StartClim2007

Impacts of Climate Change on Austria: Case Studies

Final Report

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Juli 2008

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Final Report

Project Leader

Institute of Meteorology
Department of Water-Atmosphere-Environment
BOKU - University of Natural Resources and Applied Life Sciences Vienna
Univ.-Prof. Dr. Helga Kromp-Kolb

Contracting Parties

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

Administrative Coordination
Federal Environment Agency

Vienna, July 2008

StartClim2007
"Impacts of Climate Change on Austria: Case Studies"

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Vienna, July 2008

Contributions to StartClim2007

StartClim2007.A: Enlargement and completion of the StartClim dataset for the element daily snow depth. Update of the already existing StartClim datasets (air temperature, precipitation and vapour pressure) until April 2007
Central Institute of Meteorology and Geodynamics: Ingeborg Auer, Anita Jurković, Reinhard Böhm, Wolfgang Schöner, Wolfgang Lipa

StartClim2007.B: Health risks for the Austrian population due to the depletion of stratospheric ozone
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Institute of Medical Physics and Biostatistics, University of Veterinary Medicine Vienna: Alois W. Schmalwieser
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StartClim2007.C: Adaptations of insect pests to climate change in crop production of eastern Austria: conception of a long-term monitoring system
Bio Forschung Austria: Eva-Maria Grünbacher, Patrick Hann, Bernhard Kromp
Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Vienna: Herbert Formayer

StartClim2007.D: Consequence of the climate-induced upwards shift of the timberline on the release of greenhouse gases - dynamics of soil organic matter
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StartClim2007.E: Global change and its effect on runoff behaviour of glacierised basins with regard to reservoir power stations
Institute of Meteorology and Geophysics, University Innsbruck:
Michael Kuhn, Marc Olefs, Andrea Fischer

StartClim2007.F: ALSO WIKI – Alpine summer tourism in Austria and the potential effects of climate change
Austrian Institute for Regional Studies and Spatial Planning: Cornelia Krajasits, Gregori Stanzer, Adolf Anderl, Wolfgang Neugebauer, Iris Wach
Central Institute of Meteorology and Geodynamics
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StartClim2007.G: Integrated modelling of the economy under climate change in application of the STERN report (STERN.AT)
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Abstract

The five StartClim phases covered a wide range of topics and highlighted the vast catalogue of questions connected with climate change.

Quality-tested past and present multiple-climate datasets are the indispensable basis for climate variability studies. Therefore, one goal of StartClim2007.A project was to update (until April 2007) already existing, quality-tested datasets of temperature, precipitation and vapour pressure. The main focus was on the completion and the analysis of daily snow depth datasets.

Changes in snow cover duration

Using measured daily total snow depths it was possible to calculate fictive fresh snow sums (*pseudo fresh snow*). This gave rise to a large number of observation and digitisation errors, which were corrected in a subsequent analysis step.

Many gaps in the time series were closed using information from highly correlated stations in the neighbourhood. During this process no distinction was made between stations from the network of the Central Institute for Meteorology and those from the national hydrographical service (HZB).

An essential prerequisite for any kind of trend analysis is the homogeneity of the underlying time series. Thus, a classification into homogenous and non-homogenous stations was made using the *HOCLIS* homogeneity test. The trend analysis was done for the predefined characteristic snow parameters "*number of days with snow*", "*winter cover*", "*snow cover*" and "*maximum snow depth*".

For the two characteristic parameters *"winter cover"* and *"number of days with snow cover"* the trend test showed significant negative trend values for most stations in southern Austria. In the northern part of Austria the Mann-Kendall test revealed both insignificant and significant negative trend results (see Fig. A1 and A2).

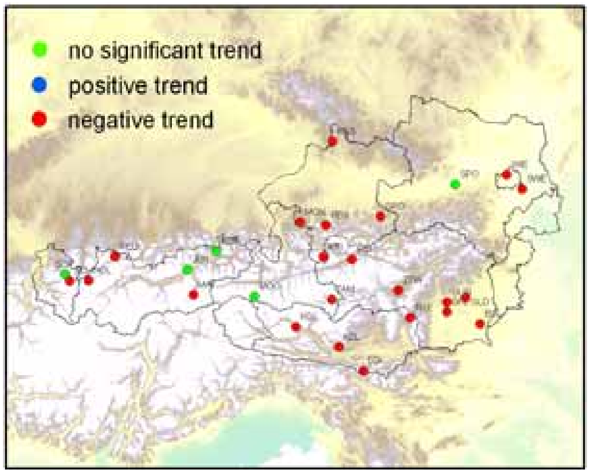

Fig. A1: Significant trend test results for the parameter **winter cover duration** for the high quality StartClim dataset

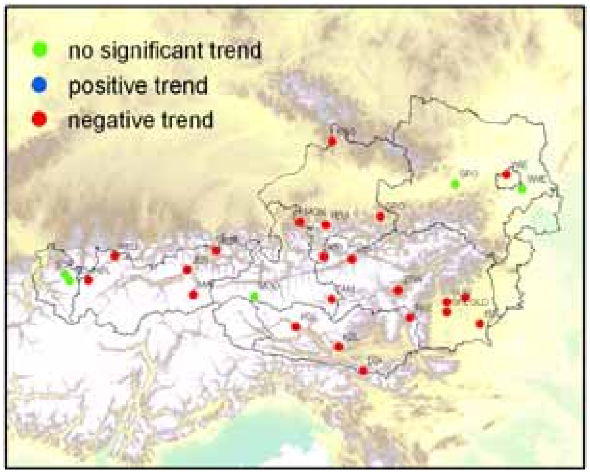

Fig. A2: Significant trend test results for the parameter **number of days with snow cover** for the high quality StartClim dataset

The *Schöner snow model* driven by daily temperature and precipitation values generated daily snow depth values. In general the model underestimated the height of snow cover and the difference between calculated and observed data tended to grow with increasing altitude. The trend test for the computed datasets showed similar results to the previous trend test for original data. This means that for regions without snow information the model cannot calculate the correct snow depth values but can predict trends.

Stratospheric ozone depletion is one of the severest changes that the earth's atmosphere has experienced in recent times. As a result of the long-term decrease in ozone, the number of days with low total column ozone und thus enhanced erythemally effective UV radiation has increased. Episodes of ozone depletion by up to 30%, which significantly raise UV strain imposed on the human skin, are especially common in late winter and spring. Beginning with the early 1990s, so-called ozone mini-holes have been appearing during early and late winter even in Austria. Under the influence of such an ozone mini-hole, the ozone level can drop to a value similar to the Antarctic ozone hole, which can increase the risk of sunburn by a factor of 2 and the risk of damage to the DNA by a factor of 4. Over the last two decades there has been a significant rise in the number of new cases of malignant melanoma, especially among men.

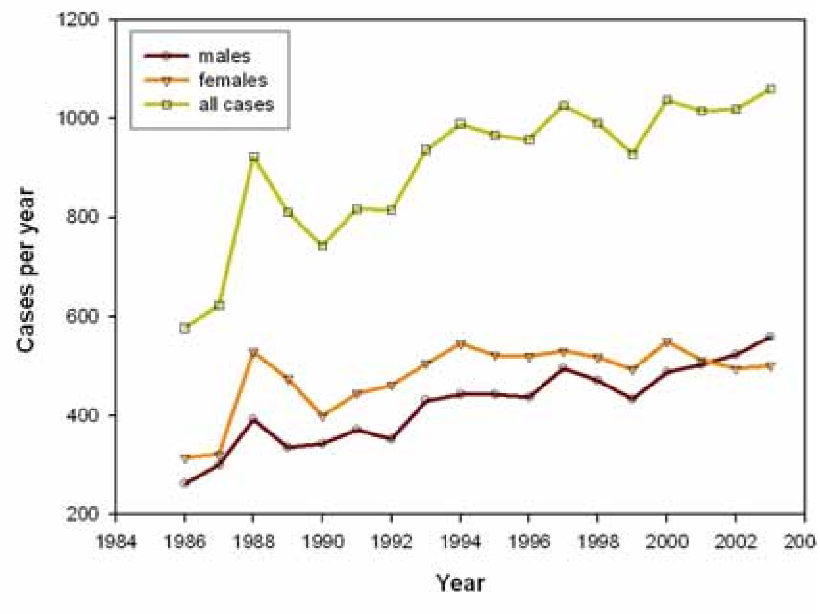

Fig. A3 Yearly new cases of malignant melanoma in Austria, absolute numbers

As a result of the Montreal Protocol for the protection of the ozone layer and the ban on production of CFCs and HCFCs, which was signed 20 years ago, the concentration of ozone-depleting substances has already reached its maximum and has now started to decline. However, it remains to be seen how global climate change will affect the stratosphere and hamper or delay recovery of the ozone layer.

Additionally, not only ozone but also cloud cover and the changes to it are a major influence on UV strain. Various regional climate change scenarios for the Alpine region indicate significantly decreasing cloud cover during the summer months, which would, along with leisure behaviour, lead to raised daily UV doses and sun exposure and thus augmented occurrence of skin cancer.

During the past few years, changes in pest occurrence have been detected in arable farming in eastern Austria. Pest species that prefer warmth have become more prevalent after having hitherto caused damage mainly in the south-eastern region of Central Europe. Because of the lack of congruent long-term data on population fluctuations of the relevant species it is impossible to determine with certainty whether these changes already indicate that pest insect fauna are adapting to climate change. This project therefore aimed to establish a monitoring concept to survey pest spectrum changes in Austrian arable farming as a function of climate change. Existing pest monitoring systems in Austria and their operators were to be involved. The concept was devised on the basis of a literature and Internet search and interviews with plant protection and climate specialists at relevant institutions.

