in numerous regions, namely in the Rhine valley, the Danube valley, the eastern parts of the province of Burgenland and parts of the frontier area to Slovenia. Even in the case of a temperature rise of 0.5°C, several regions would focally fulfil the ecological criteria for the occurrence of *Ph. mascittii* (see Fig. 1).

For *Ph. neglectus* and *Ph. perfiliewi* the necessary January temperature is fulfilled in almost all parts of Austria outside the Alps, the necessary July temperature is, however, not (yet) reached in Austria. Again, in case of a rise of the temperature of less than 1°C, suitable conditions for these species would be reached (Fig. 2).

Taking biogeographical as well as ecological and, in particular, climatoogical factors into consideration, in the future (if not sporadically already at present), *Ph. mascittii* can be expected in western Austria and *Ph. neglectus* and *Ph. perfiliewi* in the east.

Ph. neglectus and *Ph. perfiliewi* are confirmed vectors of *Leishmania*, most probably; however, *Ph. mascittii* can also transmit the parasite. It is of interest that the three published cases of possibly autochthonous leishmaniosis in Austria occurred in regions which lie within the calculated areas, particularly for *Ph. neglectus* (and *Ph. perfiliewi*).

Leishmaniosae are very likely to be among those infectious diseases which will – in the course of global warming – become (further) established in central Europe with a growing distribution. Due to the fact that no vaccine is available, prophylactic measures must focus on minimizing the risk of infection. An essential precondition is the localization of areas of possible occurrence of sandflies in order to perform effective control measures in time.

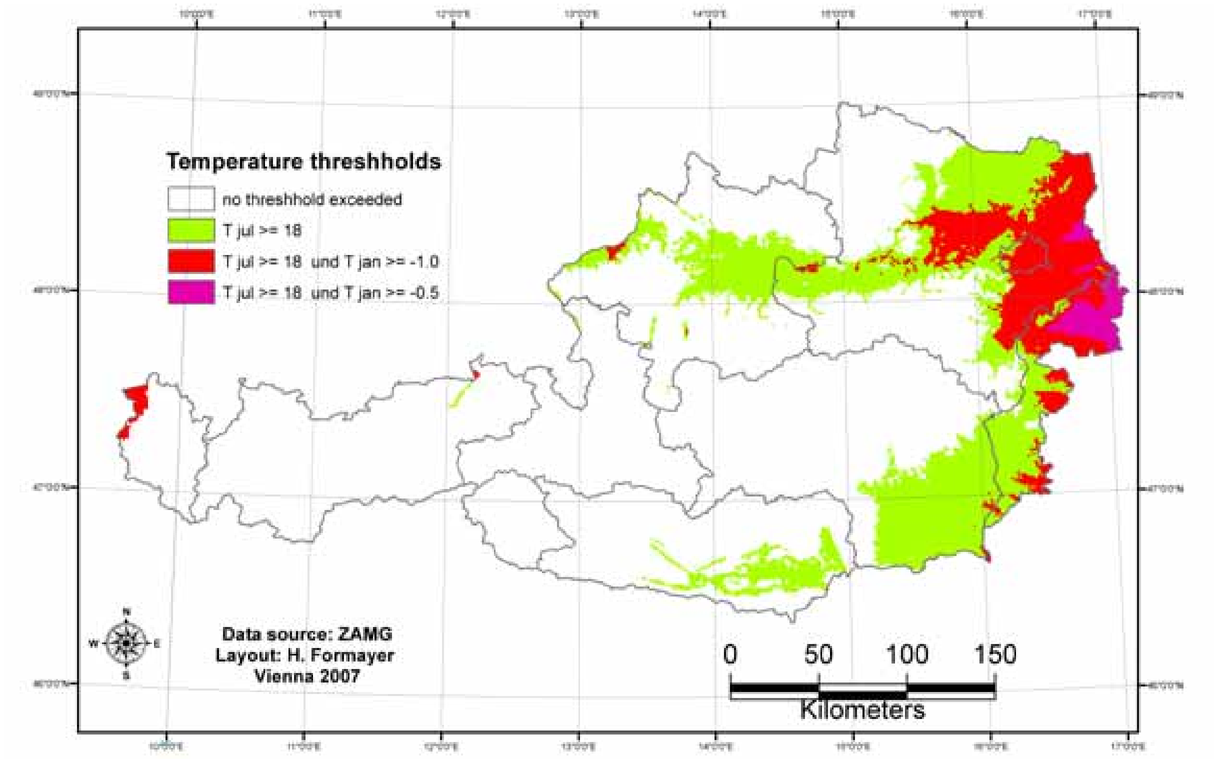


Fig. 1: Monthly mean temperature thresholds in Austria (1971-2000). Temperature criteria for *Phlebotomus mascittii*: at least 18°C July mean and at least 0°C January mean.

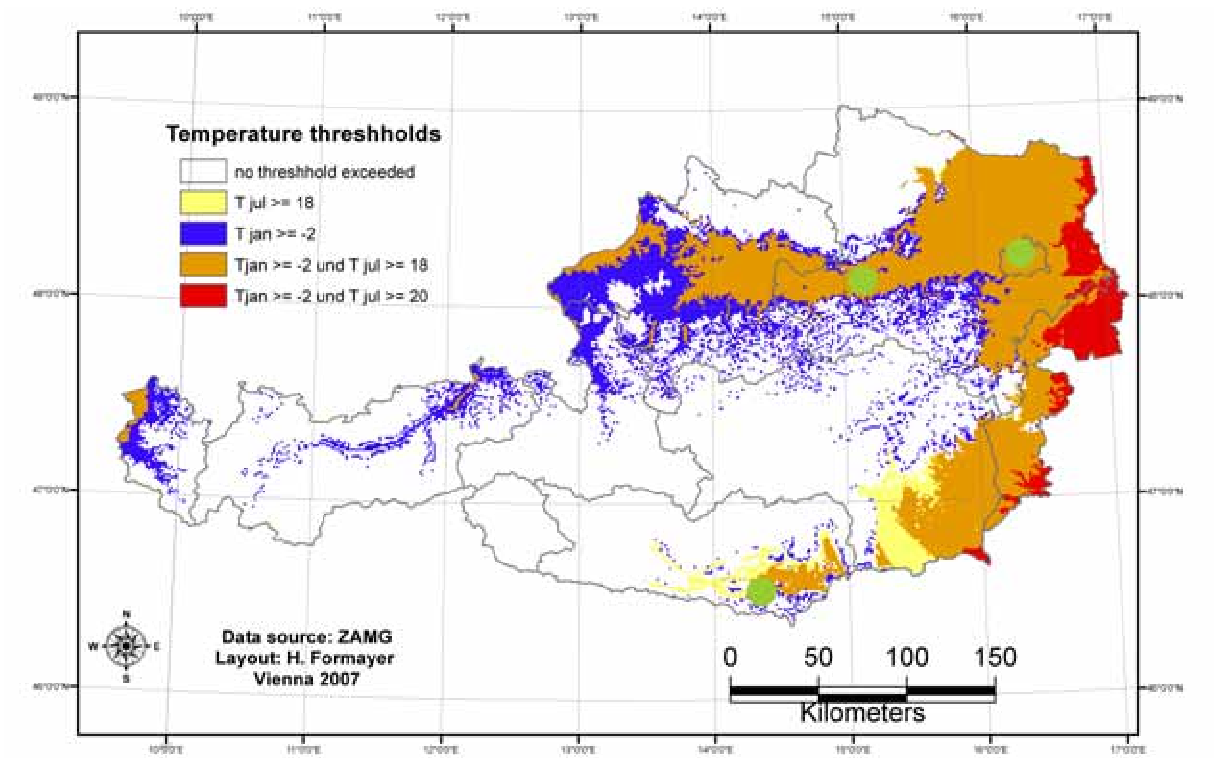


Fig. 2: Monthly mean temperature thresholds in Austria (1971-2000). Temperature criteria for *Phlebotomus neglectus* and *Phlebotomus perfiliewi*: at least 20.7°C July mean and –2°C January mean. Potential autochthonous cases of leishmaniosis were found on places marked in green.

2.2 StartClim2006.C: Effects of climate change on the dispersion of white grub damages in Austrian grasslands

In the last few years, significant damages to Austrian cultivated grassland were caused by soil-dwelling grubs of the cockchafer (*Melolontha melolontha*), the june beetle (*Amphimallon solstitiale*) and the garden chafer (*Phyllopertha horticola;* Scarabaeidae, Coleoptera). In this project, interrelationships between grub damages and climate data as well as site and soil parameters were investigated as the basis for a risk forecasting system suitable in practice.

From the available literature on the biology of the above mentioned species, it was derived that climatic conditions could be a main factor responsible for the occurrence of large populations of white grubs and their feeding damages to the grass roots. Suitable soil conditions are a precondition to enable a mass development of grub populations. However, contradictory conditions are described in the literature: warm, dry and moderately water permeable soils on the one hand and deep and nutrient-rich soils on the other.

By interviewing plant protection consultants of agricultural chambers, data on grub damages and damage years as well as changes in the extent of damages since the year 2000 were collected. By means of a questionnaire sent to 74 county chambers, species assemblage, spatial and temporal occurrence, extent of damage and ecological demands of grubs and beetles as well as plant protection measures were queried. The data were evaluated and compared with climate maps.

In two damaged areas (Murau/Judenburg und Weiz), each on two selected grassland farms, inspections were performed to locate precisely grub damages in the field and to collect background data concerning the topographic situation and the cultivation measures.

From 60 replies (81% response rate) to the questionnaire, grub “damage years” since 2000 were identified. In all of Austria a cumulated damaged acreage of 14,800 hectares was found, mainly in grasslands. From the year 2000 onwards, a steady increase of white grub damages occurred, with a climax in the very hot and dry year of 2003 (Fig. 3). The infested fields extended along the main alpine ridge from Vorarlberg up to the alpine foreland. Further on, southern slopes of the Danube valley in Upper and Lower Austria as well as the Innviertel were affected. In 2003, the typical grassland regions in the alpine foreland remained rather unaffected. The massive occurrence of grubs was very likely from the garden chafer, which is encountered in the affected aforementioned regions and causes damages on southerly-exposed grassland slopes. From 2004 to 2006, the extent of damages decreased again all over Austria. From a map of Austrian precipitation anomalies in 2003 (Fig. 4), it becomes obvious that the damaged areas were mainly situated in regions with a strong precipitation deficit. This suggests higher temperatures, lower precipitation as well as dryness and consecutive higher soil temperatures as deciding factors for population development.

