StartClim2009

Adaptation to Climate Change: Contributions for the development of a policy paper for adaptation to climate change in Austria

Final Report

November 2010

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Final Report

Project Leader

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BOKU - University of Natural Resources and Life Sciences Vienna
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Contracting Parties

Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
Austrian Federal Ministry of Health
Austrian Federal Ministry of Economic Affairs, Family and Youth
Austrian Federal Ministry of Science and Research
Austrian Federal Forests
Austrian National Bank
Austrian Hail Insurance
Federal Environment Agency
Verbund AHP

Administrative Coordination
Federal Environment Agency

Vienna, November 2010

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Adaptation to climate change in Austria: contributions to the development of a policy paper for adaptation to climate change in Austria

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Contributions to StartClim

StartClim2009.A: Vegetation change according to different climate and management conditions in Austrian mountain grassland – a case study on Styrian mountain grasslands
Institute of Botany, BOKU: Gabriele Bassler, Gerhard Karrer,
Institute of Meteorology, BOKU: Herbert Formayer
LFZ-Raumberg-Gumpenstein: Andreas Schaumberger, Andreas Bohner, Walter Starz
Bio Ernte Steiermark: Wolfgang Angeringer

StartClim2009.B: Climate-growth response of Norway spruce provenances in the Alpine region – an opportunity for adaption of the Austrian forestry
Federal Research and Training Centre for Forests, Natural Hazards and Landscape: Silvio Schüler, Stefan Kapeller,
Central Institute of Meteorology and Geodynamics: Johann Hiebl

StartClim2009.C: Analysis of vulnerability and adaptation to climate change in the Wienerwald biosphere reserve
Institute of Silviculture, BOKU: Stefan Schörghuber, Werner Rammer, Rupert Seidl, Manfred J. Lexer

StartClim2009.D: Humus assays as a practical tool for farmers to support carbon sequestration in agriculture
Bio Forschung Austria: Wilfried Hartl, Eva Erhart

StartClim2009.E: Adapting office buildings to climate change: optimisation of thermal comfort
Danube University Krems: Tania Berger, Peter Pundy

StartClim2009.F: AlpinRiskGP - estimation of present and future risk potential for Alpine tourists and infrastructure caused by glacier retreat and permafrost changes in the Grossglockner-Pasterze glacier area (Hohe Tauern, Austria)
Geography and Regional Science, Karl-Franzens-University Graz:
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Table of Contents

Abstract

Analyses of the impact of climate change and corresponding measures to mitigate them are already accepted in many fields and are seen as necessary measures. However, knowledge about the need for adaptation to climate change is still not sufficiently widespread or accepted. Unlike mitigation, adaptation is more decentralised and often has to take place at the local level. There are still many unanswered or not yet formulated scientific questions.

StartClim is therefore once again looking at the subject of adaptation to climate change as a way of contributing to the development of an Austrian strategy in this regard.

The intensity of grassland farming (timing and frequency of cutting, fertilisation) has increased during the last decades throughout Europe. Besides strong commercial constraints, many farmers have probably intensified production because of climate change. Systematic studies of the central Styrian Enns valley have revealed a decline in the diversity of plant species between 1997 and 2010, as a result not so much of adaptation to climate changes as of changes in management intensity.

Climate change in this region has manifested itself amongst other things through an extension of the vegetation period in the years 1987 and 1994 of around three weeks compared with previous decades. It starts two weeks earlier because of more rapid warming in spring and ends one week later because of deferred winter onset. According to model calculations, this allows valley grasslands to be cut four times a year instead of three and mountain grasslands to be cut three times instead of two or three (occasionally four) customary or possible previously.

The more intensified grassland farming in the last thirteen years has been reflected in an increase in cutting frequency, a shift from solid dung to slurry and an earlier first cut. One of the focuses of the investigation was to examine how natural grassland vegetation, today reseeded with modern grass and clover cultivars, reacted to this intensification.

Mean ecological indicator values calculated from the species composition showed no change in vegetation as a result of climate change. However, the increase in cutting frequency and the change from solid dung to slurry produced significant changes including species loss, even in grassland cut three times with no change in management. It mostly affected ruderal taxa, which were very frequent in 1997. Species traditionally seen in grasslands cut twice also become rarer. Certain species with strong vegetative propagation (*Poa trivialis*, *Trifolium repens*) also spread more in 2010 in intensively managed three-cut systems than in the original census.

As the documented increase in mean annual temperature is still under 1°C, the direct impact of climate change is barely perceptible in closed vegetation systems. The possible effects of climate warming on mountain grassland ecosystems is apparently overlaid by the influence of changed management forms. As a result of the more frequent early utilisation and the increase in cutting, the prolongation of the vegetation period also has an indirect impact on grasslands by reducing the variety of species and increasing the amount of weeds.

These results are characteristic for the mountainous grasslands in the eastern Alps but they cannot be extrapolated generally. At least two or three further representative case studies (Waldviertel, northern Tyrol, Carinthia) are required to corroborate the findings.

Forests play an essential role in preserving natural resources such as water and soil and in maintaining regional biodiversity under changing climatic conditions. The tree species that determine a particular forest ecosystem are directly affected because they cannot evolve fast enough to keep up with the speed of climate change. However, the natural distribution of most tree species over large parts of Europe gives tree species a high tolerance to different climatic conditions. This intraspecific variation has long been used in forest management to improve the productivity and quality of forest plantings based on provenance tests. Moreover, the intraspecific variation in climate response can be used to adapt current forests to future

climate conditions without disturbing ecosystem functions. This can be done, for example, by using seeds from trees that are tolerant of dryness and less sensitive to heat. In this project the climate response of Norway spruce (*Picea abies*) was investigated based on results from an Austrian provenance test series with 540 provenances planted on 44 test plots.