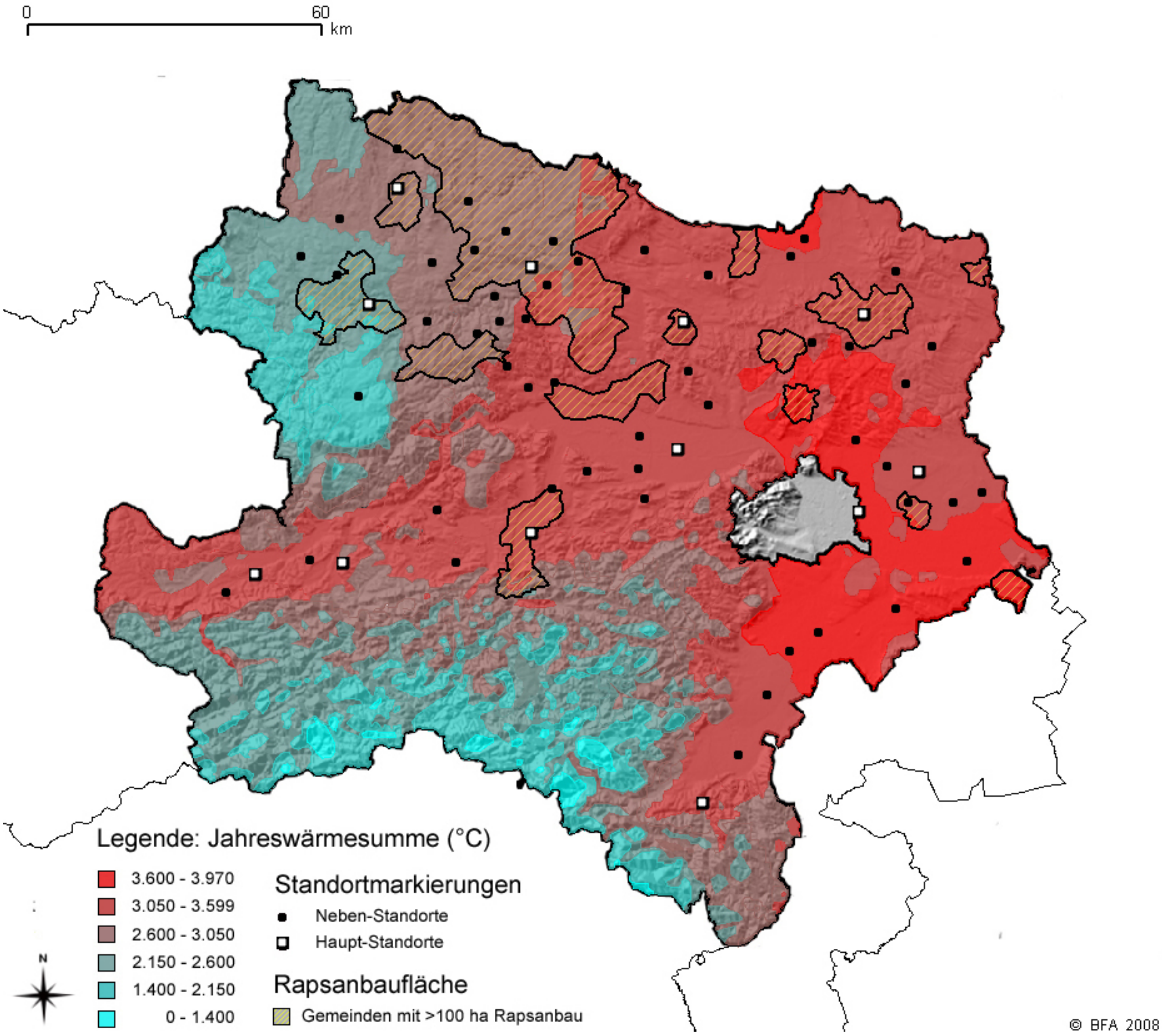

Fig. A4 Distribution of pest monitoring sites in Lower Austria: secondary sites (black boxes) are farms on which the density of the main pests is recorded simply and cost-effectively by the farm manager. Main sites (white boxes) are agricultural institutions at which the pest spectrum of selected crops, including overwintering data, is recorded in greater detail by qualified personnel. The sites cover the pest occurrence in the main ecoclimatic types, as depicted by the relief of Lower Austria, overlaid by the yearly temperature sum classes (°C; colour shades) according to HARLFINGER & KNEES (1999). The distribution of oilseed rape production in Lower Austria from 2005 is also overlaid: the hatched areas represent municipalities with more than 100 hectares of rape (Source: Statistik Austria, www.statistik.at).

A survey of existing pest recording systems in Austrian arable farming revealed gaps which were to be closed by the monitoring concept elaborated in this project. At present, only a few pest species are surveyed regularly; the mesh density of surveying sites is very low and the pest populations are usually surveyed only until the date of insecticide application. Based on our own investigations (StartClim 2005) and expert statements, a preliminary list of crops and pests to be surveyed was compiled. The grid of monitoring sites had to cover pest-relevant factors like acreage, crop proportions and especially the different climatic conditions in arable regions of eastern Austria (see Fig. A4). A two-stage set-up consisting of main sites (e.g. agricultural institutions) with high recording intensity but low mesh density and secondary sites (e.g. farms) with lower recording intensity but higher mesh density was therefore suggested. The monitoring methods were chosen for their accuracy and ease of use on the basis of expert statements and literature and also the extensive experience of Bio Forschung Austria.

A long-term objective of this project was the application of the concept in the framework of climate change research. Since no long-term monitoring systems for climatic changes in pest insect fauna could be found in the adjacent European countries, a system of this type in Austria could be the first of its kind in Europe.

The timberline shifts upwards because of climate change and changes in land use. The effect has been well documented for several decades. Soil analysis at a site that was investigated and documented 50 years ago showed the effects on soil properties of a conversion of dwarf shrub communities into a stone pine forest. The Poschach experimental site near Obergurgl, Ötztal, was the object of detailed phytophysiological and mesoclimatic research in the 1950s. The experiments were conducted in support of large-scale afforestation projects in high altitudes and were performed by the former Forstliche Bundesversuchsanstalt Mariabrunn. A reassessment of the vegetation and soils demonstrated the change in these site properties over the previous 50 years.

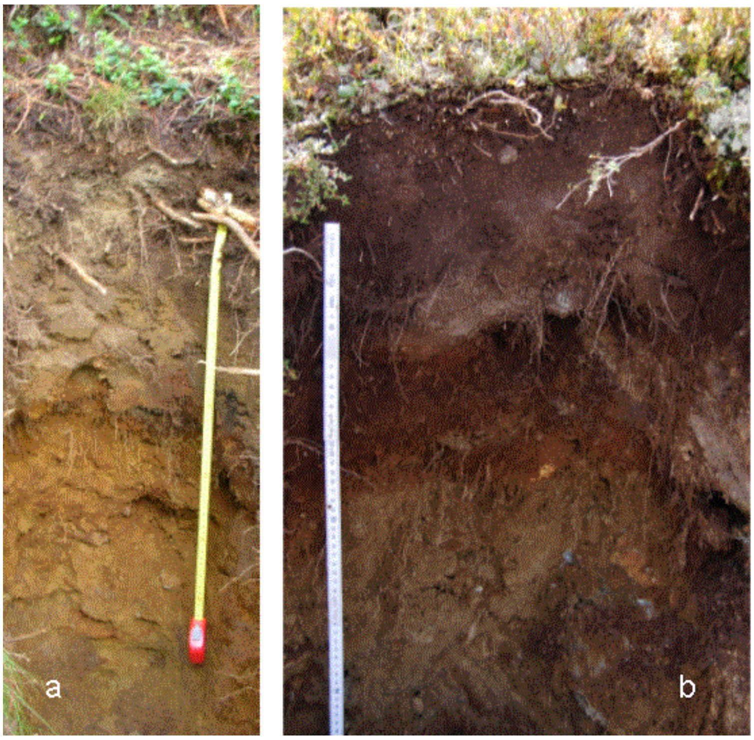

Fig.A5 Soil profiles: a) in a stone pine forest the soil is poor in organic matter, b) in dwarf shrub communities a rich organic layer forms. With a rise of the timberline and a change in the dominant vegetation from dwarf shrubs to stone pines the soil loses carbon that is partly incorporated in the aboveground biomass and partly released into the atmosphere

In Obergurgl the forest replaces dwarf shrub communities, dominated by heather and rhododendrons. These dwarf shrubs yield a poorly degradable litter and are renowned for their closed nutrient cycle. Soils under dwarf shrubs were richer in carbon than soils under 50-year-old stone pine forests. This has far-reaching implications for the carbon balance: although a large carbon pool is formed in the aboveground biomass, the usually more stable carbon pool of the soil is reduced. The implication for the Austrian carbon balance is that the changing vegetation results in the formation of a soil carbon pool that strongly responds to increasing temperatures. In summary, the rise of the timberline leads to significant changes in the soils linked to a higher release of carbon. Our results open a wide array of hypotheses that will be addressed in future research projects.

Climate changes lead to changes in the runoff regime of glacierised basins. This is an aspect that is of prime importance for the production of hydro power in Alpine reservoirs since both the annual hydrograph and the total amount of runoff are affected. While previous studies investigated the effect of the changed energy balance with unchanged glacier shape, this study calculates the down-wasting and the ensuing change of surface elevation and glacier area available for melt.

The proposed project modelled the water balance of three adjacent basins that are strongly or weakly glacierised or totally ice-free for the reference period 1983 to 2003. Based on this reference, changes in melt and runoff were modelled for a scenario in accordance with IPCC A1B.

Starting with the present distribution of ice thickness on Gepatsch Glacier and its measured change from 1997 to 2006, ice melt, ice volume and glacier surface area were calculated for increments of 1°C. Up to a temperature increase of 3°C (which corresponds to the decade 2030-2040 in the model assumptions) total ice melt continued to increase. With further warming the reduction of glacier area outweighed the increase in specific melt and reduced glacier runoff. For glaciers smaller than Gepatsch Glacier (17 km^2) this turning point occurred at lower temperatures.

The investigation of the effects of climate change on summer tourism refers only to the direct consequences. The impact of climate protection measures on tourism and other sectors is not the object of this study. Moreover, most of the results are based on plausibility estimates, since the necessary data is not available for real analysis.

In the medium term the rise in temperature will offer the opportunity to extend the summer season in the Alpine regions and to concentrate more on all-year tourism, e.g. through an anticipated increase in summer days and a decrease in rainy days during the summer. The infrastructure, services offered and marketing in the regions will have to be adapted, however. As the anticipated climate trends at certain altitudes promise climatic advantages, it may be assumed that more land will be required, with an attendant increase in the impact on environmentally sensitive areas. Strict regional planning and a suitable framework for the development of tourist services in Alpine regions will be needed.

While the Stern Review (Stern, 2007) analysed and roughly quantified the economic impacts of climate change, adaptation and mitigation on the global scale, it asked for detailed analyses at the regional level as impacts, vulnerability, adaptation and even mitigation strongly diverge across sectors and regions. The STERN.AT project thus aimed to model at the regional scale the interactions between climate change, physical and socio-economic impacts thereof and policy responses to mitigate impacts. The project coupled a regional climate scenario, sectoral analyses for two sectors, agriculture and energy, and a three-region economic Computable General Equilibrium model to assess the economic effects of local climate change for a study region in Austria. The impacts were computed for a year representative for the 2040s. We analysed separately the economic impacts of climate change under autonomous adaptation, the impacts of policy-induced adaptation and the impacts of a mitigation scenario. The simulation results illustrate the direction and magnitude of effects for economic indicators such as regional GDP and prosperity. Thus, climate change via altered energy demand was found to increase regional prosperity (amount of consumption goods) in the 2040s by 1.3%, via a shift in agricultural production to decrease prosperity by 0.3%. Through mitigation policies in the housing sector (enhanced insulation) or renewable energies (expanded biomass), for realistic policy scenarios regional GDP can be increased by up to 3% and regional prosperity by up to 0.7%.

The project points out that the assessment of damage costs requires a proper specification of changes in climate parameters not only with respect to the period of time (annual, seasonal, monthly, daily) but also with respect to the scale under consideration (global, national, regional, local). In order to attain more realistic simulations of socio-economic impacts from climate change more detailed sectoral analyses are required and further sectors, such as tourism, have to be considered. The current project demonstrated, however, that the chosen approach is feasible and promising.