In the questionnaires, most references were made to the garden chafer (*Phyllopertha horticola*) with 36% and the cockchafer (*Melolontha melolontha)* with nearly 40%, and the June beetle (*Melolontha melolontha)* with 24%.

From the random farm surveys in 2007, some indications were found that, in accordance with some of the literature, ecological conditions on dry sites with warm soils on southerly exposed slopes match the physiological demands of the garden chafer and provide optimal prerequisites for the development of eggs and grubs. This might contribute to an abbreviation of the egg- and larval-period, towards a strong population development and feeding damages. The interviews contained indications for further enhancing factors, such as attraction by yellow-blossoming plant species, incomplete swards as well as extensive cultivation.

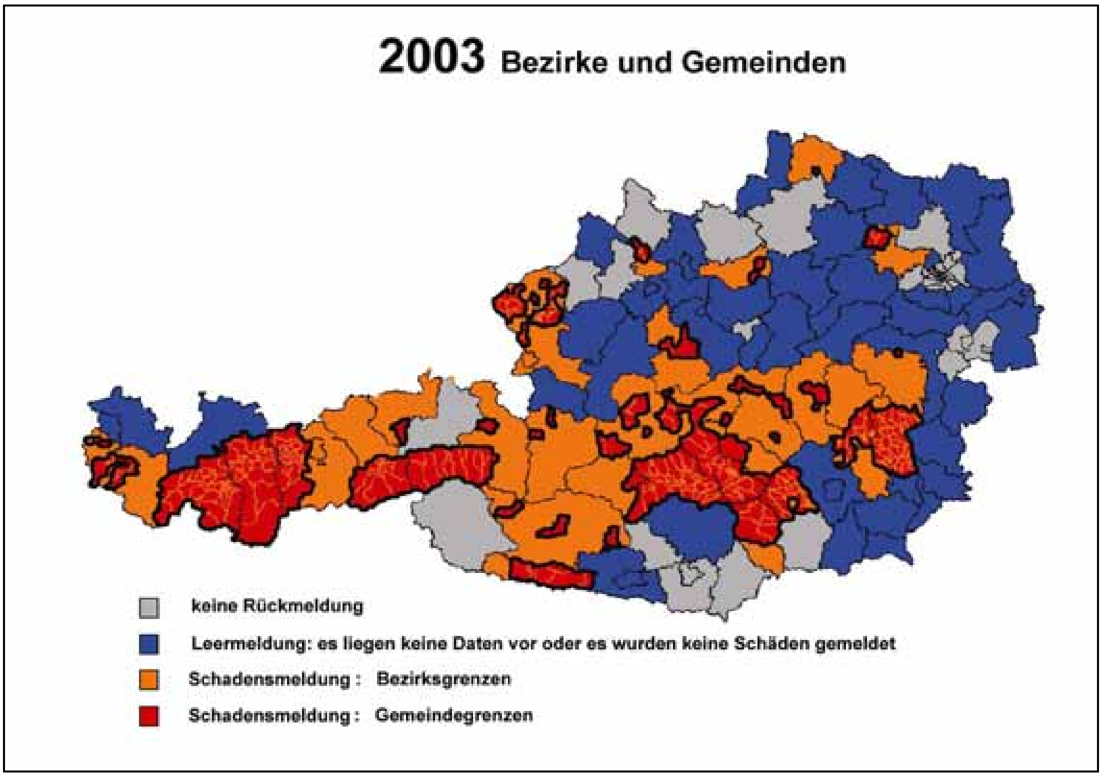


Fig. 3: Counties (orange) and communities (red) affected by grub damage in the year 2003. Counties without response are coloured in grey, whereas counties without reported damages or missing data are coloured in blue.

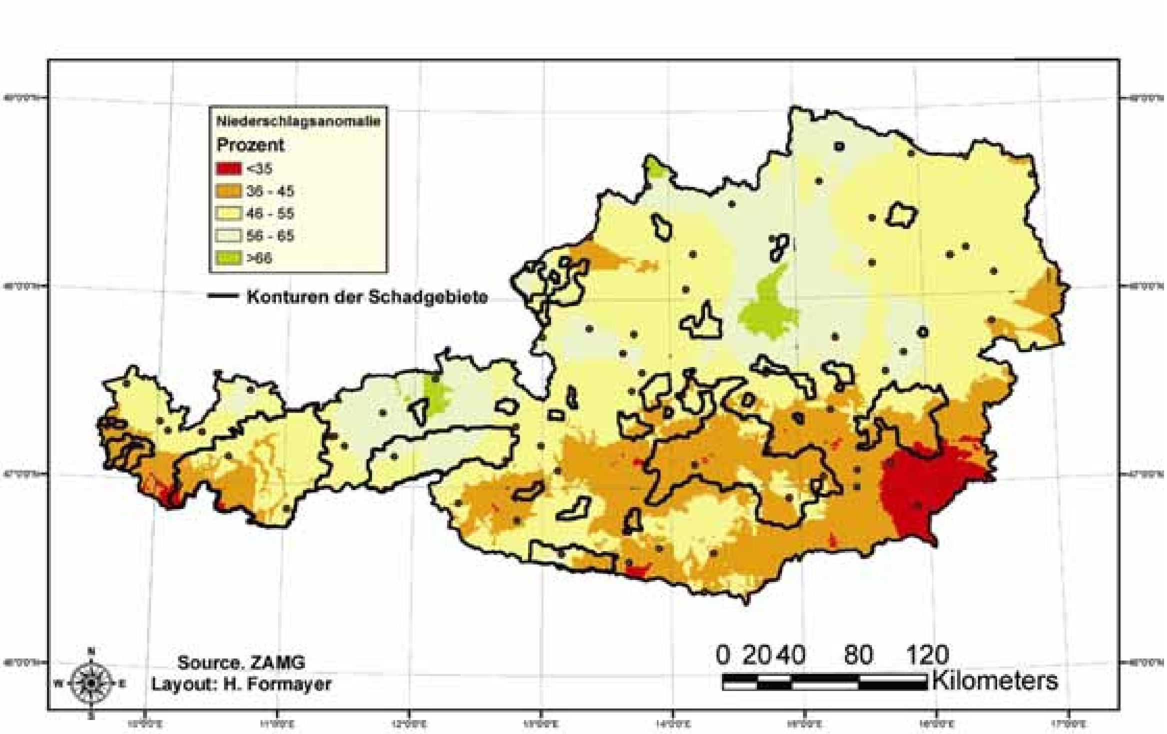


Fig. 4: Precipitation anomalies (in %) of the period 1.1.-28.8.2003 in relation to normal precipitation (100%), averaged from the precipitation sums from 1.1.-28.8. of the years 1961-1990. Precipitation deficits are visualized as a percentage of normal precipitation < 35% in red, 36-45% in orange, 46-55% in yellow, 55-65% in light green and > 66% green. Areas damaged by grubs on a community level in 2003 are outlined in black.

Grub damages (e.g. as uncovered sites in the sward) often remain unrecognized and unreported. Drought can significantly amplify the effects of grub feeding. After feeding, under humid conditions roots can regenerate faster thereby reducing the extent of damage. Damages, however, often remain unrecognized until cutting or cultivation when, even after rainfall, the sward does not recover. Furthermore, grub damages are indicated by secondary damages caused by wild boars, badgers and crows digging for grubs. Strongly damaged sward on slopes can cause slipping of farm machines and thus endanger farm workers. The questionnaires as well as the interviews confirmed that dry weather and warm, dry and moderately permeable soils are decisive for the emergence of grub damages. For the conception and realization of a grub warning service, it is essential to test the identified parameters for their effect on the beetles and grubs, respectively, and subsequently quantify them. The implementation of a reliable risk assessment system needs accurate knowledge of the distribution of grub species as well as their ecological demands, mainly concerning soil parameters. The validation of prognoses of ecological demands of damaging scarabaeid species should be performed in long term outdoor-investigations, backed by laboratory experiments.

2.3 StartClim2006.A: Particulate matter and climate change – Are there connections between them in north-eastern Austria?

Possible links between particulate matter and human health with respect to climate change were investigated for the area of north-eastern Austria and especially for the area surrounding Vienna. Data from meteorological and air quality measurements, daily mortality rates and the results of a regional climate model were used.

Representative PM10[1] data have been available for north-eastern Austria since 2001, for Vienna since 2002; mortality data have been accessible since 1999; meteorological data obtained between 1975 and 2006 were used to calculate mixing height and the ventilation coefficient. Climate scenarios were based on the control period (1981 – 1990) and a future scenario period (2041 – 2050).

To investigate health stresses and strains under changed climatic conditions, dependencies of health upon meteorological parameters were studied in regression models. Meteorological parameters which are decisive for pollutant exposure and can be obtained and calculated from Global Climate Model (GCM) climate scenario run data were chosen. These included weather patterns, mixing heights and ventilation coefficients derived from the latter.

Air pollution, especially locally generated particulate matter (e.g. aerosol produced by combustion) have undeniably negative health effects that can be seen in the Viennese data sets. As air pollution levels depend on weather patterns, a relationship between weather patterns and mortality can also be expected. Analysis of the interactions between weather pattern and mortality risk and specifically interactions between weather pattern and air pollution exposure revealed unequal results. While mortality in Vienna is significantly higher than average with north-west, west and south-west weather patterns, these weather patterns show rather low particulate matter concentrations. A reason for lower PM10 concentrations with these weather patterns is greater dilution as the air masses are transported with higher wind speed over the main sources in western Europe, as shown in other studies.