At planting sites with 8°C mean annual temperature the height of 15-year-old Norway spruce trees averaged 400 cm, whereas at sites with 4°C mean annual temperature trees reached only 100–150 cm. The height of trees decreased with increasing temperature difference between provenance and planting site. This would appear to predict a rise in tree heights as a result of climate change in Austria in general, though not to an equal extent for all provenances. Furthermore, the increase in tree height is not likely to be unlimited. At very dry test sites limits to productive capacity are already noticeable. These sites will hardly be affected by climate change. In contrast, the effects of drought and pest infestations can be expected to increase.

The aim of the next study was to assess the vulnerability to climate change of the ecosystem in the Wienerwald biosphere reserve and to analyse the effects of forest management adaptation. The study region was defined as the forest area owned by the Austrian Federal Forests within the biosphere reserve.

The PICUS 1.4 forest ecosystem model was used to simulate forest development for typical stand-site combinations for a period of 100 years (2001–2100). For the simulations a baseline climate dataset (instrumental period 1961–90) and three climate change scenarios were used. The simulated stands were beech stands of different age classes. To analyse the effects of different management regimes a "business as usual" (BAU) and an adaptive management concept (AM) were simulated. In contrast to the BAU management, the AM was characterised by heavier thinnings and the introduction of oak as an admixed species.

The results show that in the first half of the twenty-first century productivity of BAU under climate change conditions remained more or less at the level of the baseline climate. In the second half a slight decrease of productivity was observed for BAU. In general, the productivity of AM without climate change was below the level with BAU management. However, under climate change conditions the AM was more stable and resulted in productivity very similar to the BAU management. The results indicate that adaptive management concepts will be able to provide the required ecosystem performance in the Wienerwald biosphere reserve under the analysed climate change scenarios.

The humus content of the soil is of critical importance in connection with climate change. With increasing soil humus content, carbon is sequestered in the soil in the medium term and hence kept out of the atmosphere. Soil with high humus content holds more water and supplies crop plants longer under dry conditions. It also allows greater water infiltration in heavy rain, and so reduces erosion. Improving the humus content of the soil also increases cation exchange capacity and nutrient storage.

In the last few years, (organic) farmers have been made aware of the value of soil humus. With the help of humus assays, farmers can find out how their crop rotation and management measures affect the humus content of the soil. However, the simple humus assay method used at the moment does not take sufficient account of regional crop rotation and yield conditions and certain management measures, such as cover crops.

A humus assay method needed to be found that could be calculated quickly using input data collected easily by farmers, and that indicated the humus development on farms in the Weinviertel with acceptable accuracy as a way of providing farmers with a tool to plan and better understand carbon sequestration in agriculture.

Five humus assay methods were assessed using data from the STIKO long-term field experiment by Bio Forschung Austria (BFA). The results of the different humus assays were compared with data for humus content in the compost-fertilised soils measured after 12 years. The forecast accuracy of the five humus assay methods differed widely. While the HE (REPRO), Bayerische Landesanstalt für Landwirtschaft and Kolbe methods showed deviations of -8, +12 and -13 per cent from the measured values and predicted the development of soil carbon content fairly accurately, the VDLUFA and ROS methods had deviations of +69 and +94 per cent and thus clearly overestimated the carbon content.

After discussion with farmers and with account taken of the data available and the costs of humus assays, the Kolbe method was chosen. Subsequent tests of this method using data from working farms were successful and this method will therefore be used in future in BFA's regular workshops for farmers from other regions.

A comparison of the amount of carbon sequestration that could be attained by humus accumulation in agricultural soils with Austria's carbon dioxide emissions and the Austrian Kyoto commitments shows that carbon sequestration in agricultural soils could make an appreciable contribution to the reduction of greenhouse gas emissions. This contribution could come into effect quickly, as the techniques to be used are well known. The humus accumulation achievable in practice will not suffice, however, to compensate for all of the carbon dioxide emissions from fossil fuels. The sequestered carbon will nevertheless improve soil functions such as water-holding capacity, which is valuable particularly with a view to adaptation to climate change.

Natural processes in high mountains (e.g. rock fall) are likely to increase as a result of climate change and could thus become a hazard for people and infrastructure. While an elaborate system of permanent and temporary protective measures exists for residential areas, transport routes and highly frequented tourist areas (e.g. ski slopes), the safety of persons moving outside these protected areas on trails and routes cannot be guaranteed. Rock fall and other denudation processes, mainly caused by glacier retreat and permafrost degradation, were therefore studied and modelled in one of the most visited high mountain areas in Austria. Based on the modelling results, it was possible to plot geomorphological hazard maps subdividing the study area into four hazard classes. By overlaying the hazard maps with trail and route network information, vulnerability maps were created. Local stakeholders then reviewed these maps and considered possible measures, ranging from targeted trail protection to new organisational forms of trail maintenance. The developed method is easily transferable to other study sites.

The reduction of cooling energy demand in office buildings while maintaining comfortable indoor thermal conditions is an important consideration in the light of global warming and an imminent shortage of energy. The effectiveness of various cooling strategies was compared using model calculations.