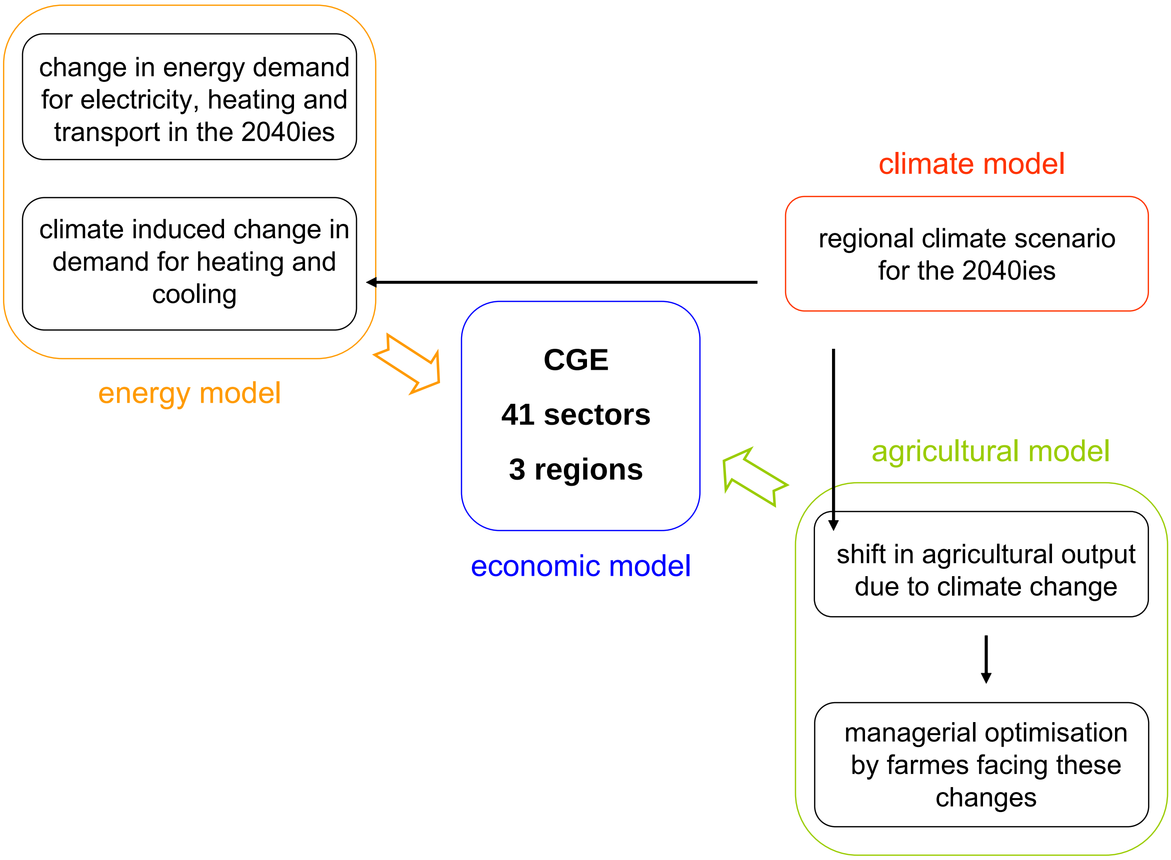

Fig. A6 Model coupling: The climate model supplies inputs for the energy model and the agricultural model, which in turn enter the economic model.

1 The StartClim research programme

The StartClim climate research programme was implemented in 2002 following extensive floods in Austria based on an initiative by the Austrian Federal Minister of the 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. Around 90 Austrian scientists and more than 30 Austrian institutions worked in StartClim since the beginning of the programme. StartClim achieved so far many interesting results that are often continued in projects financed by other programmes and institutions. The extensive participation in StartClim shows that the required know-how is available in Austria.

StartClim is financed by a donor consortium presently consisting of eight institutions. The donors together with the scientific project leader develop the topics of research in a coordinating group. 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.

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 StartClim2007

StartClim2007 dealt with health, agriculture, forestry, water management, tourism and economic issues.

The basis for the various analyses was reliable past and present climate data: quality-controlled meteorological data was updated and supplemented as part of the StartClim2007 project, which also included an analysis of snow data.

The project analysed the impact of stratospheric ozone depletion on the health of the Austrian population and investigated changes in the incidence of insect pests in biological farming, as well as the effect of the shift in the treeline on the carbon dioxide content of the soil. A further aspect of the project was an investigation of changes in the runoff of glacierised basins and its effect on storage power stations. The impact on summer tourism was also dealt with and on the basis of the Stern report a model for Austria was developed to estimate the economic effects of climate change.

The StartClim database (MEDEA) was also developed as part of the StartClim2007 project.

1.2 Structure of this report

The StartClim2007 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 StartClim2007 will be made available for download at http://www.austroclim.at/startclim/, the StartClim website.

1.3 Organisational aspects of StartClim2007

The organisational structure of StartClim2007 was similar to that of former StartClim phases. StartClim2007 consisted of seven subprojects involving 44 people from 15 institutions and representing far more than the 50 months of scientific work calculated in the project proposals. The breakdown of participating scientists reveals 17 female contributors.

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 website (http://www.austroclim.at/startclim/) at the Institute for Meteorology of the BOKU University of Natural Resources and Applied Life Sciences, Vienna.

2 StartClim2007 projects in detail

2.1 StartClim2007.A: Enlargement and completion of the StartClim dataset for the element daily snow depth. Update of the existing StartClim datasets (air temperature, precipitation and vapour pressure) until April 2007

The completion, correction and quality testing of the element snow depth enhanced and enlarged the existing dataset (StartClim1).

This dataset contains plausibility-tested temperature, precipitation and vapour pressure data for 71 Austrian meteorological service measuring points. Because many reports were lost during the Second World War, most of the time series begin not earlier than 1948. In the framework of StartClim2007.A this dataset was updated to April 2007.

With data from non-digitised Austrian hydrographical service reports, Central Institute for Meteorology climate sheets and other databases it was possible to close the main gaps in the daily snow depth chronology.

A quality test applied to the depth of *pseudo* fresh snow (difference in daily total snow depth: actual day - previous day) made it possible to detect various digitisation and observation errors that occur because of sporadic and imprecise measurements.

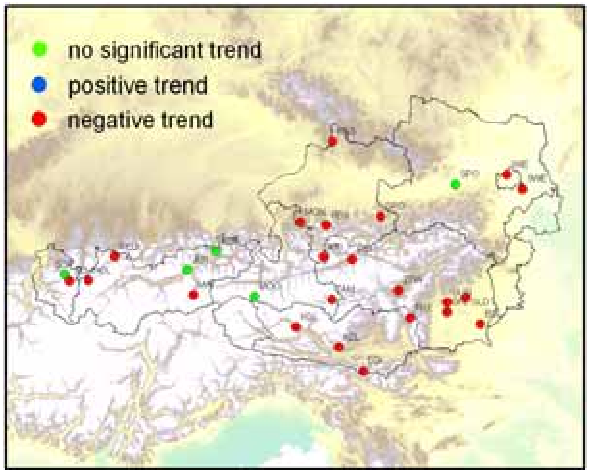

Fig. 1 Significant trend test results of the parameter **winter cover duration** for the StartClim high quality dataset

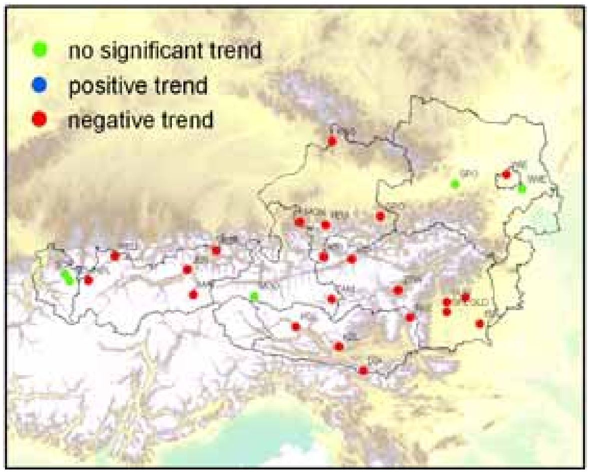

Fig. 2 : significant trend test results of the parameter **number of days with snow cover** for the StartClim high quality dataset

Only stations that could offer a long, complete, quality checked and homogeneous time series were trend tested. The homogeneity of the underlying datasets was examined with a relative procedure named HOCLIS. Ultimately, 20 stations could be classified as homogeneous. For some characteristic snow parameters like *number of days with snow*, *duration of snow cover*, *duration of winter cover* and *maximum snow depth* the trend was tested using the Mann-Kendall method. Because of the sparse data for the parameter *duration of snow cover* (the days from first to last day with snow cover in a winter half year, without consideration of snow-free phases) only the Jenbach station showed a significant negative trend test result. As a result of the high variability of the *maximum snow depth* only a few stations like Kolbnitz, Kanzelhöhe and Mayerhofen showed a significant negative trend. At most stations (particularly the stations in the south of Austria) the other two parameters revealed significant negative trends. Hence the *duration of winter cover* and the *number of days with snow* decreased significantly (see Fig. 1 and 2). No single homogenous station offered a positive trend test result for the above-mentioned parameters.

Using the *Schöner snow model* we also calculated daily snow depth values from daily temperature and precipitation. In general the model underestimated the snow depth. The higher a station was situated the greater the difference between the theoretical and actual values (see Fig.3 and 4). At the low-altitude Klagenfurt station (450 m) the actual values agreed with the modelled values (the differences about the zero point are almost normally distributed), whereas Sonnblick, the highest station (3105 m), showed the largest differences. The range of the original data here was greater (from 0 m to 9 m snow depth) and uniformly distributed. By contrast the modelled data values ranged from 0 m to 2 m only and were right-skewed. Because of the great discrepancy the difference in values reached up to 7 m snow depth.

However, the discrepancy had no influence on trends and the modelled time series showed similar trend test results. For regions without snow information the model cannot therefore calculate the snow depth, but the trend information is useful.