Contrarily, the highest PM10 exposures in the Viennese region occur during high pressure weather patterns. Although this is the weather pattern with the highest occurrence, it shows average mortality values. From this contradiction it can be assumed that weather patterns are also decisive for other health parameters that have a greater influence on mortality.

The mixing height proved to be an adequate value to be measured. Higher mixing heights lead to greater dilution of air pollutants and should therefore be associated with lower mortality risk. This was especially evident for winter, the season with the highest air pollution exposure. This association could not be found for the summer season.

[1] PM10 = Particulate Matter with diameters < 10 µm

The mixing height shows a strong seasonal cycle with low heights in winter, the season with the most exceedences of PM10 thresholds, and high heights in summer. Considering this parameter for the Viennese region since 1975, a slight increase from 1980 onwards can be seen. This trend would continue if this were to implicate that due to higher dilution in the future, the probability of greater particulate matter exposure would decrease. However, comparison of a control run of a regional climate model for the period 1981 – 1990 with a scenario run for the period 2041 – 2050 did not show a general increase in mixing height.

Another finding from the 32 year database is that the increase of the mixing height in spring of the second period occurred 2 weeks earlier and the decrease occurred 2 weeks later, in comparison to the first period. This effect could also cause a decrease of days which exceed the legal threshold of PM10. The mean seasonal cycles of the mixing height during the periods 1975 to 1990 and 1991 to 2006, calculated using data from the Wien Hohe Warte station, are shown as 30 day running averages in figure 5. This effect was also found in the data from the regional climate model. The scenario run also shows an earlier increase of the mixing height in spring and a later decrease in autumn than shown in the control run.

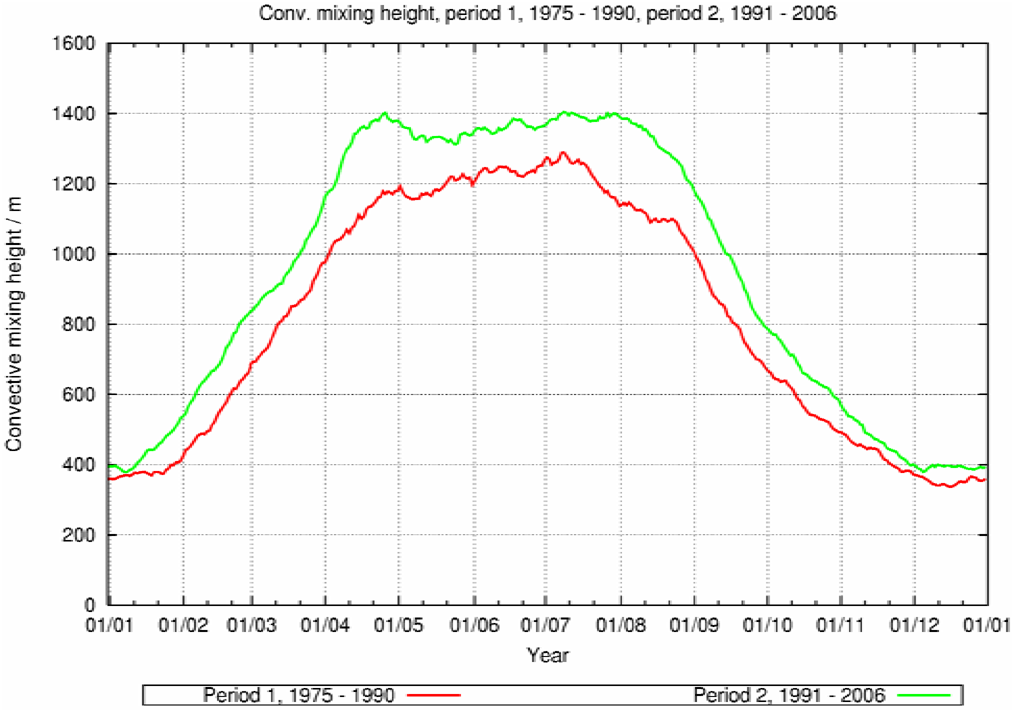


Fig. 5: Mean annual cycle of the mixing height calculated using radiosonde data from the Wien Hohe Warte station for the periods 1975 to 1990 (red) and 1991 to 2006 (green), as a running average over 30 days.

The ventilation coefficient as a product of the mixing height and the wind speed can be seen as a dimension that expresses the dilution and exchange of air masses. Similar connecections could be found between the ventilation coefficient and the PM10 concentrations as those found between the mixing height and PM10.

The results of this study show existence of an interaction of meteorological parameters, mixing height, ventilation coefficient and to a small extent also weather patterns with both particulate matter exposure and mortality risk. Conclusions regarding future modifications in relation to climate change can only be made insofar that a shortening of the winter period with low mixing heights reduces the risk of exceeding the legal thresholds of PM10.

Presumably other parameters are also decisive for future changes in air pollution exposure. The source of particulate matter, in reference to both the area of emission (long-distance transport, regional or local emission sources) and to the types of emission sources, is certainly more important.

An interaction between emission and climate could be e.g. established to the sector of space heating due to the dependence of demand and related emissions on the prevailing temperature. Future emissions will however strongly depend on technical changes. Based on political pressure to reduce the number of days that exceed the legal thresholds, a decrease of particulate matter emissions can be expected in the future. However, investigation of this topic was not within the scope of this research project.

Another possible interaction between climate and weather, respectively, and particulate matter could be due to varying speeds of deposition and redispersion of particles with and without snow cover. Due to many uncertainties regarding this topic, both in capturing the mechanisms and the scenario calculations, it would be an interesting topic for future research projects.

2.4 StartClim2006.F: Impacts of climate change on energy use for space heating and cooling in Austria

New approaches in regional climate modelling make high resolution predictions of changes in heating and cooling degree days in Austria possible (20X20km grid). Using alpine climate data with a high resolution in space and time and a climate change scenario for the period 2041-2050, changes of the heating and cooling degree days were calculated for the whole country with 1981-90 as the base period. Then, this data was combined with a dataset of Austrian buildings and their heating systems in order to calculate the usable and total energy needs of different types of buildings on a regional scale as well as for the whole country.

The heating degree days were calculated based on the “20/12” definition, which is commonly used in Austria. According to this definition, the heating degree days are calculated as the sum of the hourly differences between an assumed room temperature of 20 degrees and the outside temperature for all days with an average temperature below 12 degrees. The cooling degree days were calculated in a manner analogous to the internationally accepted standard of 18.3 degrees as a lower threshold.

The results show a climate-induced decrease of 15 to 23 per cent of the average demand for heating over the period 2041-2050 compared to the base period 1981-90, with most regions near an average of 19.59 per cent. Larger relative decreases (21-23 per cent) were calculated for the Vorarlberg region, while smaller values (15-17 per cent) were found in high alpine regions like *Venediger Gruppe, Ötztaler Alpen* etc.

In absolute numbers, this means 600 fewer heating degree days in lower regions (North-Eastern Austria, the Danube valley, South-eastern Styria), 700 to 800 fewer heating degree days in the valleys of western Austria (Salzachtal, Inntal, Rheintal) and even higher values in alpine regions. For the average location of Austrian homes, a decrease of 686 heating degree days (from 3501 to 2815) was calculated.

The increase of cooling degree days is much more spatially heterogeneous than the heating degree days. While there is little average increase in alpine regions, significant increases occur in the lower regions, especially below 400 meters elevation. In the warmest regions of Austria (north-eastern Austria, southern Styria and southern Burgenland) the increase amounts to between 200 and 300 cooling degree days. But the increase also amounts to as much as 200 cooling degree days in large parts of Upper Austria, the Rhine valley and Lower Carinthia. For the location of the average Austrian home, there will be an increase from 137 to 315 cooling degree days (+130 per cent).

In summary, the results show that based on the chosen climate scenario for the period 2041-2050, households in alpine regions are significantly advantaged regarding changes in the energy demand for space heating and cooling, because the absolute decrease of the heating degree days is higher in alpine regions than in regions at lower elevations. On the other hand, the number of cooling degree days especially increased in lower regions. These results were illustrated with case studies for the two cities Vienna and Lienz. In Lienz, for example, the increase of cooling degree days occurs mostly in July and August and is small in absolute terms, while in Vienna there are significant increases over the whole period from May to September.

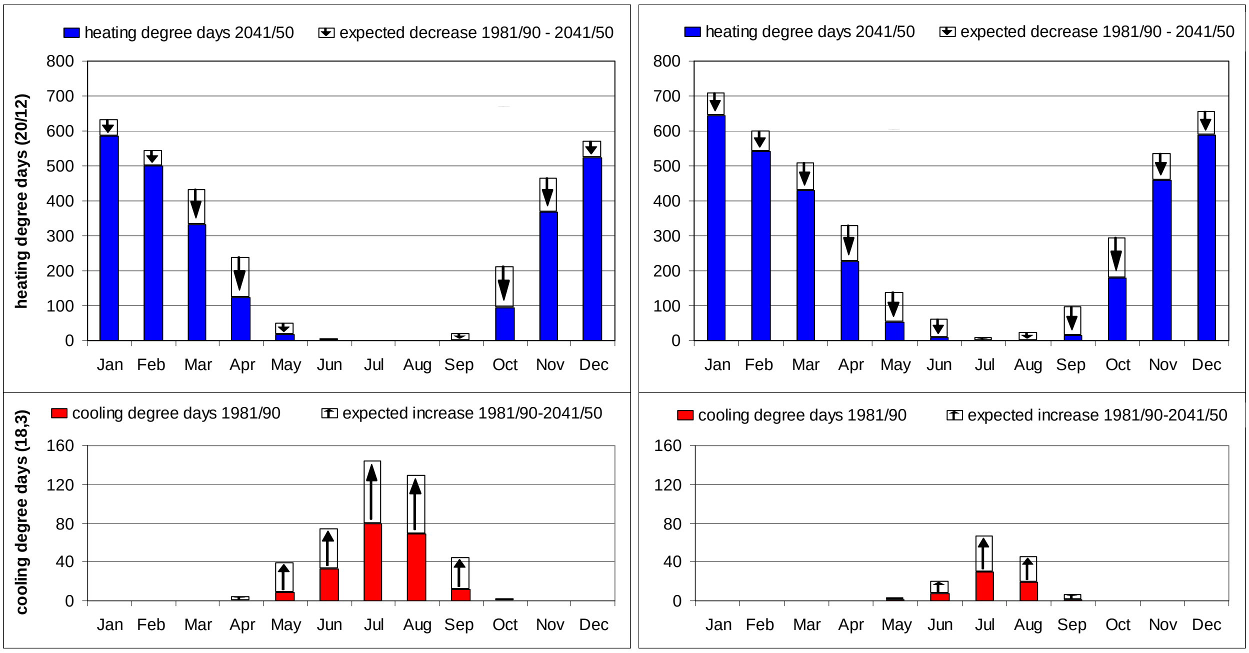


Fig. 6: Heating and cooling degree days: Expected changes in Vienna, 200m (left) and Lienz, 673 m (right)

Furthermore, the relationship between the decrease of heating degree days and the increase of cooling degree days was examined. While in higher regions every additional cooling degree day corresponds to a decrease of 20 (900m) and 5 (400m) heating degree days, this relationship is 1:4 at 300 meters, 1:3 at 200 meters, and 1:2 at 100 meters. Although, direct conclusions from the change in energy demand for heating and cooling are not valid, as cooling and heating degree days are only one of many factors determining the energy demand.