More efficient electronic appliances and energy-saving lighting would more than compensate for the anticipated increase in cooling energy required as a result of climate change. Shifts in the time window during which users are present and their appliances are in use away from the hottest time of day or a reduction in occupancy through teleworking could reduce the cooling energy demand but are of questionable feasibility in practical and social terms.

In offices with natural ventilation, nocturnal ventilation could improve comfort, but there are no reliable computing tools to calculate the indoor flow conditions as a function of local outdoor wind conditions. The increase in the frequency of warm nights is also likely to reduce the effect of nocturnal cooling.

Innovative technologies such as radiative and evaporative cooling were also investigated. Radiative systems draw on the radiative cooling potential of cold night skies whereas evaporative systems extract warmth from indoor spaces through water evaporation. The combination of these two systems with conventional systems to cover peak loads in office buildings proved to be the most feasible option.

1 The StartClim research programme

The StartClim climate research programme is a flexible instrument. Because of the short project duration it can react quickly to topical aspects of climate and climate change. It is financed by a donor consortium consisting of nine institutions (see page 4).

Analyses of the impact of climate change and corresponding measures to mitigate them are already accepted in many fields and are seen as necessary measures. However, knowledge about the need for adaptation to climate change is still not sufficiently widespread or accepted. Unlike mitigation, adaptation is more decentralised and often has to take place at the local level. There are still many unanswered or not yet formulated scientific questions.

StartClim is therefore once again looking at the subject of adaptation to climate change as a way of contributing to the development of an Austrian strategy in this regard.

The projects in StartClim2009 deal with agriculture, silviculture, hazards in Alpine regions, and building engineering.

The StartClim2009 report contains an overview of the results in German and English along with separately bound documentation in which the individual projects are described in detail by the respective project teams. All reports and documents about StartClim2009 will be made available for download at http://www.austroclim.at/startclim, the StartClim website. A limited number of CDs with all StartClim reports and folders with a short summary will also be published.

2 StartClim2009.A: Vegetation change according to different climate and management conditions in Austrian mountain grassland – a case study on Styrian mountain grasslands

In recent years grassland management has changed with respect to the timing and frequency of cutting and the type of fertilisation. Apart from economic constraints, this is probably a reaction to climate change. This study investigated the development of grassland vegetation in the central Enns valley in Styria between 1997 and 2010 in the light of these changes.

The studied grasslands were at an altitude of between 640 and 1,200 metres and were situated between Tauplitz (Northern Limestone Alps), Stainach, Irdning (Enns valley) and Oppenberg (Lower Tauern). A total of 49 records were taken of test areas in which the cutting frequency had increased between 1997 and 2010 or the type of fertilisation (from solid dung to slurry) had changed. They were compared with plots in which no changes had taken place (see table 1). Apart from the composition of the cover vegetation, changes in the yield on first cutting and selected soil chemistry parameters were also noted.

Tab. 1: Grassland management options

Variant	Cutting frequency 1997	Cutting frequency 2010	Manure type 1997	Manure type 2010
1	2	2	solid	solid
2	2	2	slurry	slurry
3	2	2	solid	slurry
4	2	3	solid	solid
5	2	3	slurry	slurry
6	3	3	solid	solid
7	3	3	slurry	slurry
8	3	4	solid	slurry

Regional climatic data from three stations show that in the period 1987–94 the vegetation period was three weeks longer than it had been in previous decades (see Fig. 1). It started about two weeks earlier because of more rapid warming in spring and ended one week later because of deferred winter onset. A model for estimation of possible maximum cutting frequency per year showed an increase from three to four in the valley and from two to three at higher altitudes.

The intensification of grassland farming in the last 13 years has been reflected in an increase in cutting frequency, a shift from solid dung to slurry and an earlier first cut.

Model calculations show no change in vegetation attributable to warming, in other words the proportion of thermophil plants has not increased. A change in vegetation as a result of the earlier first cut was observed but the change is not significant. By contrast, the increased cutting frequency and switch from solid dung to slurry produced significant changes in vegetation (higher Sørensen indices between 1997 and 2001), in particular a reduction in species diversity (fig. 2). In grasslands cut three times instead of twice as in 1997 there was a mean species loss of 9.1; in grasslands that continued to be cut three times the species loss was 4.8; and in those cut four times instead of three there were 5.8 fewer species than in 1997. There was a slight though not significant change in vegetation as a result of an earlier first cut.