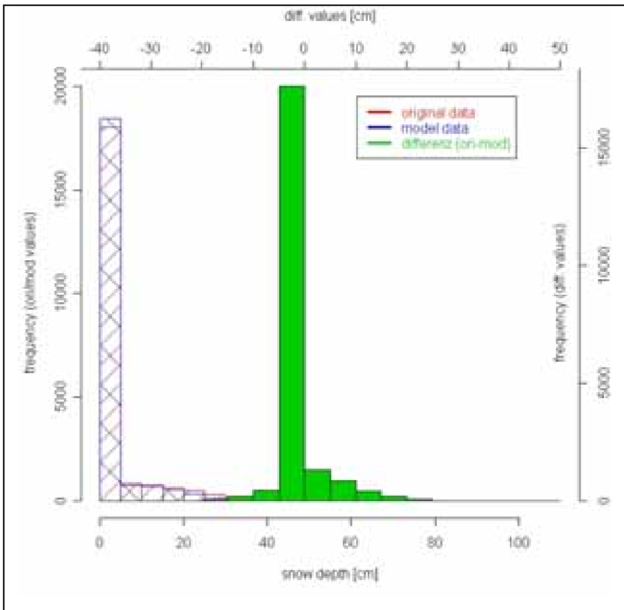

Fig. 3 Klagenfurt station (450 m): frequency distribution of the element snow depth showing original, model data and differences

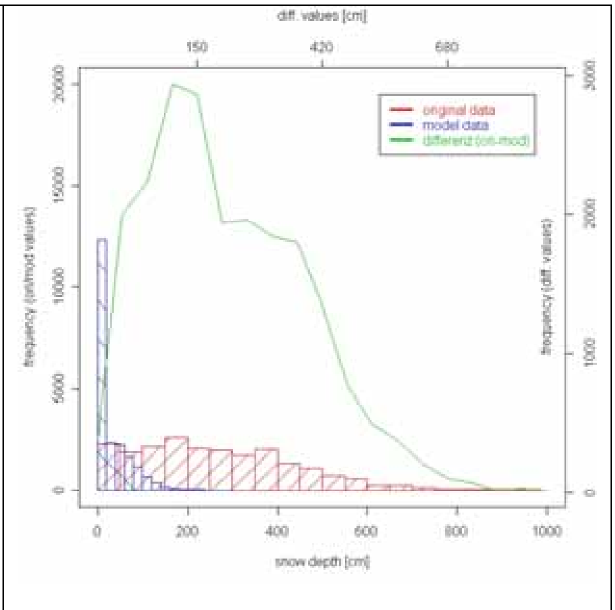

Fig. 4 Sonnblick station (3105 m): frequency distribution of the element snow depth showing original, model data and differences

With regard to the usefulness in climate and climate impact analysis, the stations were divided into three classes taking into account criteria such as completeness and homogeneity of the time series and number of corrected values. The following distribution resulted:

- 10 class 1 stations (14%) *(complete, accurate and homogenous time series)*
- 36 class 2 stations (50%)
- 25 class 3 stations (36%)

An analysis of extreme values shows that the number of winters with less snow has increased in the last few years. Winters with high snow amounts occurred in the 1960s. Fig. 5 demonstrates the temperature anomalies (red line) and precipitation anomalies (in percent, blue line) of the 1961-1990 mean of all HISTALP stations. For a better understanding of the interrelation of temperature, precipitation and snow cover, both curves were faced with the mean number of days with snow (anomalies of the 1961-1990 mean) of the 71 Austrian StartClim stations. With a positive temperature anomaly of +3.1°C and 94% of the mean winter precipitation the last winter 2006/07 was aboveaveragely warm. This had a great impact on the depth and duration of snow cover. In winter 2006/07 the number of days with snow cover decreased by a mean 48 days. In comparison with the 1961-1990 mean value of 101 days' snow cover in a winter half year, the year 2006/07 showed a deficiency of nearly 50%. As an illustration of the high variability, the other extreme was found only one year earlier. In winter 2005/06 the negative temperature anomaly of -0.9°C and 91% mean winter precipitation induced a positive anomaly of the number of days with snow cover (+29 days).

In general, the ambient temperature has greater influence on the duration of snow cover than the amount of precipitation. High temperatures in connection with fluid precipitation induced a melting of snow cover and consequently reduced the *number of days with snow cover* and so the *winter cover duration*.

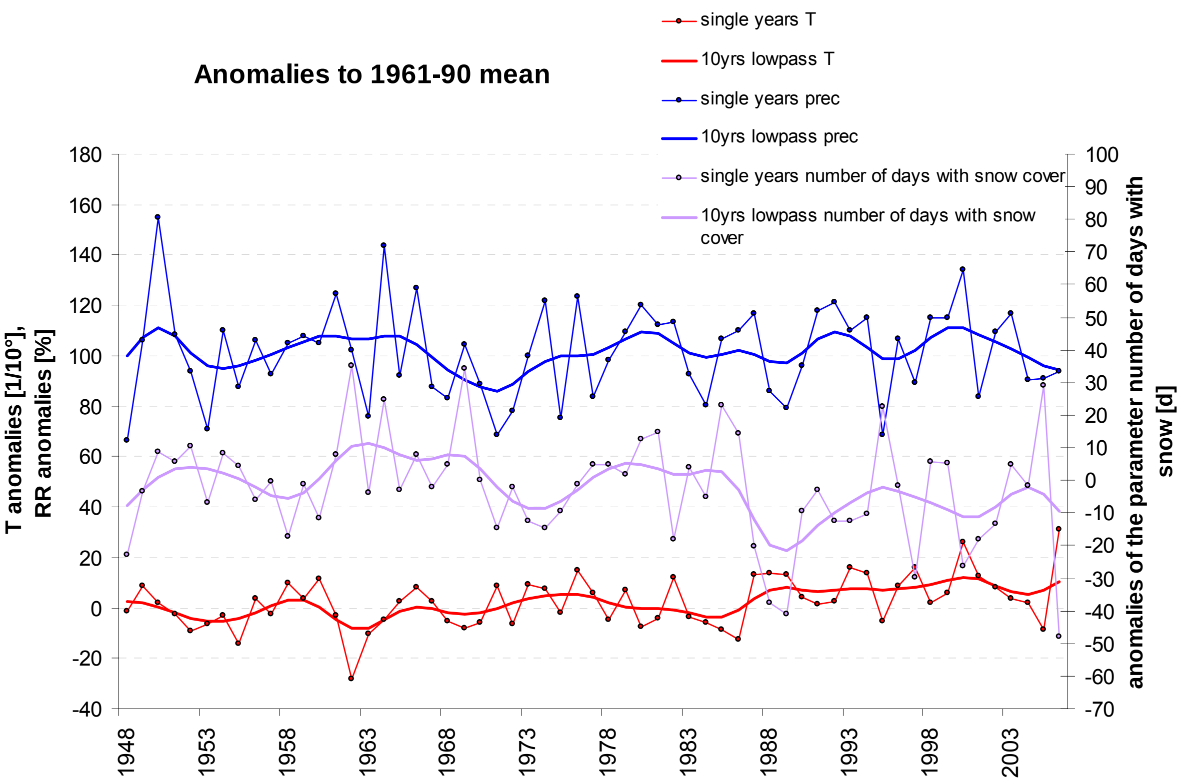

Fig. 5 Mean temperature, precipitation and number of days with snow anomalies. In comparison with the 1961-1990 mean

Within this project the snow depth dataset was completed, tested, corrected, modelled and finally analysed. All these procedures turned out to be time-consuming. Considerable computer resources were necessary in particular for modelling daily snow depth. Apart from the projects results described, there is an evident need for further research in the following sectors:

- **Increase in the number of stations:** Particularly in the Alpine area, where the topography is extremely complex, it is essential to have an adequate number of stations to analyse the cumulative snow depth in detail.
- **Homogenisation:** Homogenisation of monthly and, at a later date, daily data of climate elements (including snow depth) would be desirable. The elimination of heterogeneities within a time series is a precondition for interpolation and trend analysis. In the framework of this project some preliminary work on the homogenisation of snow depth was done. Only with a homogenised time series will it be possible to evaluate and analyse the variability of extreme values.

- **Extension of time series:** Better statements in regard to climate variability and extreme value analysis could be achieved with long (100-year) time series.
- **Additional elements:** The interaction with other climate elements could be investigated by considering aspects such as radiation, cloudiness and atmospheric pressure.

2.2 StartClim2007.B: Health risks for the Austrian population due to the depletion of stratospheric ozone

Stratospheric ozone depletion is among the severest changes in the earth's atmosphere in recent times. In the last 40 years, total column ozone has decreased by more than 8% in mid-latitudes. As a consequence of this long-term decrease, the occurrence of days with low total ozone is now much more frequent than it was 30 years ago (Fig. 6). The risk of sunburn and additional reactions induced by UV-B radiation (skin cancer, DNA damage) has increased as well.

Episodes of ozone depletion by up to 30%, which significantly raise UV strain imposed on the human skin, are especially common in late winter and spring. Meteorological phenomena like high-pressure conditions with a life span of one to five days can cause spatially and temporally limited decreases of more than 100 DU (Dobson units) compared with the long-term mean values. Such structures are called ozone mini-holes (OMH), which are associated with an increase in harmful UV-B radiation. From the early 1990s onwards, such structures, which are characterised by low ozone values, have been observed even in Austria. Under the influence of such an ozone mini-hole, ozone can drop to values similar to the Antarctic ozone hole (Fig. 7), which could boost the risk of sunburn by a factor of 2, and the risk of damage to the DNA by a factor of 4 (Fig. 8). As the human skin is not yet adapted to higher UV-B doses, the UV risk is even higher in spring.

Over the last two decades there has been a significant rise in the number of new cases of malignant melanoma, particularly among men (Fig.9). Malignant melanoma has caused more deaths than the sum of all other skin tumours. In the early 1990s, 2.6 per 100,000 men and 1.8 per 100,000 women were newly affected; the corresponding figures today are 3.1 for men and 1.7 for women. The latency period for malignant melanoma is about 20 years, which is why only about a third of the new cases occur before the 50th year of age, another third between 50 and 69, and the last third from 70 years onwards. Presumably, the increase in received UV radiation is not the only reason for a growth that significant but rather also changes in lifestyle such as leisure behaviour, clothing style and holiday habits. This can be seen by comparing trends from different groups. The increase seems to be more pronounced with wealthier classes of population.

As a result of the Montreal Protocol for the protection of the ozone layer and the ban on production of CFCs and HCFCs, which was signed 20 years ago, the concentration of ozone-depleting substances has already reached its maximum and has now started to decline. However, it remains to be seen how global climate change will affect the stratosphere and hamper or delay recovery of the ozone layer. The future development of the stratospheric ozone layer attracts considerable scientific and social attention today. There is some discussion as to whether the ozone layer has begun to recover. There appear to be some indications but it is not clear whether the reduced chlorine content in the atmosphere is a sign of recovery or whether the observations only represent natural fluctuations caused by other factors such as the 11-year solar cycle. It will therefore be years before these observations can be properly verified.

UV intensity incident at the earth's surface is affected by stratospheric ozone, cloud cover, composition and concentration of aerosols and surface albedo. Cloud cover has particular relevance in terms of global climate. Various regional climate change scenarios for the Alpine region indicate significantly decreasing cloud cover during the summer months which would, along with leisure behaviour, lead to raised daily UV doses and sun exposure and thus augmented occurrence of skin cancer. It is known from other countries that information to the population can successfully counteract this trend.