In addition, the sea level shift of heating and cooling degree days due to climate change was examined. The results show that heating as well as cooling degree days may shift by about 300 meters by the period 2041-2050. Typical values for the period 1981-1990 at 200 m sea level (e.g. Vienna) could be found at about 500 m (e.g. Aspang) in the period 2041-2050.

Finally, the relevance of these changes for future demand of usable and total energy in Austria was examined. Changes in regions with a higher population density were weighted more heavily and the calculated heating degree days on a regional scale were combined with building data . This enabled conclusions regarding the regional change in the energy demand of buildings to be drawn and, after aggregation of the regional data, an assessment of the influence of Climate Change on the overall future for usable and total energy demand for space heating in Austria.

These calculations result in a decrease of approximately 10 800 GWh within the periods 1981-90 and 2041-50 based on the total energy demand for space heating in 2004. It can be expected, however, that changes in energy demand will be smaller due to thermal improvements in buildings.

Detailed assignment of total energy demands for Austrian buildings shows that in regions with a low population density the heating energy demand per home is approximately twice that of areas with a high population density. This is caused by the greater share of single family houses in rural areas. On the other hand, areas of high population density are mostly in lower lying regions. Accordingly, areas of high population density have twice as many cooling degree days as areas of low population density.

As space cooling has only become a general practice in Austria during the last few years, there are no reliable statistical data available yet that would enable a calculation of space cooling energy demand based on cooling degree days. Estimates show that space cooling energy demand currently amounts to approximately one per cent of space heating energy demand. However, it can be assumed that the cooling energy demand in Austria will strongly increase in the near future due to changes in consumption and behavioural patterns, even without an increase of cooling degree days.

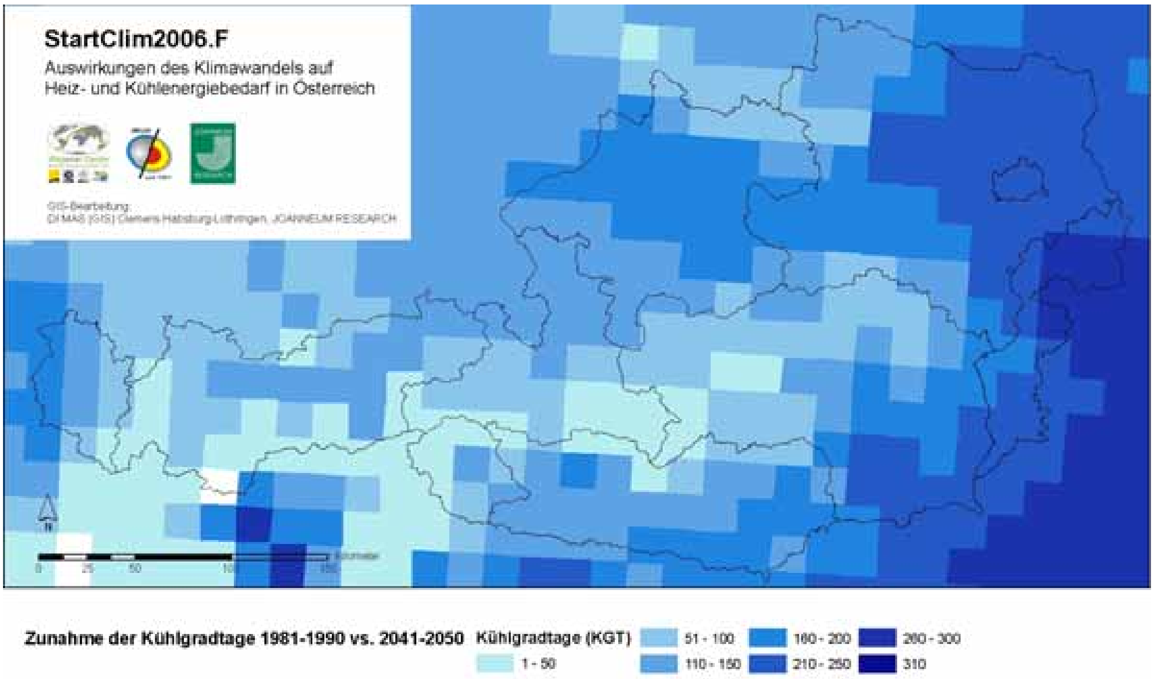


Fig. 7: Increase in cooling degree days from 1981-1990 to 2041-2050

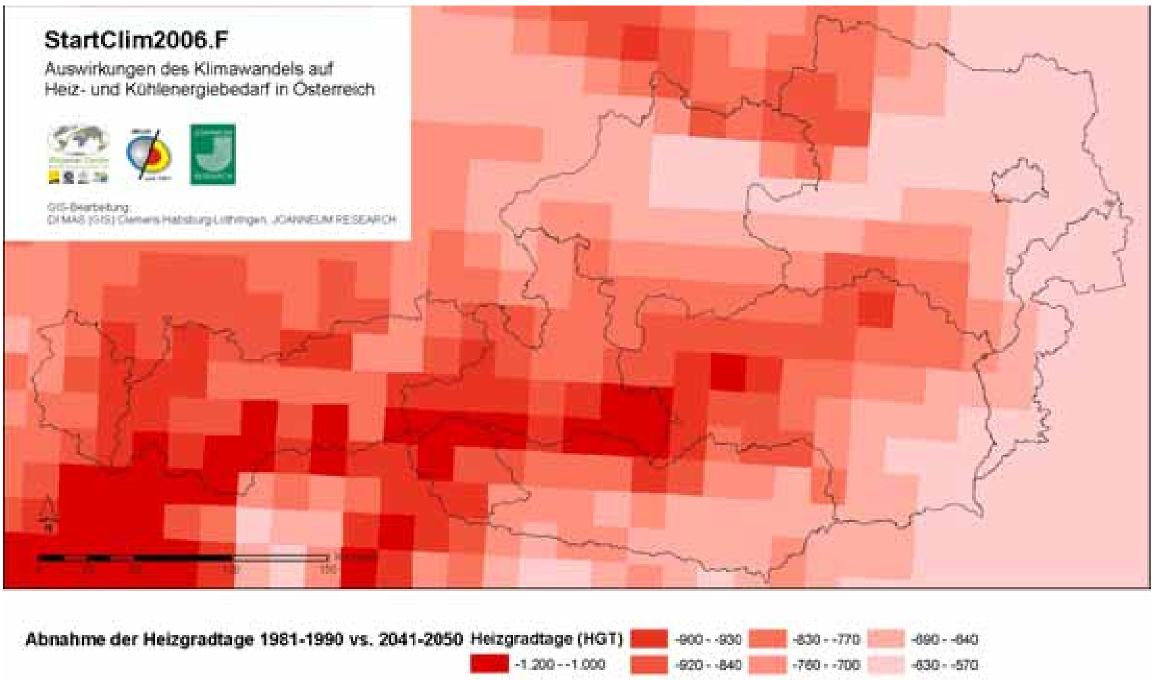


Fig. 8: Decrease in heating degree days from 1981-1990 to 2041-2050

3 Climate Change and Tourism

3.1 Startclim2006.D2: Effects of climate change on the climatic potential for tourism

According to the “Fourth Assessment Report” of the IPCC (4AR) the increase of global air temperature over the continents in the 21st century will be strongest in higher northern latitudes and an increase of extremely hot temperatures and heat waves is very probable (probability > 90%). Austria and the Austrian economy are therefore strongly affected by climate change and its consequences. Two thirds of the gross domestic product (GDP) is allotted to the service sector, where Austria particularly profits from tourism. The effect of climate change on winter sports was and is treated in many scientific studies. But summer tourism will also be affected by climate change: a shortening of the winter sports season and an extension of the summer season seems to be a logical development. These changes are regarded as changes of the climatic potential for tourism - only one of many variables, which determine the kind and extent of tourism. In the present investigation special attention is given to summer tourism.

The frequently asked question arises, whether simple climate parameters, such as air temperature or the height of the snow cover that can be assessed and quantified sufficiently well, can describe current and future climatic potential for tourism and whether this is feasible with usual climatological methods or whether interdisciplinary approaches are necessary. In the context of the StartClim2006 project “effects of climate change on the climatic potential for tourism” an integral approach is applied, which is based on climatological and human-biometeorological and tourism-climatic methods. Apart from the thermal situation and/or bio-climatic conditions the integral approach includes different important physical (wind, rain, etc.) and aesthetic factors (duration of sunshine/cloud conditions, visibility), in order to offer a comprehensive quantitative description of the climatic potential for tourism.