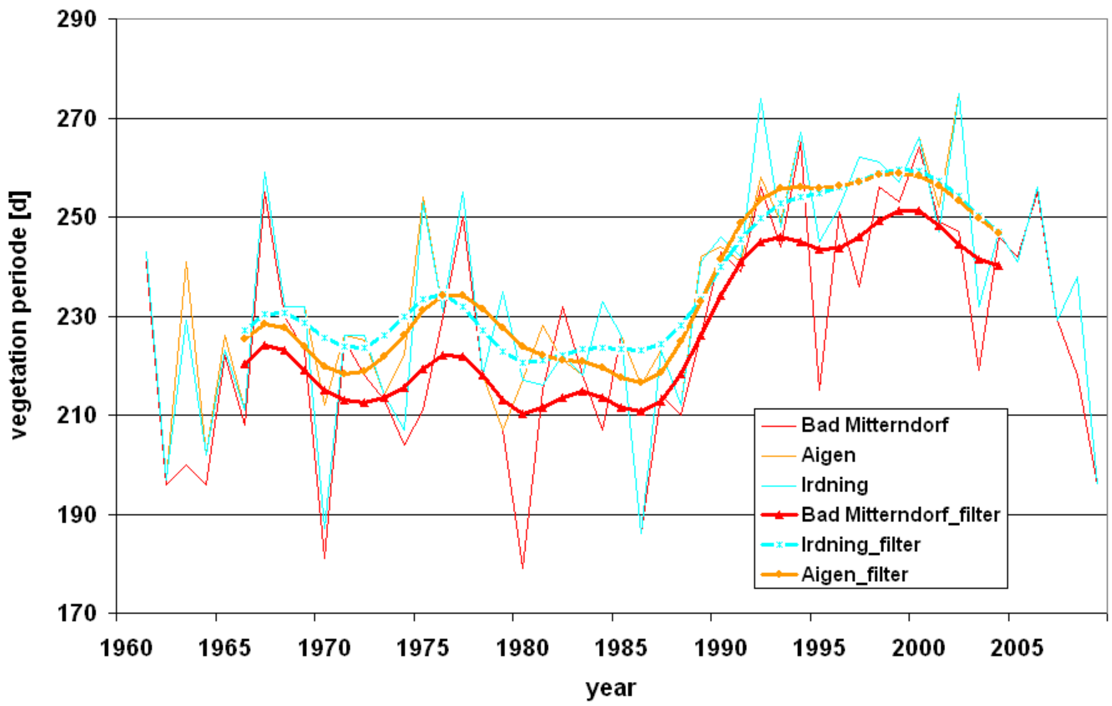


Fig. 1 : Changing length of vegetation period (days) at three meteorological stations in the central Styrian Enns valley between 1960 and 2009 (single years and Gauss filter 11y).

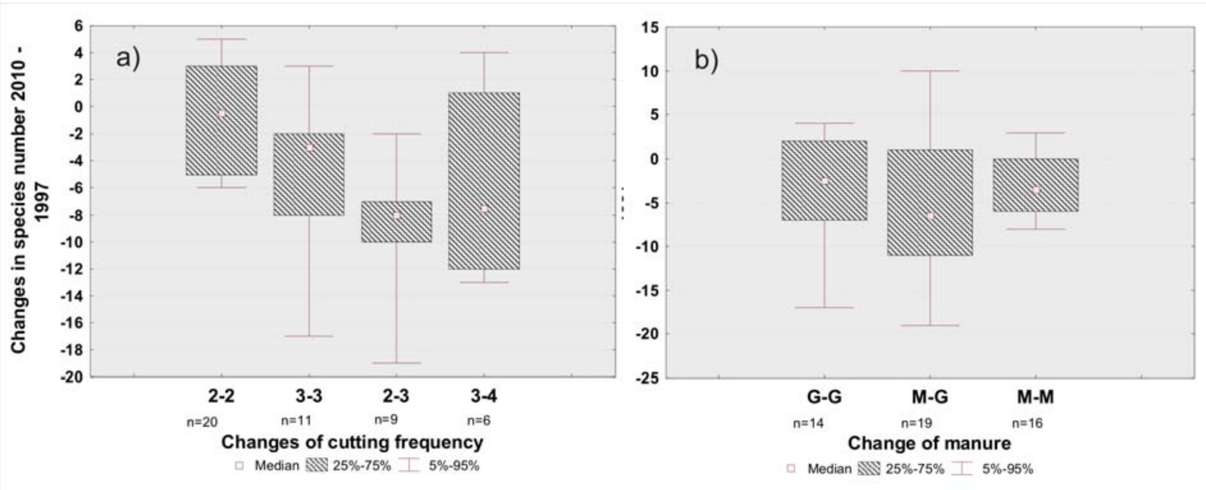


Fig. 2 : Change in species numbers (excluding annuals) between 1997 and 2010 in plots with changed or unchanged cutting frequency (a) or type of manure (b).

A reduction in species was also noted in grasslands with an unchanged frequency of three cuts per year. This was attributable in part to the loss of gap fillers (e.g. shepherd's purse, great plantain), which were very common in 1997, and species frequently found in grass-lands cut twice (e.g. spreading bellflower, ox-eye daisies). In 2010, competitive species with high dissemination and reproduction potential (rough meadow grass, white clover) were more abundant in intensively exploited grasslands with three cuts than they had been in 1997. There were fewer changes in species composition as a result of different fertilisation techniques, the most prominent although not significant being in the switch from solid dung to slurry in grasslands cut three times.

In summary, direct effects of climate change on species composition in grassland are not yet discernible since the warming (annual mean temperature) is still less than 1°C. The possible impact of climate change on mountain grassland ecosystems is currently overlaid by changes in management strategies. Because of the earlier date at which the grassland is used and an increase in the cutting frequency, however, the shift in the vegetation period has an indirect effect resulting in a decrease in species diversity and an increase in weeds. This development has also led to the disappearance of colourful and attractive meadow flowers (fig. 3).

Fig. 3 : Colourful meadows (left) have become less frequent in managed grassland of the Enns valley because climate change has led to earlier and more frequent cutting.

The investigation area is fairly representative of Austrian mountainous grasslands, but the results cannot be extrapolated for the entire country. At least two or three further representative case studies (Waldviertel, northern Tyrol, Carinthia) are required for corroboration.