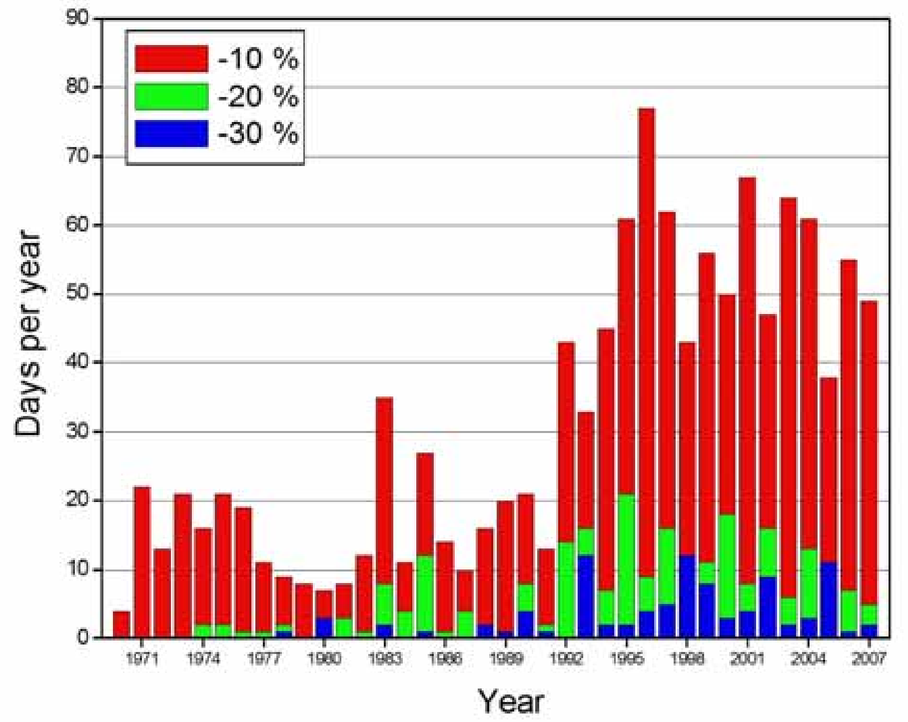

Fig. 6 Yearly occurrence of days with low total column ozone during February to August at Sonnblick observatory. Different bar styles indicate ozone depletion of 10, 20 or 30 % compared with the period 1928-1978.

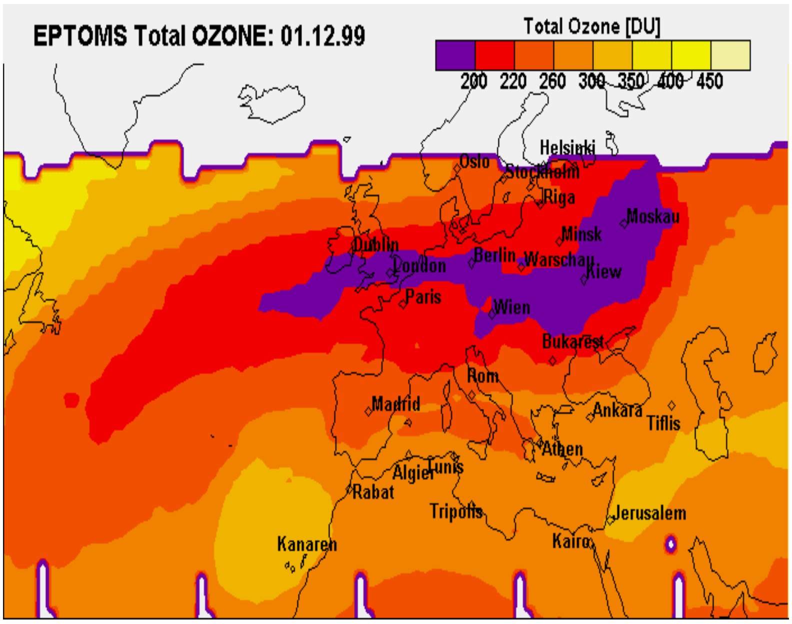

Fig. 7 Ozone mini-hole in Austria, 1 December 1999

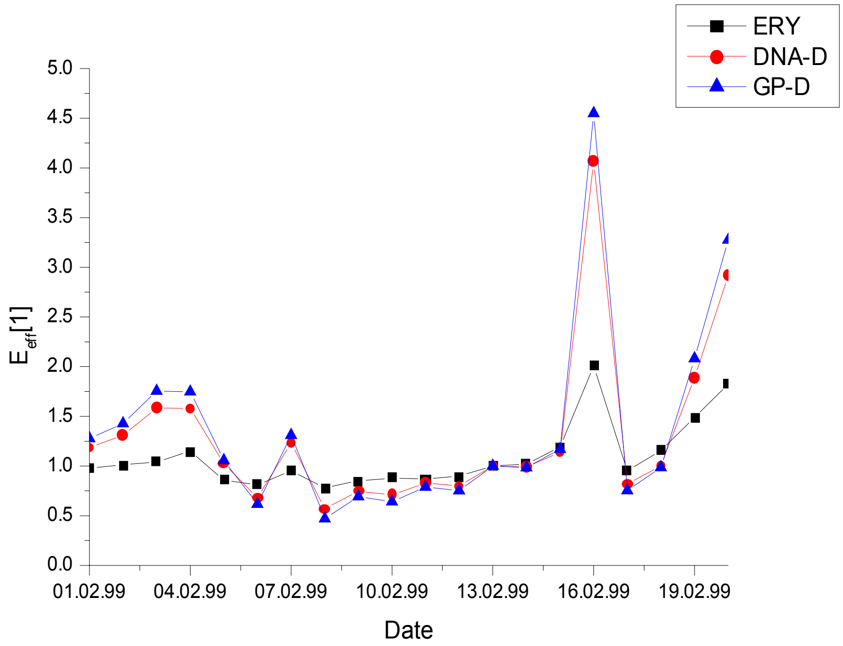

Fig. 8 Development of biologically effective UV radiation during the occurrence of an extreme ozone mini-hole in February 1999. Shown are the series for erythemally effective (ERY), DNA-damaging (DNA-D) and vegetation-damaging (GP-D) UV radiation.

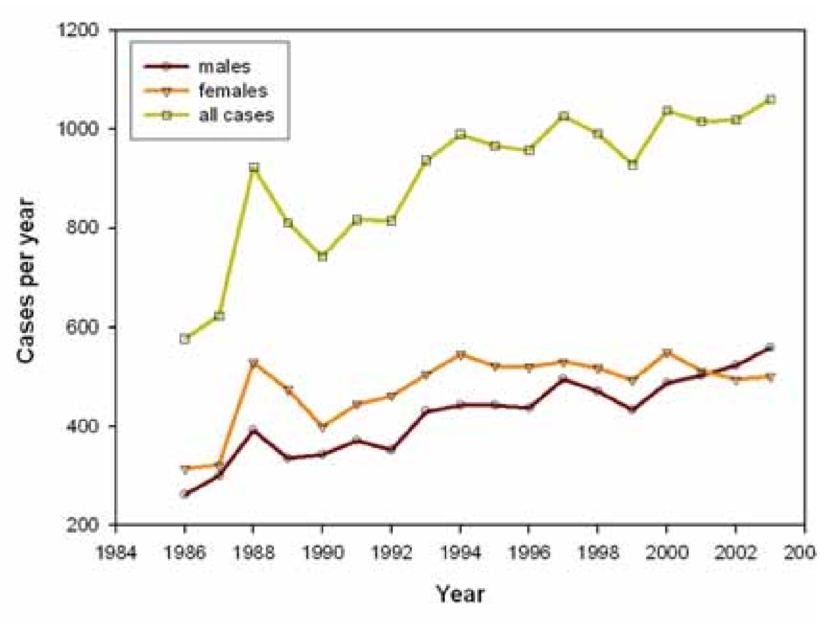

Fig. 9 Yearly new cases of malignant melanoma in Austria, absolute numbers

2.3 StartClim2007.C: Adaptations of insect pests to climate change in crop production of eastern Austria: conception of a long-term monitoring system

Introduction and objectives

During the last few years, changes in pest occurrence have been detected in arable farming in eastern Austria, especially in the climatically deviant years from 2000 onwards, culminating in the year of heat and drought in 2003. Some of these pest species have caused severe economic damage, e.g. cereal aphids as vectors of yellow barley dwarf virus, wheat bugs and sugar beet weevils. Pest species that prefer warmth have become more prevalent after having hitherto caused damage mainly in the south-eastern region of Central Europe. Because of the lack of congruent long-term data on population fluctuations of the relevant species it is impossible to determine with certainty whether these changes already indicate that pest insect fauna are adapting to climate change. A coherence with global warming seems to be evident, since pest insects are poikilothermic animals that rely heavily on ambient temperature.

In Austria, the recently run surveillance and early-warning systems for arable pests have been adjusted to the short-term detection of damage thresholds and subsequent plant protection recommendations for a few species. Since they are not designed for recording long-term changes, this project was designed to establish a monitoring concept for surveying the changes in the pest spectrum in Austrian arable farming in the context of climate change. It aimed to make an inventory of existing surveillance and early-warning systems in Austria, analyse their weak points and adaptability and finally to create a long-term monitoring concept in cooperation with the Austrian experts. The data should permit early recognition of climate-dependent changes in pest occurrence and the prediction of pest outbreaks based on climate data, thereby making it possible to develop prevention and adaptation strategies to avoid harvest and income losses for farmers. Finally, it will contribute towards sustainable supply security for locally produced staples.

Methods

At the beginning, a literature survey and Internet search were performed to identify existing pest monitoring systems and pest forecasting and advisory services in Austrian arable and field vegetable production. In a next step, plant protection and climate experts from relevant institutions in Austria were interviewed. Survey and interview results were used to identify weak points and gaps in the existing systems and to estimate their adaptability to a long-term climate-related monitoring system.

On this basis a long-term surveillance and monitoring system for changes in the pest spectrum in Austrian arable farming as a function of climate change was worked out. Besides the selection of main crops and pests to be surveyed and the choice of appropriate monitoring methods for the selected pest species, a draft grid of monitoring sites covering the crop growing and climate regions of Austrian arable farming was created. A basic principle thereby was to consensually involve the already existing pest monitoring systems in Austria and their operators. A preliminary version of the concept was delivered to the interviewed experts for critical review. In this place, thanks are due for the substantial feedback and suggestions.

Results and discussion

The current pest monitoring systems in Austrian arable and field vegetable production are rather fragmentary and only a few pests are surveyed regularly and supraregionally (e.g. Western corn root worm, European corn borer, wheat bugs). Also the mesh density of the few active pest surveying sites is very low. A further deficiency in the existing pest surveillance systems is their recording of damage thresholds, with only limited aspects of seasonal population dynamics being recorded either at pest occurrence or for a limited time until peak pest density so as to generate short-term recommendations for spraying dates. Records of complete seasonal pest population dynamics including overwintering densities and soil-inhabiting stages are not currently available, although they are required to calculate correlations with climate data and for predicting the long-term development.