To describe the thermal aspect of the suitability of climate for tourism the physiologically equivalent temperature (PET) was selected, because it takes into account the influence of the complete thermal environment (air temperature, air humidity, wind velocity as well as short and long-wave radiation) on humans. The frequency of individual PET classes quantifies thermally suitable conditions for leisure and recreation and gives information about cold and heat stress. “Sultriness” - defined according to the classical criterion of vapour pressure above a certain limit (VP > 18 hPa) – is also considered to be part of the thermal aspect of the suitability of climate for tourism.

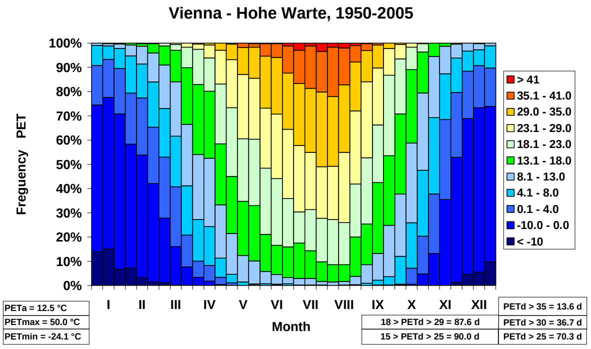
The aesthetic aspect includes factors such as duration of sun shine, cloudiness and fog, as well as the range of visibility and daylight hours. These factors are represented by the number of days with little or no clouds as well as the number of days with fog.

The physical aspect that contains influences such as wind, rain, snow conditions, air quality and extreme weather situations, is described by the factors high wind velocity and precipitation (days with few or no precipitation as well as long duration precipitation events).

Climate data from the Central Institute for Meteorology and Geodynamics (ZAMG) for the period 1950 - 2005 from eleven selected stations that are representative spatially and in elevation were used for the analysis. These stations are: Badgastein, Feldkirch, Graz-Universität, Innsbruck-Universität, Linz-Hörsching, Obergurgl, Salzburg-Flughafen, Sonnblick, Vienna-Hohe Warte, and Villacher Alpe.

The future climatic potential for tourism in Austria is calculated using scenario runs of the REMO model from the Max-Planck Institute for Meteorology in Hamburg and covers the period 1961-2050.

The present investigation focuses on thermal (bioclimate) and precipitation conditions, because these parameters represent the most important weather factors for tourism and recreation. Instead of the frequently used monthly averages, frequencies were computed and presented in high temporal resolution - Each month is divided into three 10 day time intervals (see e.g. Figures 9 and 10).



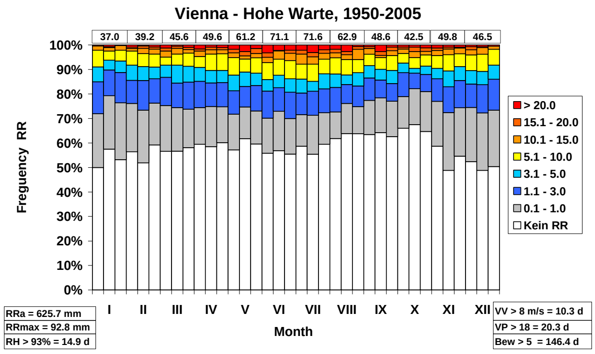


Fig. 9: Bioclimate diagram (PET-frequencies) for Vienna for 1950 - 2005 and number of days with PET-threshold values

Fig. 10: Precipitation frequencies in Vienna for 1950 – 2005

To describe, in an integral manner, the climatic potential for tourism, a flexible “climatic tourism information scheme” CTIS was developed that can include as many or as few climatic factors as desired, depending on the aim of the study. The CTIS quantifies frequency (number of months per decade in %) for every month of the year for which each factor is conducive or aversive to recreation or leisure activities. The factors considered here are thermal suitability (such as cold stress, heat stress, sultriness), sunshine duration, little or no precipitation, fog situations, rain conditions, as well as stormy days in addition to winter sports conditions (skiing potential) described here by the days with more than 10 cm of snow cover. Examples of CTIS diagrams are given in figures 11 and 12 for Vienna, for the reference period 1961 – 1990 and the scenario 2021 – 2050.

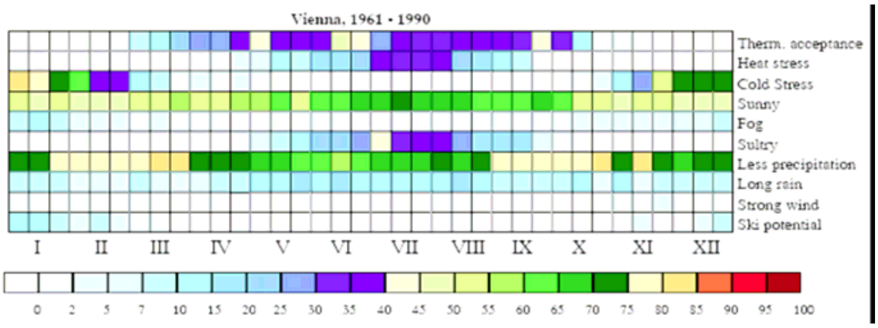


Fig. 11: CTIS-diagram for Vienna based on the A1B-climate scenario for the period 1961–1990. Colours denote months per decade (%), the description of the factors is given in the full text.

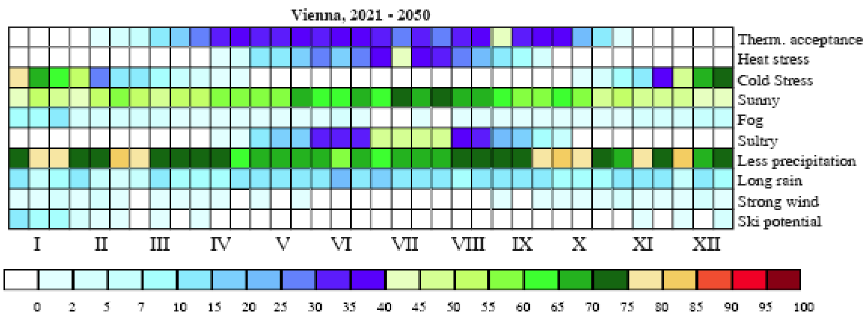


Fig. 12: CTIS-diagram for Vienna based on the A1B-climate scenario for the period 2021–2050. Colours denote months per decade (%), the description of the factors is given in the full text.

Climate scenarios for the period 2021-50 show the following:

- The number of days with cold stress is reduced by up to 20 days, particularly in the south and southeast of Austria. The period with a potential for cold stress is shortened.
- The number of days with thermal comfort conditions increases by approximately 10 days, but the trends are not clear - urban areas do not show a trend. The period of thermal suitability for recreation and leisure increases and extends into the late autumn.
- The number of days with heat stress increases, but areas above 1000 - 1200 m are not affected. In the southeast, more than 40 days with heat stress may occur; the duration of heat stress periods increases. The number of days with sultriness also increases.
- The number of sunny days increases in the higher areas.
- In general there is a slight upward trend for days with high precipitation. The frequency of days with little or no precipitation as well as days with long precipitation experience an increase in summer.
- The number of days with fog generally decreases.
- No definite statement can be made about the change of strong wind conditions (especially in view of recreation and leisure).
- (The potential for skiing decreases, however it is ensured at higher elevations.)

Overall, the future bioclimatic conditions in Austria are favourable for summer tourism and will lead to an extension of the season with pleasant thermal conditions into late autumn. The accompanying increase of days with sultriness will have positive effects for lake tourism, but might be impair spa/health and wellness tourism. The reduction of summer precipitation described by the climate scenario will affect nearly all sectors of summer tourism favourably.

3.2 StartClim2006.D1: The sensitivity of Austrian summer tourism for climate change

In Austrian summer tourism, the high volume of almost 60 million overnight stays is triggered by a wide range of interests that can be described by several spatial or specific market segments: city tourism, congress tourism, spa/health tourism, holidays in climatic spas, lake tourism, Danube tourism, tourism in natural sanctuaries, tourism along the traditional wine routes, countryside holidays or alpine/ mountain tourism. All these segments have different requirements for “natural quality criteria”, such as landscape/nature and weather/climate. The summer tourists consume outdoor activities that are highly dependent upon weather conditions to different extents, depending on the market segment. The individual market segments therefore have different climate change vulnerabilities.

As no assessments are available regarding the segment specific requirements for natural factors or the outdoor activities of summer tourists in Austria, a pragmatic approach was chosen to overcome this deficit. With a subjective assessment based on long term expertise and partly on experimental data (the T-Mona survey on summer tourism 2004), in the first step the market segments were ranked with regard to their requirements on natural factors and outdoor activities on a scale ranging from 0 to 3. In a second step the evaluation of the present climate/weather sensitivity of the individual segment, based on the climate parameters temperature, number of heat days, precipitation, sunny days and extreme events was performed.

The results of these two assessments were plotted in a scatter diagram, which clearly indicates the strong differences of segment specific sensitivities. Lake and alpine tourism strongly depend on natural factors and outdoor activities are very important for tourists of this segment. At the same time these segments have high climate/weather sensitivity. The opposite is true for the segments: city tourism, congress tourism, spa/health tourism and holidays in climatic spas that have quite a low sensitivity to climate/weather.

Lake tourism, as an example of a segment with high climate/weather sensitivity, was chosen to investigate the correlation of summer tourism demand and climate/weather conditions in more detail. For two lake regions in Austria, the lake region in Carinthia “Kärntner Seenregion” and the lake region at the border of Salzburg and Upper Austria, correlations between seven climatic parameters, such as heat-, summer- and cool days, and the number of overnight stays for the period 1996 to 2006 were tested. Parameters containing precipitation information showed the least correlation with overnight stays.

The following conclusions can be drawn from the correlation analyses: As was to be expected, weather information alone can not explain the development of the overnight stay frequency during the analysed period. External factors such as economic development or single events and internal factors such as regional competitiveness also have to be considered. However, both lake regions clearly show weather sensitivity. Correlation of the summer demand and the climatic parameters are slightly different in the two regions (Tab. 1). Summer days are a more robust indicator for “fine weather” than heat days due to the high variability of heat days in regions where this temperature threshold is seldom reached. In the lake region of Salzburg-Upper Austria (OÖ-Sbg region) the three chosen parameters show quite similar results, which is not the case in Carinthia. It can also be shown that “fine weather” influences the over night stays by Austrian tourists more strongly than that of tourists from foreign countries.