3 StartClim2009.B: Climate-growth response of Norway spruce provenances in the Alpine region – an opportunity for adaptation of Austrian forest management

Forests play an essential role in preserving regional biodiversity. The tree species that determine a particular forest ecosystem are directly affected because they cannot evolve fast enough to keep up with the speed of climate change. However, the natural distribution of most tree species over large parts of Europe makes them highly tolerant to different climatic conditions. Tree populations of the same species therefore adapt to different climates and respond differently to climate changes. This diversity in climate response is crucial for the adaptability of species to environmental changes.

Based on provenance tests, intraspecific tree variation has long been used to improve the productivity and quality of forest plantings. Today, the variation in climate response can be used to adapt current forests to future climate conditions without disturbing ecosystem functions.

In this project we investigated the diversity of Norway spruce (*Picea abies*), the economically most important tree species in Austria, based on height measurements of 15-year-old trees from 379 provenances planted at 29 test sites in Austria. The results were entered into a database. Together with climatic data of all provenance locations and test sites, a thorough analysis could be conducted for the first time.

At each site we found considerable height differences among tested provenances. Figure 4 shows results of the test site St. Stephan (Styria) as an example.

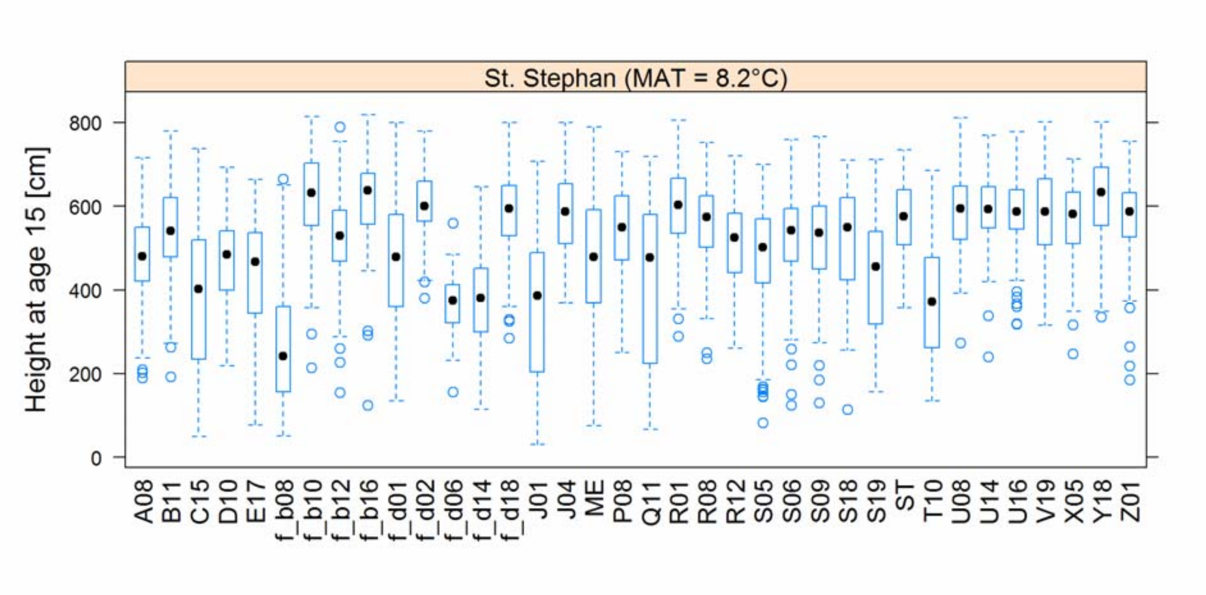


Fig. 4 : Tree heights of all tested provenances at the test site St. Stephan (Styria). Each boxplot shows median and variation in tree heights of one provenance based on single tree measurements.

In combination with climate data, climate-response (fig. 5, left) and climate-transfer functions (fig. 5, right) were derived. Climate-response functions show the correlation between tree height and climate (here: mean annual temperature) for a single provenance planted at several test sites, while climate-transfer functions show the correlation between height and climatic difference between planting site and provenance location for a single test site.