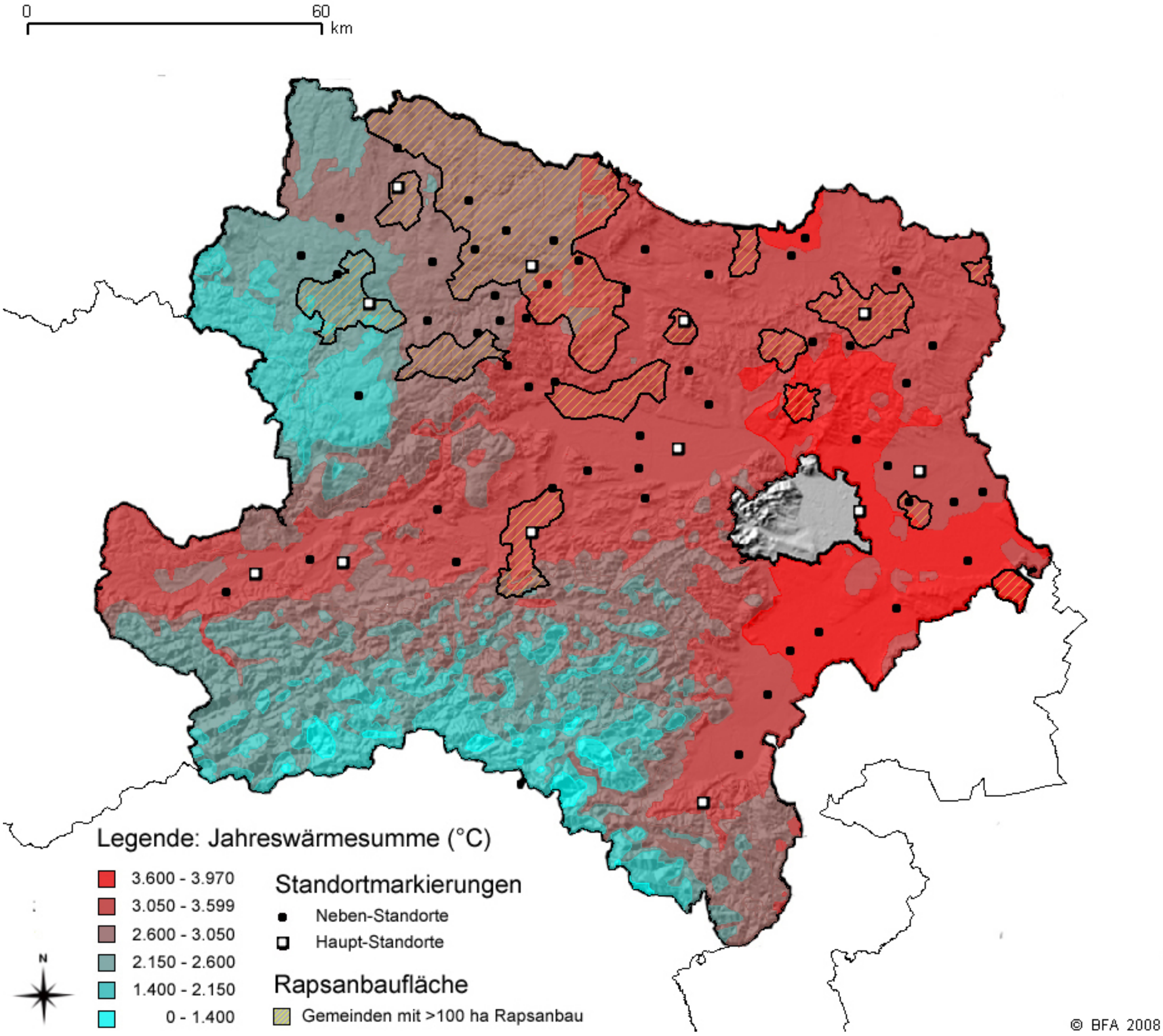

Fig. 10 Distribution of pest monitoring sites in Lower Austria: secondary sites (black squares) are farms in which the density of main pests are recorded by the farm manager using time- and cost-efficient methods. Main sites (white squares) are agricultural institutions in which the pest spectrum of selected crops, including overwintering data, is re-corded in greater detail by qualified personnel. The allocation of sites covers the main ecoclimatic types in terms of pest occurrence, as depicted by the relief of Lower Austria, overlaid by the yearly temperature-sum classes (°C; colour shades) according to Harlfinger & Knees (1999). The distribution of oilseed rape production in Lower Austria from 2005 is also overlaid: the hatched areas represent municipalities with more than 100 hectares of rape (source: Statistik Austria, www.statistik.at).

Based on an earlier study in the framework of StartClim 2005 (GRÜNBACHER et al. 2006) and the experts' statements, a preliminary shortlist of crops and pests to be monitored was drawn up. A long-term climate-related pest monitoring system calls for the configuration of a dense grid of monitoring sites. This will be built up from the existing pest monitoring and forecasting systems and their operators will be integrated in the new surveillance net as far as possible. A two-step approach will be used: the monitoring sites in existing agricultural institutions (e.g. agricultural schools, district agricultural chambers, AGES and Bio Forschung Austria experimental stations, BOKU experimental farm) but also experienced arable farms (see Fig. 10) will be designated as main sites for the different ecoclimatic regions. Here, overwintering pest data and relevant winter climate data will be recorded. Secondary sites will be in the form of arable farms in which farmers are trained in pest surveillance of selected crops voluntary or for a small reimbursement. Both organic and conventional farms will be included. The selection of pests as well as the location of monitoring sites is in accordance with the regional distribution of main crops (e.g. distribution of oilseed rape fields as shown in Fig. 10). Further on, the main arable production areas will be covered as representatively as possible in terms of pedological, geomorphological and climatic site conditions. The ecoclimatic classification of the finance soil valuation system according to HARLFINGER & KNEES (1999) is suggested as frame of reference.

The monitoring methods selected for the pests to be recorded had to be sufficiently accurate with a minimum recording effort. Besides experts´ statements and literature, the long-term methodological experience of Bio Forschung Austria was taken into account. Simple recording methods (e.g. sweep net, yellow pans, pheromone traps, recordings by sight) which can be used after a short period of training by voluntary pest surveyors at the secondary monitoring sites will be used. More specialised methods (e.g. emergence traps, soil excavations, UV light traps) will be used only by qualified personnel at the main sites.

Conclusions and outlook

Since no long-term monitoring systems for climate-dependant changes in pest fauna have been found in neighbouring countries, a system of this type in Austria would be highly innovative. To implement the concept, the required resources and existing deficits need to be identified and proposals made for their adaptation. A long-term objective of this concept outreaching this project is its implementation in the framework of climate change research.

2.4 StartClim2007.D: Consequence of the climate-induced upwards shift of the timberline on the release of greenhouse gases - dynamics of soil organic matter

The timberline shifts upwards because of climate change and causes an alteration to land use. The effect has been well documented for several decades. The effects of the shift from dwarf shrub communities to stone pine (*Pinus cembra*) forest was investigated by soil analyses at a site that was intensely monitored and well documented during the 1950s. The Poschach experimental site near Obergurgl, Ötztal, has been the object of detailed phytophysiological and mesoclimatic research. The experiments were conducted in support of large-scale afforestation projects at high altitudes and were performed by the former Forstliche Bundesversuchsanstalt Mariabrunn (now Forschungszentrum Wald [BFW]). On that occasion a micro-investigation was made of vegetation, geomorphology and soil typology. A new assessment of vegetation and soils half a century later revealed changes in these site properties. In Obergurgl the advancing forest replaced dwarf shrub communities, dominated by heather and rhododendrons. These dwarf shrubs yield a poorly degradable litter and are renowned for their closed nutrient cycle. Soils under dwarf shrubs were richer in carbon than soils under the 50-year-old stone pine forests. This has far-reaching implications for the carbon balance: although a large carbon pool is formed in the aboveground biomass, the usually more stable carbon pool of the soil is reduced. The observation was supported by the geostatistical analysis: soils under dwarf shrubs have a deep A horizon that is hardly distinguishable from the litter layer. The indicators for podzolisation are masked. In the stone pine forest the litter layer and the carbon-poor mineral soil are clearly separated. Soils are typical podzols, called “ironhumus podzols” in the initial survey of 1955.

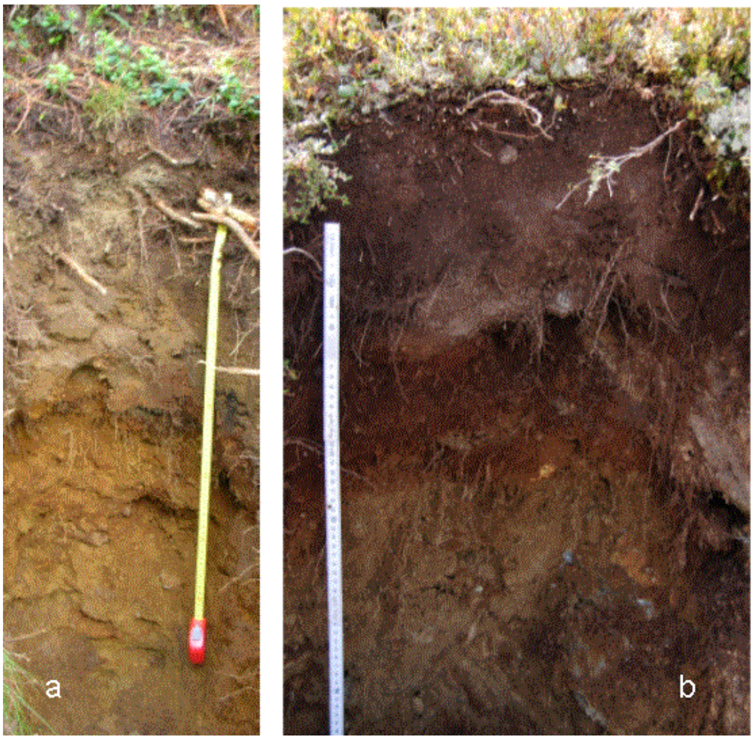

Fig. 11 Soil profiles: a) in a stone pine forest the soil is poor in organic matter, b) in dwarf shrub communities a rich organic layer forms. As the timberline rises the dominant vegetation changes from dwarf shrubs to stone pines and the soil loses carbon, which is partly incorporated in the aboveground biomass and partly released into the atmosphere.

Representative soil samples from four positions along an elevational gradient were incubated in the laboratory at five temperature intervals (5, 10, 15, 20, 25°C) in order to quantify how much carbon is released as CO_2 as a consequence of the temperature increase. Soils under dwarf shrubs hardly responded to the temperature increase, indicating the high chemical stability of soil organic matter at these sites. The measured values were below the values of most other previously investigated forests in Austria. Soils under stone pine responded much more to the temperature increase. The implication for the Austrian carbon balance is that the changing vegetation results in the formation of a soil carbon pool that strongly responds to increasing temperatures. A soil biological characterisation by means of the phospho-lipid-fatty acid (PLFA) method, distinguishing between the dominating taxonomic groups of soil microbes, actinomycetes, bacteria, vasicular-arbuscular mycorrhizae and fungi, and an estimation of the total soil microbial biomass showed similar spectra along the elevational gradient. Large differences were found with respect to the total microbial biomass. Soils under dwarf shrubs are obviously a poor substrate with a low microbial population density. Soils under stone pine are biologically active. Organic matter that enters the soil via litterfall (needles, roots) is quickly mineralised and released to the atmosphere as CO_2. In conclusion it would appear that the rise of the timberline leads to significant changes in the soils, which are linked to a higher release of carbon. Our results open a wide array of hypotheses that will be addressed in future research projects.