Tab. 1: Correlation between climate parameters and the number of overnight stays in summer for the two test regions for the period 2000 to 2006

Climate parameter	Correlation coefficient R^2 Climate parameter versus overnight stays					
	Carinthia lake region			OÖ-Sbg. Lake region		
	Total	Foreign	National	Total	Foreign	National
Summer day >=25° C	0,250	0,130	0,442	0,631	0,350	0,720
Heat day >=30° C	0,002	0,035	0,025	0,451	0,130	0,680
Cool day <=20° C	0,951	0,913	0,935	0,441	0,288	0,457

Source: ITR-database; BOKU-Met; Statistik Austria

Based on regional climate change scenarios from the research project reclip:more, the change of relevant climate parameters such as temperature increase, heat waves, precipitation and extreme events where derived for the decade 2040 and the potential impact on the individual marked segments were defined (ranging from very positive to negative). Assessment of the sensitivity and the impact was also plotted in a scatter diagram (Fig. 13). The figure clearly indicates that lake tourism in Austria with its high climate/weather sensitivity will probably profit from climate change. Positive effects can also be found for tourism in natural sanctuaries, tourism along the traditional wine routes and countryside holidays, but these segments only have moderate climate/weather sensitivity. For segments with low sensitivity, congress tourism and spa/health tourism, the effects of climate change can be classified as indifferent. The highly sensitive segments, Alpine- and Danube tourism, generally react positively to climate change, but there are some negative aspects. In Alpine tourism the glacier- and permafrost retreat and the more pronounced water fluctuation in the rivers are negative effects and for Danube tourism low water levels during summer and early autumn may become detrimental.

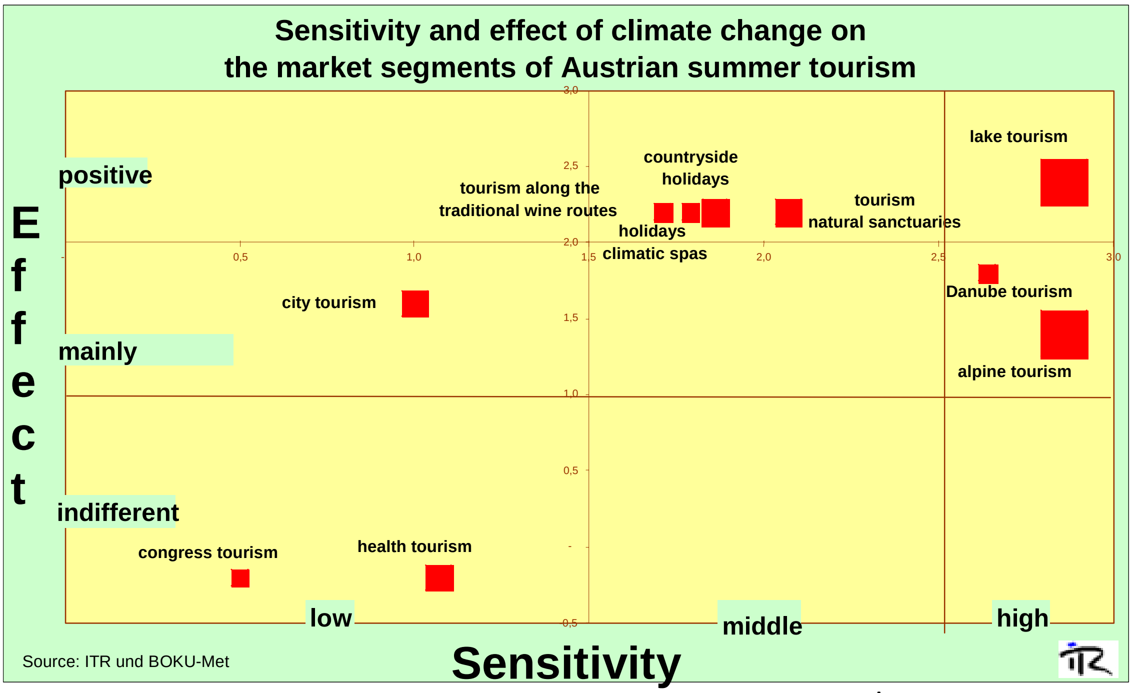


Fig. 13: First Assessment of the sensitivity and effect of climate change on the market segments of Austrian summer tourism. The characteristic positions of the individual market segments within this portfolio analysis result from the average scores of the evaluated dimensions “sensitivity” (0.6 to 2.86) and “effect of climate change” (-0.2 to 2.4). Different sizes of the portfolio squares result from derived threshold values of the sensitivity and effect stages. The three different sizes of market segments reflect their diverse importance and the number of over night stays of the individual respectively.

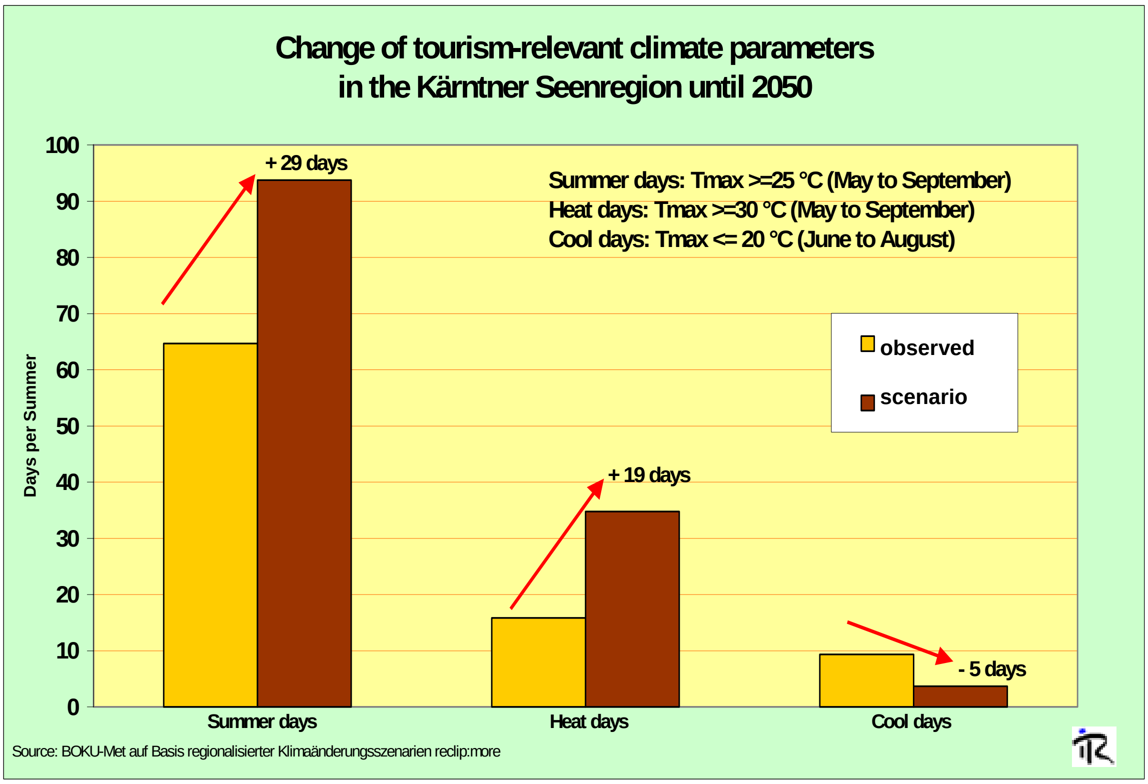


Fig. 14: Change of the tourism-relevant climate parameter in the”Kärntner Seenregion” by the year 2050 (Regionalmodell MM5, reclip:more, 2007).

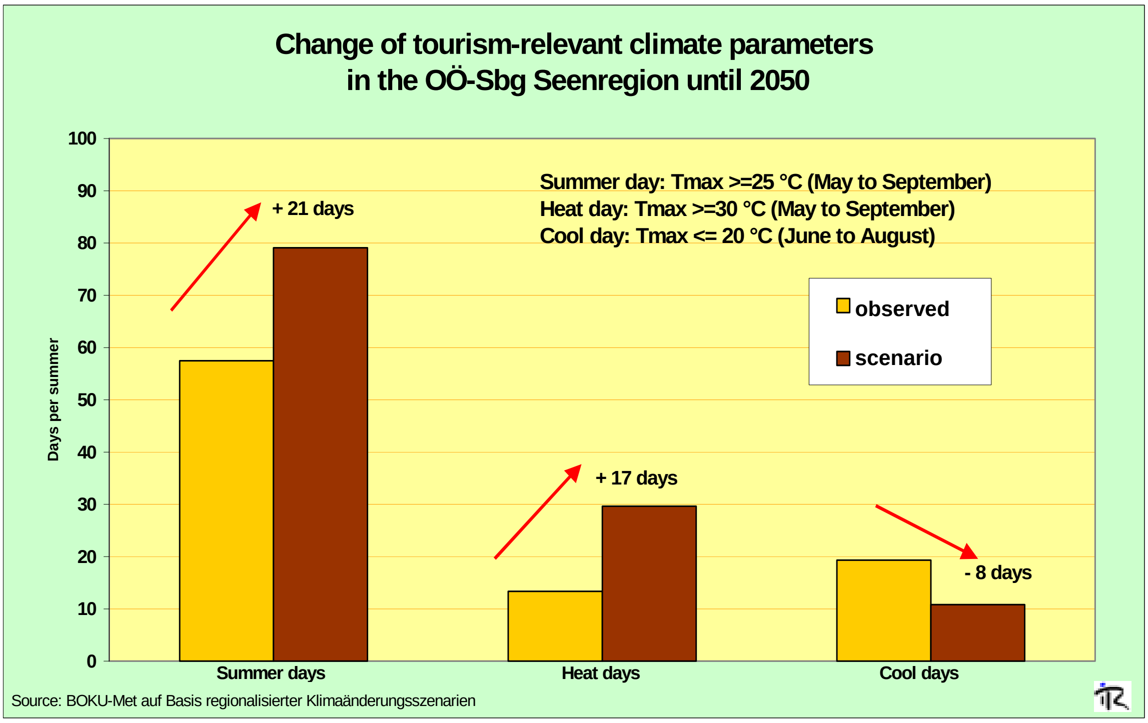


Fig. 15: Change of tourism-relevant climate parameters in the OÖ-Sbg. Seenregion by the year 2050 (Regionalmodell MM5, reclip:more, 2007)