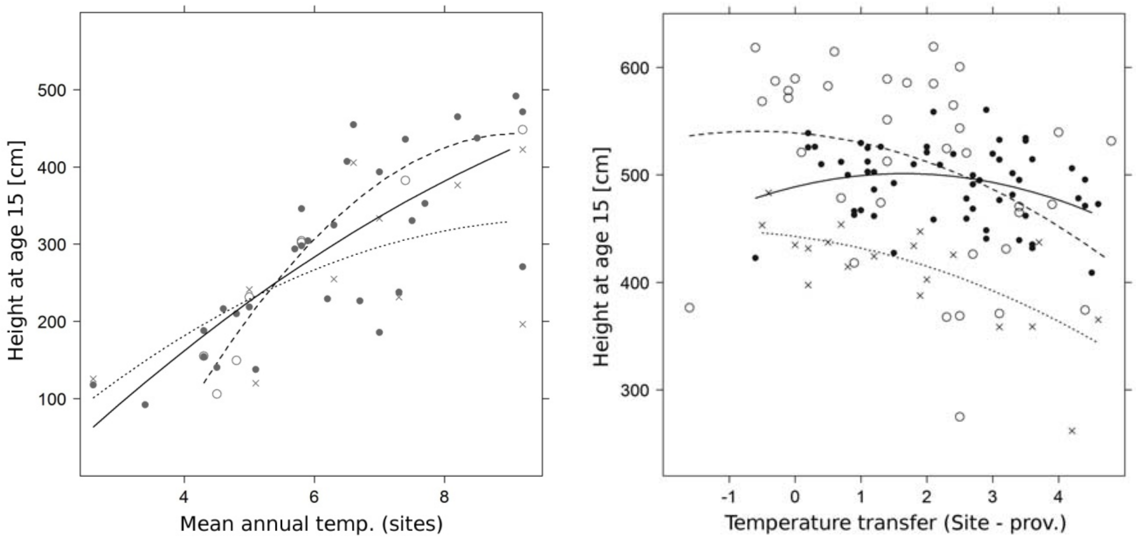


Fig. 5 : Left: Climate-response functions of three provenances (Murau: continuous line, Liezen: dashed line, Chepelare (Bulgaria): dotted line) show that in general an increase in tree heights can be expected with rising mean annual temperatures (MAT). All data points are mean tree heights of one provenance at one test site. The temperature response varies depending on the provenance. **Right:** Climate-transfer functions of three test sites (Schönborn: continuous line, St. Stephan: dashed line, Wieselburg: dotted line) show the influence of temperature differences between test sites and provenance location (prov.). This influence varies depending on the local climate of the test site. Data points are mean tree heights of tested provenances.

These functions can be used to estimate the growth potential of specific tree provenances and their adaptability to climate change.

Mean annual temperature (MAT) or other correlated climate parameters (e.g. length of vegetation period) can be used to predict tree height. Generally, height increases with temperature at test sites: at sites with an MAT of 8°C trees reached an average height of 400 cm in 15 years, whereas with an MAT of 4°C they grew only up to 100–150 cm. The variances are very high, however (fig. 5, left). With the impending climate change, an increase in the productive capacity of Norway spruce can be expected in Austria. However, spruce populations from different regions will not be affected equally by warmer temperatures. For one reason, trees of different provenance will react differently to climate change (fig. 5, left) on account of the local climate conditions in the provenance region. Second, the effect of increasing temperatures varies from site to site (fig. 5, right). In very dry and warm sites, limits to the productive capacity of spruce are already noticeable (fig. 5, right – continuous line). These sites will hardly be affected by further warming; on the contrary, additional droughts and pest infestation can be expected. Since more and more regions will suffer from drought conditions, its consequences should be investigated in greater depth.

These analyses do not make full use of the potential of the Norway spruce provenance test of 1978. The investigations will continue within the INTERREG project MANFRED with the inclusion of international provenance studies.

4 StartClim2009.C: Analysis of vulnerability and adaptation to climate change in the Wienerwald biosphere reserve

The aim of the study was to assess the vulnerability of ecosystems in the Wienerwald biosphere reserve to various climatic change scenarios and to analyse the effects of ensuing adaptations to climate change.

The study region was defined as the forest area owned by the Austrian Federal Forests within the biosphere reserve (fig. 6).

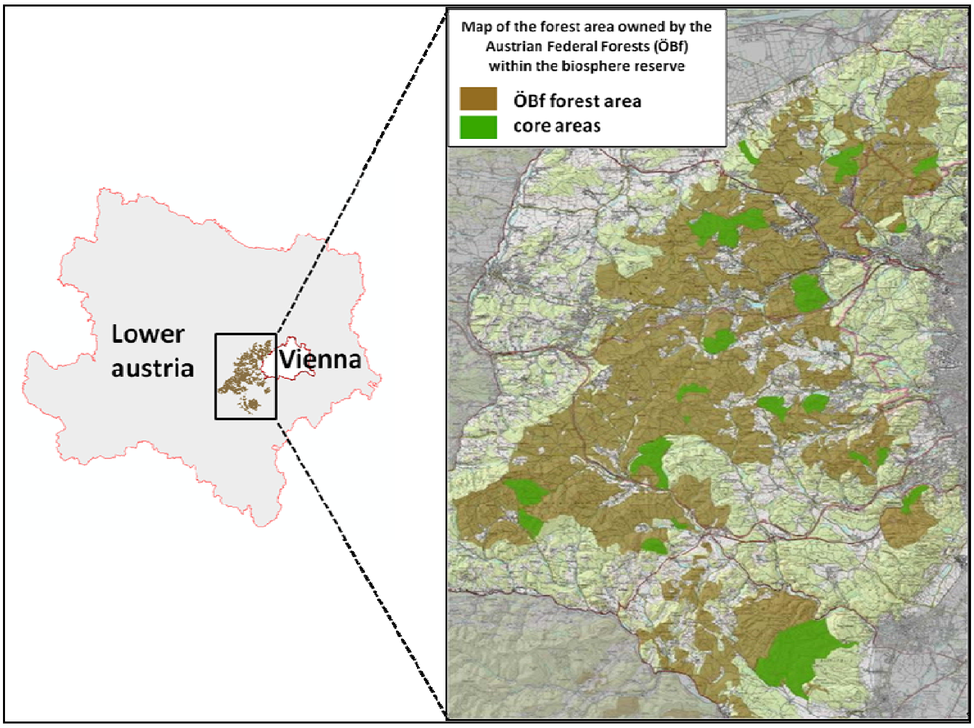


Fig. 6 : Map of the Wienerwald biosphere reserve located south-west of Vienna. Brown = forest area owned by the Austrian Federal Forests (ÖBf), green= core areas.

The PICUS 1.4 forest ecosystem model was used to simulate forest development for typical stand-site combinations for a period of 100 years (2001–2100). The model simulated forest development based on individual trees and considered the dynamic interaction of regeneration, growth and mortality. For the analysis three transient climate change scenarios for the period 2000–2100 generated by a regional climate model were used. They were based on "business-as-usual" emission scenarios A1B and A2, and on an environmental friendly scenario B1. As a reference for the analysis a baseline climate derived from the instrumental period 1961–1990 was used. Figure 7 shows changes in temperature and precipitation in the climate change scenarios in relation to the baseline climate.