2.5 StartClim2007.E: Global change and its effect on runoff behaviour of glacierised basins with regard to reservoir power stations

Reservoir power stations need information on the quantity and availability of water from glacierised basins. As these change with a change in climate, and as a large part of Austria’s reservoirs are situated in glacierised basins, the present project investigated the consequences of climatic change for the runoff regime of glacierised basins from the standpoint of reservoir power stations. Emphasis was placed on the following five points:

1. The runoff regime for the period 1983 to 2003 with reference values of monthly means of the components of the water balance in a strongly glacierised basin, Gepatschalpe gauging station, Kaunertal, 1910 – 3500 m, 10°44' E, 46°54' N, 55 km^2, approx. 40% glacierised), in a moderately ice-covered basin (Radurschlbach, 1790 – 3300 m, 10°37' E, 46°55' N, 25 km^2, 1.5% glacierised) and an ice-free basin (Nauderer Tschey, 1795 - 3000 m, 10°36' E, 46°55' N).

2. Modelling of monthly water balance values in these three basins for a climate scenario derived from IPCC A1B, where the winter temperature is one degree higher than today and the summer temperature two degrees; winter precipitation is 15% higher and summer precipitation 20% lower than today.

The modelling of topics 1 and 2 was carried out at the Institute of Meteorology and Geophysics at the University of Innsbruck with the hydro-meteorological model OEZ 2.1. An earlier version of this model had been used in the project “Modelling the effect of climate change on Austrian drainage basins” (Vol. 46 of *Schriftenreihe der Forschung im Verbund*).

3. Surface elevation changes of the glaciers in grid points were determined from the elevation models of the Austrian Glacier Inventory 1997 and the laser scanner flight of the government of Tyrol in 2006. They represent the effect of three processes: a) melting at the glacier surface, b) lowering of the surface on account of internal and basal melting including basal streams, c) horizontal resupply of ice by glacier flow. These surface elevation changes are primarily the consequence of climate warming from 1997 to 2006, but they also contain the decaying effect of previous disturbances such as the warming from 1982 to 1997; these can be quantitatively determined from the imbalance (the negative mass balance) of the reference period 1983-2003.

4. Based on these data, the changes following 2006 were simulated for temperature increases of one degree up to four degrees. Linear extrapolation of temperature from 1983 to 2003 and beyond would indicate a one degree increment approximately for each decade so that the final four degree warming would be reached in about 2046 – the attribution of a year to the four degree warming scenario is, however rather uncertain. The sensitivity of specific mass balance to temperature was assumed to amount to 800 mm/°C from OEZ modelling and records of the mass balance of Hintereisferner.

In the construction of this time series, the change in surface elevation, ice volume and annual melt water supply was calculated for each time step corresponding to one degree warming. The ice thickness distribution being known from radar surveys, the changes in surface area corresponding to the simulated thickness changes and the ensuing new area-altitude distribution were calculated as the prerequisite for modelling the next step.

5. As the Gepatsch Glacier has maximum ice thickness of over 220 m and its tongue is more than 100 m, it can withstand long-lasting melt conditions. Its glacier melt contribution to total runoff increases up to a total warming of three degrees from 2006, and then declines.

In order to know the behaviour of a more typical, medium-size Austrian glacier, the procedure was applied to Fernauferner, 1.5 km^2, 11°08'E, 46°59'N, with maximum ice thickness of 80 m. This glacier reaches its maximum volume contribution to annual runoff after a warming of two degrees, when the decrease of melting surface area outweighs the increase in specific melting. In contrast to the Gepatsch Glacier, the contribution of ice flow to the thickness changes is nearly negligible in smaller glaciers.

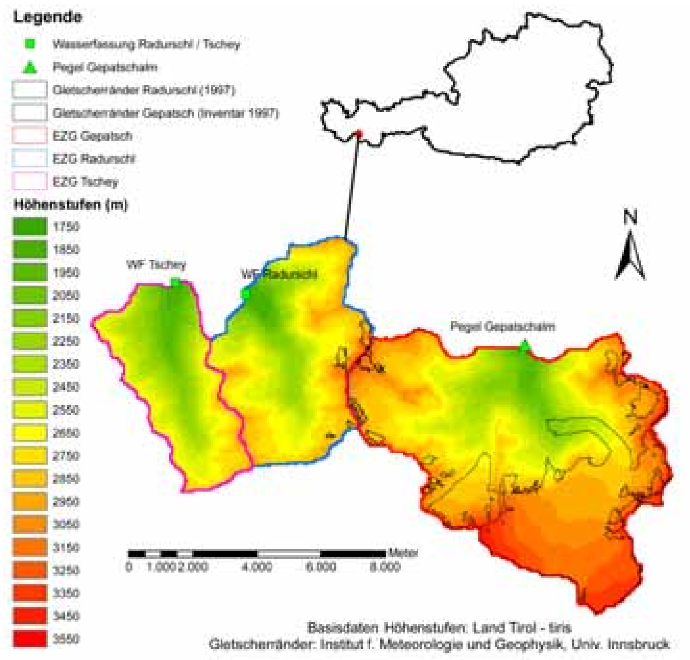

Fig. 12 This map shows the basin of the Gepatschalpe gauging station and the outlines of its glaciers, which cover 40% of the basin. Next to the left is the Radurschl basin with minor glacier cover, and the ice-free Tschey basin. Colours indicate the surface elevation..

2.6 StartClim2007.F: ALSO WIKI – Alpine summer tourism in Austria and the potential effects of climate change

The project "Alpine summer tourism in Austria and possible impacts of climate change —ALSO WIKI" is designed to investigate future scenarios for Alpine summer tourism and make specific policy recommendations for tourism in the light of the changing climate. To cover the different climatic conditions and tourism structures in Austria four destinations with differing geographical location, climate conditions and regional/local tourist structure and demand were selected and analysed and regional climate and tourism profiles developed.

The investigation refers only to the direct consequences. The impact of climate protection measures in tourism and other sectors is not the object of this study. To establish baseline climate values for summer tourism a best-case and worst-case scenario for the summer months June, July and August was devised on the basis of an estimate of the number of summery and humid days for the year 2050. The projection revealed that the frequency of extremely hot summers will increase in future and the anticipated change in temperature will be the same both south and north of the Alpine divide. Regional differences in summery and humid days will be influenced in particular by topographical conditions. The higher the altitude of a destination, the smaller the probability that there will be an increase in summer days of relevance to tourism, whereas in the lower regions a manifest increase could occur. This change is even more pronounced on humid days although, as mentioned above, there is no significant difference between regions north and south of the Alpine divide. Past climate time series show a marked increase in the amount of sunshine in summer since around 1980. This has been very beneficial for Alpine summer tourism. Existing climate scenarios also indicate that a decrease in summer rain is likely in the future, with a greater decline on the south side of the Alps than on the north side. It is not possible to determine, however, whether this reduction refers to a general drop in the number of rainy days or merely in the intensity of the rainfall.

The evaluation of the regional climate data and the analysis of the factors influencing tourism, the tourism demand and the regional tourism structure at the four destinations form the basis for the subsequent conclusions regarding tourism policy and research. They depend for the most part on plausibility estimates as the necessary tourist data is not available for real analysis.

- The increase in temperature presents opportunities in the medium term for extending the summer season in Alpine regions and focusing further on all-year tourism.
- Adaptations will be required in the regions, however, in terms of infrastructure, demand structure and marketing.
- As the anticipated climate trends offer advantages at certain altitudes, it may be assumed that more land will be required, with an attendant increase in the impact on environmentally sensitive areas. Strict regional planning and a suitable framework for the development of tourist services in Alpine regions will be needed.
- In terms of the regional economy, tourism policy and acceptable environmental development, it will be necessary not only to adapt tourism instruments but also to seek greater coordination with other sectoral policies such as regional planning, transport, energy and business development and to devise approaches and concepts for the efficient use of energy, regional management and the prevention of natural disasters.

The experience gained in this project and the analysis of the scientific and political discussion on climate change and tourism demonstrate that climate research here — and probably in other areas too — is still in its initial stages.

Data for the tourism sector would need to be systematically extracted for quantitative analysis of the interaction between climate and tourism as a basis for future scenarios.

Account also needs to be taken of the fact that the indirect impact of climate protection measures in combination with the increase in the price of fossil fuels and hence of private transport could have a greater impact on tourism than the direct impact of the climate. Future studies should therefore address these questions.

2.7 StartClim2007.G: Integrated modelling of the economy under climate change in application of the Stern report (STERN.AT)

The STERN.AT project analysed and modelled at the regional scale the interactions between climate change, its physical and socio-economic impacts and policy responses to mitigate impacts.

Starting from *The Stern Review on the Economics of Climate Change* (Stern, 2007), which discusses the effects of climate change on the world economy - released in October 2006 by the economist Nicholas Stern for the British government - regional aspects of the Review were selected and advanced and compared with global approaches. Although not the first economic report on global warming, the Stern Review is obviously the largest and most widely known and discussed report of this kind. In economic terms it covers a broader range of climate impacts than earlier reports. The present regional approach complements the global analysis of the Stern Review. While an efficient emission reduction level can be determined only by comparing global costs of climate change and mitigation – which is one of the core objectives of the Stern Review – the quantification of the costs of climate change itself is inherently a local question. Regions are diverse in terms of climate-change impact, vulnerability and adaptation options. A global figure on climate change costs thus needs to be ultimately built bottom-up; an effort that the Stern Review could not undertake itself as these numbers are not yet available for most world regions. As stated in the Stern Review (Stern, 2007, p. 99) itself: “It is not possible in aggregate models to bring out the key elements of the effects, much is lost in aggregation […]”.The aim of the present project was thus to develop methodological experience for deriving such results for a particular region – in a country like Austria with small and heterogeneous topography and land use. The impacts from climate change and the political instruments are limited to a few examples. Not the specific results of the highly simplified “economy” but the methodological development was the focus of this project. Moreover, the approach revealed the availability of the relevant data for such an assessment.

The project established an interface between a regional climate scenario, detailed analyses for the economic sectors agriculture and energy and a three-region Computable General Equilibrium (CGE) model in order to asses economic impacts at the regional level for a study region in Austria (see Fig. 13). The analysis was applied to the region of south eastern Styria, which formed the core region (Region 1), embedded within the rest of Styria (Region 2) and the “rest of the world” (Region 3), including the rest of Austria and abroad. The impacts were computed for the year 2045 as representative for the 2040s.