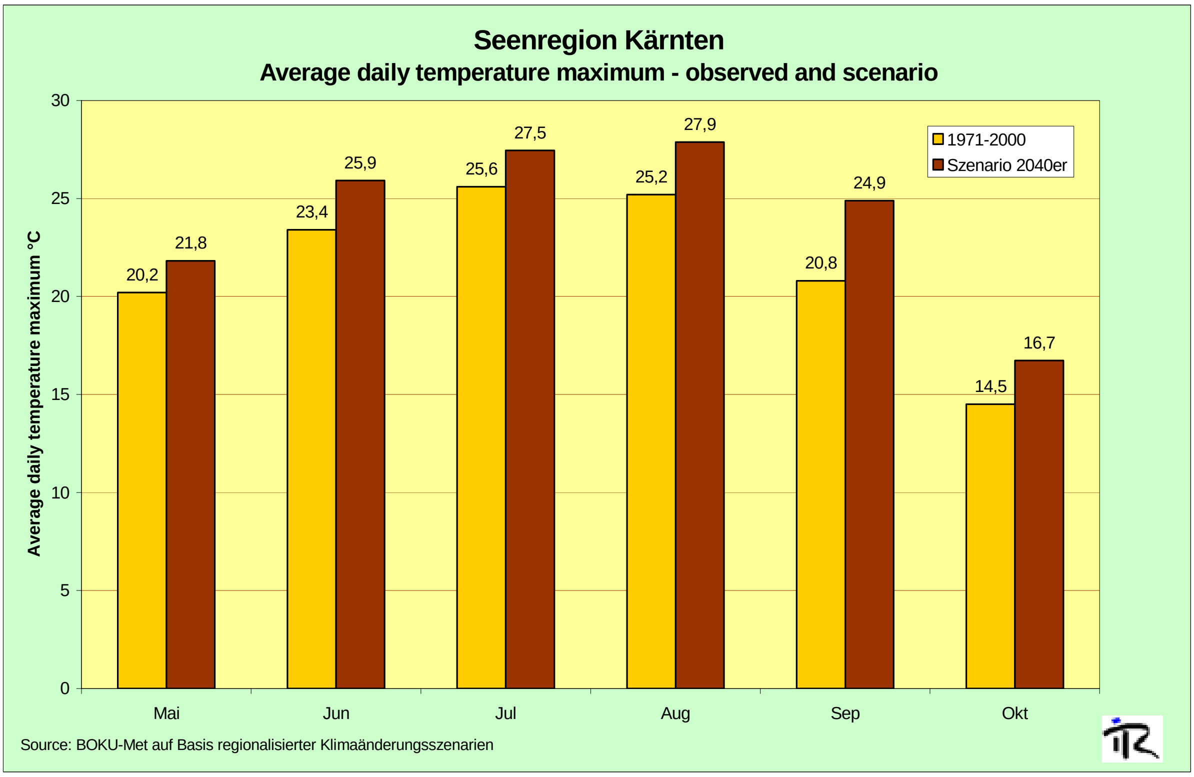


Fig. 16: Seenregion Kärnten – average daily temperature maximum – observed and scenario (Regionalmodell MM5, reclip:more, 2007)

For the two selected lake regions, the quantitative changes of climate parameters were calculated. The temperature increase by the 2040ies will lead to a 40 % increase in summer days, the heating days will roughly double and the cooling days will be reduced by 50 % (see fig. 14 and 15). The average daily maximum temperature will increase in all months but especially in September (see fig. 16). This temperature increase will extend the season for swimming in both regions to four months and improve “natural” conditions for the pre- and post season in summer tourism.

In general it can be concluded:

- State of the art regional climate change scenarios mainly tend to improve the situation for most of the summer tourism segments in Austria.
- Climate change will probably increase the attractiveness of the Austrian lake regions.
- Regional temperature scenarios are more reliable than the precipitation scenarios, therefore precipitation based indicators must be interpreted very carefully.
- An analysis for every individual summer tourism segment to determine the climate parameters that give the best estimate for tourism demands is needed. The present results give a valuable database for such studies.
- Statistical information on the climate/weather sensitivity of the summer tourists in the individual segments is missing for Austria. A professional market research would be necessary to gain information about the behaviour of summer tourists. This would be needed to analyse developments in tourism under climate change conditions.
- The demand for assessments of climate sensitivity of tourism development and adaptation strategies for individual destinations will increase in the future.

3.3 StartClim2006.D3: See-Vision: Influence of climate change-induced fluctuation of water level in Lake Neusiedl on the perception and behaviour of visitors and locals

Lake Neusiedl is situated in a relatively dry part of the Austrian province of Burgenland. It is a very shallow lake with an average water depth of less than two meters. Historical documents show that the lake had dried out several times during the 18th and 19th century for longer periods of time. Recent climate change research predicts an increasing likelihood for these events to occur more frequently in the future (Kromb-Kolb et al. 2005).

In the last few years, concerns arose about negative consequences associated with a repeated, extensive decline of water levels on tourism, especially its effects on the attractiveness of the lake and the region. The main purpose of this research project is therefore to investigate the effects of climate related changes in water level at Lake Neusiedl on the perception and behaviour of visitors to the region.

The aim of “See-Vision” is to develop and visualise future scenarios of fluctuating water-level in Lake Neusiedl for different types of shorelines, by using regional climate-data to visualise possible future landscape scenarios, which in turn affect the perception and behaviour of tourists. Thus, potential economical effects can also be estimated.

Furthermore, the study should provide indications of whether and to what extent compensation for low water level is possible e.g. through the creation of attractive swimming pools, nature experience events or wellness activities.

The questionnaire was developed with feedback from experts in the fields of tourism, nature protection, hydrology and water based recreation, resulting in future scenarios as well as hypotheses about the fluctuation of water level. Judging from recent scenarios on climate change (Kromb-Kolb et al. 2005), hydrological effects on the lake were determined.

The core element of the survey is a discrete choice experiment (in short DCE), which is a well proven method in tourism and market research (cf. Hensher et.al.2005, Haider et al.

1998), especially for the purpose of assessing non existing scenarios; the method also provides the opportunity to integrate visualisation. Visualisation is carried out according to the possible rate of incidence within the next 30 years (scenario 2040) considering different landscape types.

Fig. 17: Example – Visualisation for landscape scenarios of Lake Neusiedl

In order to test the acceptance of various adaptation strategies for the Lake Neusiedl region, possible strategies were integrated into both the DCE and the accompanying survey questions.

Results show that the main attractions of the region are its unique landscape and the various natural resources. Also, nature related opportunities are perceived positively, actually more so than those pertaining to culture or wine. In general, special events are of higher importance for vacationers than for weekend visitors. The various sports activities, on the other hand are not considered to be quite as important, which is understandable as only select groups of visitors enjoy any one of these activities. Bicycling, hiking and swimming emerge as the most popular activities. Other water sports such as sailing or surfing are only of average importance for the main sample. Recreation is more important at the lake, which again depends on the natural scenery. Both vacationers and weekend visitors consider the region to be “relaxing” and “near-natural”.

Hospitality and the authenticity of the region also contribute to the attraction – especially for vacationers. Furthermore, culinary aspects and the many-faceted wine products are also important.

Whilst the region gains positive feedback concerning its gastronomy, the quality of accommodations is judged more critically. In general, vacationers (except with regard to weather/climate and gastronomy) seem to perceive the region more positively.

About 43% of weekend visitors and more than half of the vacationers felt disturbed by low water levels. This difference in perception could coincide with the fact that vacationers predominantly visit during the summer season.

When asked for their optical perception of low water levels and the associated sensation of disturbance, vacationers and weekend visitors arrived at the same conclusion – two-thirds stated that they never felt disturbed by low water levels, 25% declared to have felt only slightly disturbed.

With regards to swimming activities, weekend visitors and vacationers behave in a similar manner – 57% use the lake for swimming activities, 38% rarely go into the lake and only 4% never go into the lake. More than half of the visitors do not find the muddy ground of the lake comfortable. However, about one quarter consider the natural mud acceptable, this being more vacationers than weekend visitors.

If they had the choice, only 30% of the tourists, both weekend visitors and vacationers would prefer a pool over the lake. Whereas vacationers are equally interested in both a hotel owned pool and a public open air pool, weekend visitors definitely prefer a hotel owned pool. Once more it became obvious that, although pools are an adequate measure to compensate for low water levels, approximately one third of the visitors find, the natural resources, and especially the lake, to bear a special meaning for the region.

The strong interest of tourists in nature at Lake Neusiedl is also confirmed by the strong interest in the landscape. More than 90% of the respondents stated to inform themselves about the landscape which they chose for their holidays. Another two-thirds declared being influenced in their perception of the landscape by that knowledge of the region and its landscape.

The results mentioned above were confirmed by the choice experiment. In the overall sample, the most popular activities were the most important ones, whereas specified products (e.g. horse riding, wellness, child care) did not turn out to be significant, but they are very important for minority segments of visitors. Furthermore the demonstrated changes of water levels in the visualisations were not judged as significant as long as they do not negatively affect the preferred activities.

The choice experiment also confirmed the divergent preferences between weekend visitors and vacationers. Weekend visitors are mainly interested in the various sports activities and associated infrastructure (i.e. swimming in the lake and a pool), while longer term vacationers are mostly attracted by the landscape related attributes of water level in the lake and nature experience; for them, the cultural and wine experience are the most important additional attractions.

The results show that the effect of water levels depends on the type of landscape (i.e. shoreline with reeds, open shoreline, artificial beach with gravel). Visitors who are interested in nature have a stronger reaction to water level fluctuations.