For the present study two common site types were selected (limestone site with medium soil depth, fresh site with deep soil) representing the range of ecological conditions in the biosphere reserve. Typical beech stands of different age classes were chosen to analyse two different management regimes ("business as usual" (BAU) and "adaptive management" (AM)). The BAU regime was a traditional beech management concept dominated by thinnings from below (light thinnings). The desired natural regeneration of beech was achieved by a shelterwood cut and subsequent overstory removal. The AM regime was characterised by heavier crown thinnings. After beech regeneration had been established via a shelterwood approach, oak was introduced by planting. The six vulnerability indicators "productivity", "damage by disturbances", "standing stock", "biodiversity", "carbon storage" and "cost intensity" were used to compare the different combinations of site types, management regimes, age classes and climate scenarios.

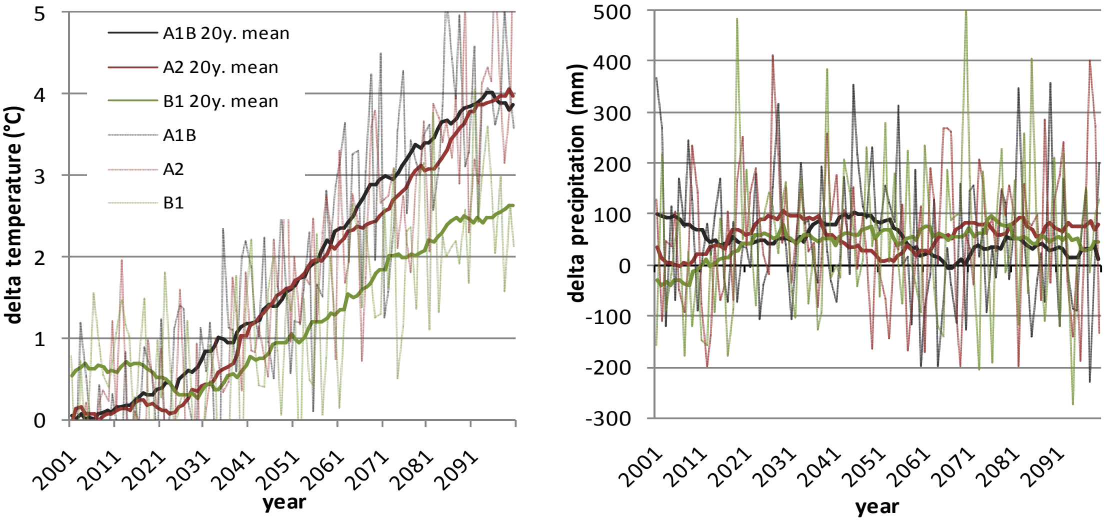


Fig. 7 : Changes in mean annual temperature and annual precipitation in the climate change scenarios A1B, A2 and B1 in relation to the baseline climate. Shown are mean values over 66 plots of the Austrian National Forest Inventory (ANFI) in the region of the Wienerwald biosphere reserve.

The results showed that in the first half of the twenty-first century BAU productivity under climate change conditions remained more or less at the level of the baseline climate. In the second half a slight decrease in productivity was observed for BAU. As an example, in Figure 8 the indicators for a young age class at the fresh site type with deep soil for the period 2051–2100 are illustrated. The analysis showed the strongest decrease in productivity in the A1B scenario relative to the baseline climate. This might be caused by drought effects due to a periodic decrease in precipitation after 2050 in combination with higher temperatures (Figure 7). In general, AM productivity without climate change was below that for BAU management. However, under climate change conditions the AM regime was more stable with productivity very similar to BAU management. There were no differences between the two man

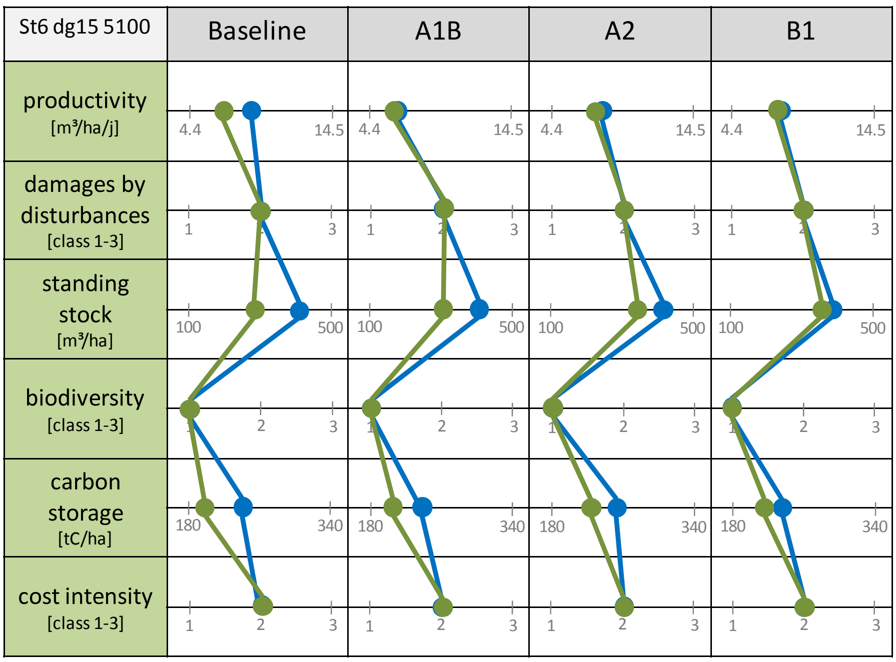


Fig. 8 : Pattern of BAU and AM management for a combination of site type, age class and period of analysis (fresh site type with deep soil, mean stem diameter 15 cm, period of analysis: 2051–2100) for

baseline climate and the three climate change scenarios A1B, A2, B1. blue line/dots = business as usual (BAU) management; green line/dots = adaptive management (AM) concept.