The coupling of models allowed quantification of the relevant socio-economic effects of local climate change in the study region. The analysis addressed climate impacts on production and consumption structures as well as the adoption of policies such as mitigation, i.e. how to reduce greenhouse gases, and adaptation, i.e. how to cope with and adapt to climate change impacts.

Regional climate change scenarios and downscaling techniques were used to provide basic information about future climatic conditions in south eastern Styria. On the one hand, the regional climate scenario was used to estimate climate-crop yield relationships for the main crops in the study region. On the other hand, it provided the necessary data to calculate the change in the number of heating and cooling degree days. Moreover, a prime interface between the CGE model and a individual optimisation model for the agricultural sector was established. The results of linking the climate model with the analyses for the agricultural and the energy sector served as inputs for the CGE model, which then quantified the relevant economic effects of local climate change for the region under consideration.

In agriculture, the impacts of climate change on crop yields, the costs and possibilities of adaptation to the changed climatic conditions as well as the costs of mitigation through an increased use of biomass were studied. In the energy sector, the analyses comprised the climate-induced change in household energy demand and the costs of adaptation and of mitigation - in the housing sector by enhanced insulation and passive house standards and the connection to agriculture through greater production of bioenergy.

First, a business as usual scenario with constant climate up to 2045 was compared with a scenario including climate change and autonomous adaptation of consumers and producers (reference scenario). With the effects selected to date and under the specific assumptions for the calculations, the reference scenario showed a reduction in prosperity for regions 1 and 2 in the agricultural sector, but a simultaneous strong rise in prosperity in the energy sector. Thus, climate change via altered energy demand was found to increase regional prosperity (amount of consumption goods) in the 2040s in region 1 by 1.3%, via a shift in agricultural production to decrease prosperity by 0.3% (see Fig. 14). Then, the effects of policy-induced adaptation and mitigation were analysed relative to the reference scenario. The simulation results illustrated the effects for regional GDP and prosperity including price changes and labour market effects. Through mitigation policies in the housing sector (enhanced insulation) or renewable energies (expanded biomass), regional GDP could be increased by up to 3% and regional prosperity up to 0.7% (see Fig. 14).

The coupling of models thus investigated direct impacts, such as impacts on physical crop yields or ecosystems, as well as socio-economic impacts, such as income changes, but also indirect effects via sectoral interdependencies. Furthermore, the sensitivity of a region was analysed with respect to climate factors relative to other factors such as e.g. the price of oil.

The assessment of impact and adaptation needs particular modelling elements for each sector and requires the modelling of sectoral interdependencies. In agriculture, for example, policy-induced adaptation, i.e. the mixed cultivation of crops, was modelled via

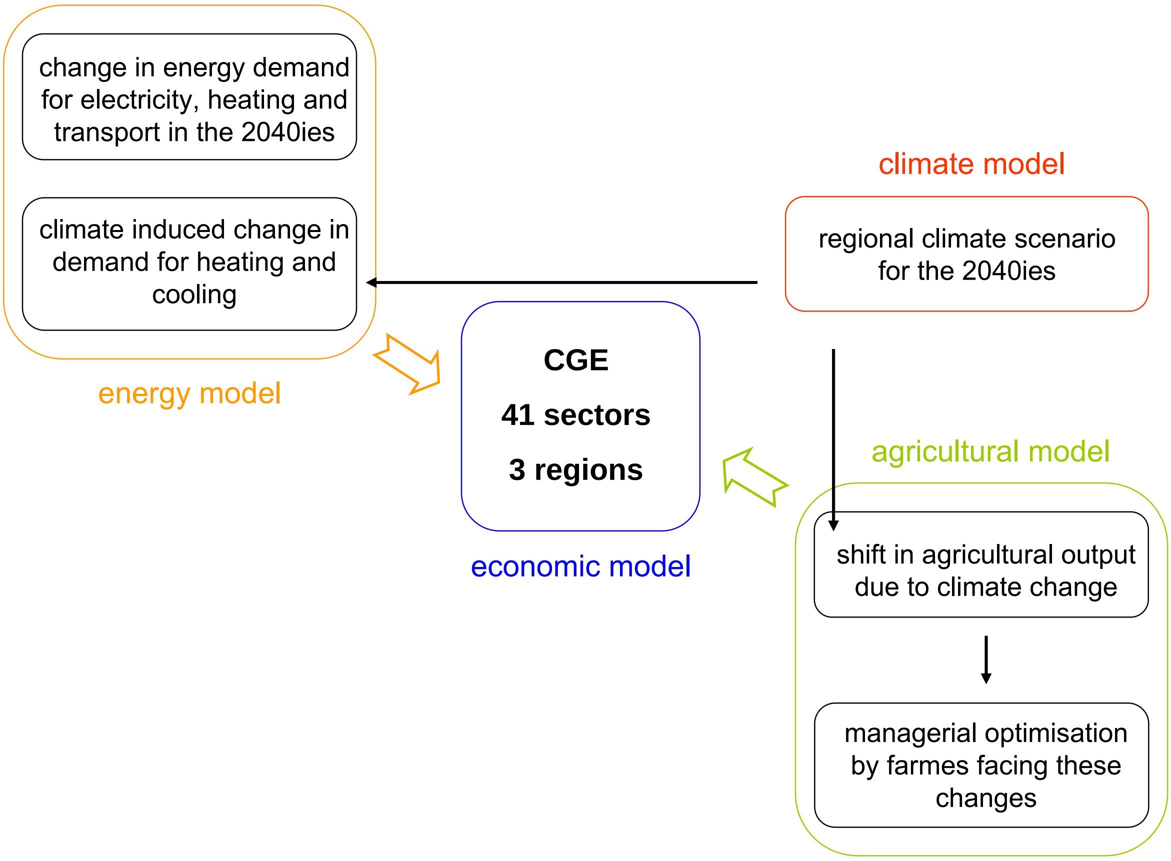

Fig. 13 Model coupling: the climate model supplies inputs for the energy model and the agricultural model, which in turn enter the economic model.

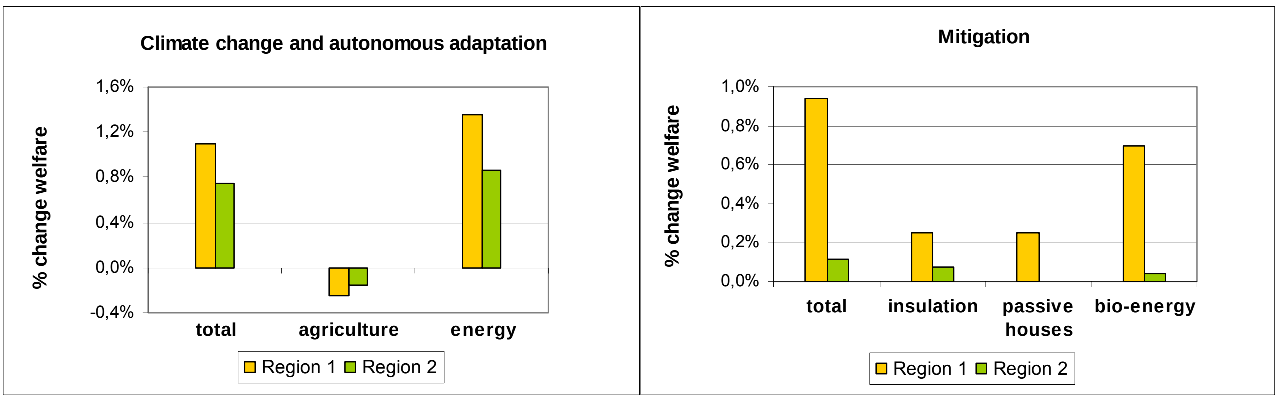

Fig. 14 Effects of climate change with independent adaptation (under consideration of a regional climate scenario compared with the development without climate change) and mitigation policies (compared with the development under climate change without policy measures) for the narrow region 1 and its surroundings (region 2) for the 2040s.

the concept of “efficiency land”, varying the available “fixed output land” in size under both climate change and adaptation strategies. Equally, the modelling of mitigation required a tailored approach for each measure analysed in the housing sector and in bioenergy. The project thus concludes that the assessment of damage costs requires an accurate specification of changes in climate parameters not only with respect to the period of time (annual, seasonal, monthly, daily) but also with respect to the scale under consideration (global, national, regional, local) and the assumed relationship between meteorological parameters and physical output in the economy.

In order to attain more realistic simulations of socio-economic impacts from climate change, more detailed sectoral analyses are required and further sectors, such as tourism, have to be considered. The current project demonstrated, however, that the chosen approach is feasible and promising.

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Annex

Subprojects of StartClim2003

These reports can be found on the StartClim2007-CD-ROM and on the StartClim website (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 prosperity 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 StartClim2007-CD-ROM and on the StartClim website (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 StartClim2007-CD-ROM and on the StartClim website (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

Subprojects of StartClim2006

These reports can be found on the StartClim2007-CD-ROM and on the StartClim website (www.austoclim.at/startclim/)

StartClim2006.A: Particulate matter and climate change – Are there connections between them in north-eastern Austria?
Institute of Meteorology, BOKU
Bernd C. Krüger, Irene Schicker, Herbert Formayer
Medical University of Vienna, Centre for Public Health, Institute of Environmental Hygiene
Hanns Moshammer

StartClim2006.B: Risk Profile for the autochthonous occurrence of Leishmania infections in Austria
Medical University of Vienna
Horst Aspöck, Julia Walchnik
Institute of Meteorology, BOKU
Thomas Gerersdorfer, Herbert Formayer

StartClim2006.C: Effects of climate change on the dispersion of white grub damages in the Austrian grassland
Bio Forschung Austria
Eva Maria Grünbacher, Patrick Hann, Claus Trska, Bernhard Kromp
Institute of Meteorology, BOKU
Herbert Formayer

StartClim2006.D1: Sensitivity of Austrian summer tourism to climate change
Institut für touristische Raumplanung
Volker Fleischhacker
Institute of Meteorology, BOKU
Herbert Formayer

StartClim2006.D2: Effects of climate change on the climatic potential of tourism
Institute of Meteorology, University of Freiburg
Andreas Matzarakis, Christina Endler, Robert Neumcke
Central Institute of Meteorology and Geodynamics
Elisabeth Koch, Ernest Rudel

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
Institute of Landscape Development, Recreation and Conservation Planning, BOKU
Ulrike Pröbstl, Alexandra Jiricka, Thomas Schauppenlehner
Simon Fraser University, Burnaby, Canada
Wolfgang Haider

StartClim2006.F: Climate change impacts on energy use for space heating and cooling in Austria
Institute of Technology and Regional Policy, Joanneum Research (1);
Wegener Center for Climate and Global Change, University of Graz (2);
Institute for Geophysics, Astrophysics and Meteorology, University of Graz (3);
Institute for Meteorology and Geophysics, University of Vienna (4);
Institute of Energy Research, Joanneum Research (5)
Franz Prettenthaler[1,2], Andreas Gobiet[2,3],
Clemens Habsburg-Lothringen[1], Reinhold Steinacker[4],
Christoph Töglhofer[2], Andreas Türk [2,5]