The responses provide the following insights regarding options for adaptation to climate change:

- Most of the long-term vacationers were not affected by the statement of limited swimming opportunities in the lake, as long as the image conveys a natural environment. Therefore, limited swimming opportunities can be compensated with pools. Day- and weekend visitors react differently, and do not support the compensation of swimming in the lake with the availability of pools to the same extent.
- Significant potential for adaptation has been shown by long-term visitors, as they consider the natural environment, as well as cultural events and wine events to be the most important product components, which can partly compensate for losses in recreation opportunities due to low water levels.
- The infrastructure for upscale sports activities such as horseback riding and golf are only important for a small segment of users and are considered to be insignificant by the large majority of visitors.
- The hypothesis that more information regarding the natural environments of the lake increases the acceptance of water fluctuations has not yet been confirmed.

More detailed results of simulating the compensational behaviour of single user groups and the division of vacationers/weekend visitors addressed above, are summarized in a support tool (excel).

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Annex

Subprojects of StartClim2003

These reports can be found on the StartClim2006-CD-ROM as well as in the StartClim-webpage (www.austoclim.at/startclim/)

StartClim.1: Quality control and statistical characteristics of selected climate parameters on the basis of daily values in the face of Extreme Value Analysis
Central Institute of Meteorology and Geodynamics
Wolfgang Schöner, Ingeborg Auer, Reinhard Böhm, Sabina Thaler

StartClim.2: Analysis of the representativeness of a data collected over a span of fifty years for the description of the variability of climatic extremes
Central Institute of Meteorology and Geodynamics
Ingeborg Auer, Reinhard Böhm, Eva Korus, Wolfgang Schöner

StartClim.3a: Extreme Events: Documentation of hazardous events in Austria such as rock avalanches, floods, debris flows, landslides, and avalanches
Institute of Forest and Mountain-Risk Engineering,
BOKU - University of Natural Resources and Applied Life Sciences
Dieter Rickenmann, Egon Ganahl

StartClim.3b: Documentation of the impact of extreme weather events on agricultural production
ARC Seibersdorf research
Gerhard Soja, Anna-Maria Soja

StartClim.3c: Meteorological extreme Event Data information system for the Eastern Alpine region - MEDEA
Federal Environment Agency, Martin König, Herbert Schentz, Johann Weigl
IIASA, Mathias Jonas, Tatiana Ermolieva

StartClim.4: Development of a method to predict the occurrence of extreme events from large-scale meteorological fields
Institute of Meteorology and Physics
BOKU - University of Natural Resources and Applied Life Sciences
Andreas Frank, Petra Seibert

StartClim.5: Testing statistical downscaling techniques for their applicability to Extreme Events in Austria
Institute of Meteorology and Physics,
BOKU - University of Natural Resources and Applied Life Sciences
Herbert Formayer, Christoph Matulla, Patrick Haas
GKSS Forschungszentrum Geesthacht, Nikolaus Groll

StartClim.6: Adaptation strategies for economic sectors affected heavily by extreme weather events: Economic evaluation and policy options
Austrian Humans Dimensions Programme (HDP-A)
Department of Economics, Karl-Franzens-Universität Graz
Karl Steininger, Christian Steinreiber, Constanze Binder, Erik Schaffer
Eva Tusini, Evelyne Wiesinger

StartClim.7: Changes in the social metabolism due to the 2002-floodings in Austria: case study of an affected community
Institute of Interdisciplinary Studies of Austrian Universities (IFF)
Willi Haas, Clemens Grünbühel, Brigitt Bodingbauer

StartClim.8: Risk-management and public welfare in the face of extreme weather events: What is the optimal mix of private insurance, public risk pooling and alternative transfer mechanisms
Department of Economics, Karl-Franzens-Universität Graz
Walter Hyll, Nadja Vetters, Franz Prettenthaler

StartClim.9: Summer 2002 floods in Austria: damage account data pool
Center of Natural Hazards and Risk Management (ZENAR),
BOKU - University of Natural Resources and Applied Life Sciences
Helmut Habersack, Helmut Fuchs

StartClim.10: Economic aspects of the 2002-Floodings: Data analysis, asset accounts and macroeconomic effects
Austrian Institute of Economic Research (WIFO)
Daniela Kletzan, Angela Köppl, Kurt Kratena

StartClim.11: Communication at the interface science - education
Institute of Meteorology and Physics,
BOKU - University of Natural Resources and Applied Life Sciences
Ingeborg Schwarzl
Institute of Interdisciplinary Studies of Austrian Universities (IFF)
Willi Haas

StartClim.12: Developing an innovative approach for the analysis of the August 2002 Flood Event in comparison with similar extreme events in recent years
Department of Meteorology and Geophysics, University of Vienna
Simon Tschannett, Barbara Chimani, Reinhold Steinacker

StartClim.13: High-resolution precipitation analysis
Department of Meteorology and Geophysics, University of Vienna
Stefan Schneider, Bodo Ahrens, Reinhold Steinacker, Alexander Beck

StartClim.14: Performance of meteorological forecast models during the August 2002 floods
Central Institute of Meteorology and Geodynamics
Thomas Haiden, Alexander Kann

StartClim.C: Design of a long term Climate-Climate-Impact Research Program for Austria
Institute of Meteorology and Physics,
University of Natural Resources and Applied Life Sciences
Helga Kromp-Kolb, Andreas Türk

StartClim.Reference database:
Implementation of a comprehensive literature data base on climate and climate impact research as a generally accessible basis for future climate research activities
Institute of Meteorology and Physics,
University of Natural Resources and Applied Life Sciences
Patrick Haas

Subprojects of StartClim2004

These reports can be found on the StartClim2006-CD-ROM as well as in the StartClim-webpage (www.austoclim.at/startclim/)

StartClim2004.A: Analysis of heat and drought periods in Austria: Extension of the daily StartClim data record by the element vapour pressure
Central Institute of Meteorology and Geodynamics
Ingeborg Auer, Eva Korus, Reinhard Böhm, Wolfgang Schöner

StartClim2004.B: Investigation of regional climate change scenarios with respect to heat waves and dry spells in Austria
Institute of Meteorology, BOKU
Herbert Formayer, Petra Seibert, Andreas Frank, Christoph Matulla, Patrick Haas

StartClim2004.C: Analysis of the impact of the drought in 2003 on agriculture in Austria – comparison of different methods
ARC Seibersdorf research
Gerhard Soja, Anna-Maria Soja
Institute of Meteorology, BOKU
Josef Eitzinger, Grzegorz Gruszczynski, Mirek Trnka, Gerhard Kubu, Herbert Formayer
Institute of Surveying, Remote Sensing and Land Information, BOKU
Werner Schneider, Franz Suppan, Tatjana Koukal

StartClim2004.F: Contiunation and further development of the MEDEA event data base
Federal Environment Agency
Martin König, Herbert Schentz,
Katharina Schleidt
IIASA
Matthias Jonas, Tatiana Ermolieva

StartClim2004.G: „Is there a relation between heat and productiviy?“ A project at the interface between science and education
Institute of Meteorology, BOKU
Ingeborg Schwarzl, Elisabeth Lang, Erich Mursch-Radlgruber

Subprojects of StartClim2005

These reports can be found on the StartClim2006-CD-ROM as well as in the StartClim-webpage (www.austoclim.at/startclim/)

StartClim2005.A1a: Impacts of temperature on mortality and morbidity in Vienna

Medical University of Vienna, Centre for Public Health, Institute of Environmantal Hygiene
Hanns Moshammer, Hans-Peter Hutter
Institute of Meteorology, BOKU
Andreas Frank, Thomas Gerersdorfer
Austrian Federal Intitute of Health Care
Anton Hlava, Günter Sprinzl
Statistics Austria, Barbara Leitner

StartClim2005.A1b: Nocturnal cooling under a changing climate

Institute of Meteorology, BOKU
Thomas Gerersdorfer, Andreas Frank, Herbert Formayer, Patrick Haas
Medical University of Vienna, Centre for Public Health, Institute of Environmantal Hygiene
Hanns Moshammer
Statistics Austria, Barbara Leitner

StartClim2005.A4: Impacts of meteorological extreme events on safety of drinking water supply in Austria

Institute of Sanitary Engineering and Water Pollution Control, BOKU
Reinhard Perfler, Mario Unterwainig
Institute of Meteorology, BOKU
Herbert Formayer

StartClim2005.C2: Studies on the distribution of tularaemia under the aspect of climate change

Gesellschaft für Wildtier und Lebensraum – Greßmann & Deutz OEG
Armin Deutz
HBLFA Raumberg Gumpenstein, Agricultural Research and Education Centre
Thomas Guggenberger

StartClim2005.C3a: Impacts of climate change on agricultural pests and antagonists in organic farming in Eastern Austria

Bio Forschung Austria
Bernhard Kromp, Eva Maria Grünbacher, Patrick Hann
Institute of Meteorology, BOKU
Herbert Formayer,

StartClim2005.C3b: Risk Analysis of the establishment of the Western Flower Thrips (Frankliniella occidentalis) under outdoor conditions in Austria as a result of the Climate change.

The Austrian Agency für Health and Food Safety, AGES
Andreas Kahrer
Institute of Meteorology, BOKU
Herbert Formayer,

StartClim2005.C5: An allergenic neophyte and its potential spread in Austria – range dynamics of ragweed (Ambrosia artemisiifolia) under influence of climate change

VINCA, Vienna Institute for Nature Conservation & Analysis
Ingrid Kleinbauer, Stefan Dullinger
Federal Environment Agency
Franz Essl, Johannes Peterseil

StartClim2005.F: GIS-sustained simulation of diminishing habitats of snow grouse, black grouse, chamois and capricorn under conditions of global warming and heightening forest limits

Joanneum Research
Heinz Gallaun, Jakob Schaumberger, Mathias Schardt
HBLFA Raumberg-Gumpenstein
Thomas Guggenberger, Andreas Schaumberger, Johann Gasteiner
Gesellschaft für Wildtier und Lebensraum - Greßmann & Deutz OEG
Armin Deutz, Gunter Greßmann