agement concepts with regard to the indicator “damage by disturbances”, because the regeneration phase was too late within the analysis period. The introduction of oak in the regeneration layer did not yet have an influence on the biomass composition of the stand and on the simulated predisposition against snowbreak and windstorm. The same applied to biodiversity. As a result of heavier thinnings the standing stock in the AM regime was lower than in the BAU concept. Because differences in productivity between BAU and AM decreased with climate change, these differences decreased over time.

For all combinations of site type, age class, and period of analysis the indicators “standing stock” and “carbon storage” were highly affected by the management concept. Because of the approximate ordinal scale (three classes) the indicators “damage by disturbances”, “biodiversity” and “cost intensity” showed less or no sensitivity to management. In all cases only differences within one class were detected. The indicators “damage by disturbances” and “cost intensity” remained average (class 2), while the indicator “biodiversity” remained low (class 1). If the costs for protection against browsing and fraying of game were included in the AM, the “cost intensity” would increase and thus lead to a less favourable classification.

The results indicated that moderate adaptive management concepts (admixed oak) are able to provide the required ecosystem performance in the Wienerwald biosphere reserve within the analysed climate change scenarios. Without climate change the AM concept would show losses in productivity. Therefore the AM was not a clear win-win option, but meant that biomass productivity was less climate-sensitive. In economic terms it should be taken into account that oak can compensate for productivity losses through higher revenues per cubic metre of timber, depending, of course, on the relationship between the price of beech and oak. Because of the difficulty in predicting such relationships and also timber quality, these factors were not considered in the analysis.

5 StartClim2009.D: Humus assays as a practical tool for farmers to support carbon sequestration in agriculture

The humus content of the soil is of critical importance for mitigating global warming and adaptation to climate changes. With increasing soil humus content, carbon is sequestered in the soil in the medium term and hence kept out of the atmosphere. Soil with high humus content holds more water and supplies crop plants longer under dry conditions. It also allows more water to infiltrate in heavy rain and so reduces erosion. Improving the humus content of the soil also increases cation exchange capacity and nutrient storage.

The soil practitioner training course, which was developed by Bio Forschung Austria (BFA) together with Distelverein and Bio Austria and which has now been held for the third time in the Weinviertel, makes (organic) farmers aware of the value of soil humus. With the help of humus assays, farmers can find out how their management measures affect humus content. However, the simple humus assay method used by BFA at the moment does not take sufficiently account of regional conditions and certain management measures, such as cover crops.

The aim of this project was to find a humus assay method that could be calculated quickly using input data obtained easily by the farmers while at the same time indicating the humus development on farms in the Weinviertel with acceptable accuracy as a way of providing farmers with a tool to plan and better understand carbon sequestration in agriculture

Five humus assay methods were assessed using data from the STIKO long-term field experiment by BFA. Three treatments with compost fertilisation (at rates of 9, 6 and 24 tons compost /ha /year) were used as models for humus-increasing management. The results of the different humus assays were compared with the soil humus content of the compost-fertilised soil after 12 years of management.

The humus assay methods tested were:

- the humus unit method (HE method) by Leithold et al., 1997, in its dynamic form using the humus assay software REPRO (Hülsbergen, 2002)

- the humus assay method of the Bayerische Landesanstalt für Landwirtschaft (Bayer. LfL; www.lfl.bayern.de/iab/bodenschutz/12458/)

- the humus assay method by Kolbe (Kolbe, 2007)

- the VDLUFA humus assay method, calculated using the upper values (VDLUFA, 2004) and

- the ROS (Reproduktionswirksame organische Substanz) method (Autorenkollektiv, 1977).

The forecast accuracy of the five humus assay methods differed widely. While the HE (REPRO), Bayerische Landesanstalt für Landwirtschaft and Kolbe methods showed deviations of -8, +12 and -13 per cent from the measured values and predicted the development of soil carbon fairly accurately, the VDLUFA and ROS methods had deviations of +69 and +94 per cent from the measured values and thus clearly overestimated the soil carbon.

The results of this comparison were discussed with farmers from the Weinviertel and information was collected as to the availability, detail and accuracy of the management and yield data they could provide for the humus assays. With account taken of the data available and costs, the Kolbe method was chosen.

Humus assays using the Kolbe method do not require too much time and effort, but at the same time they permit several soil types to be distinguished and include a gradation of the effectiveness of organic fertiliser as a function of the amount applied.

Calculations of the sensitivity of humus assay to inexact or incorrect estimations of straw weight and cover crop biomass showed that the error arising from a false estimation of straw weight for one ton was up to 120 kg C/ha, while the error arising from a false estimation of cover crop biomass was only up to 20 kg C/ha. As practical farmers usually do not have data for cover crop biomass, it is therefore feasible to estimate cover crop biomass using reference data from cover crop experiments of BFA.

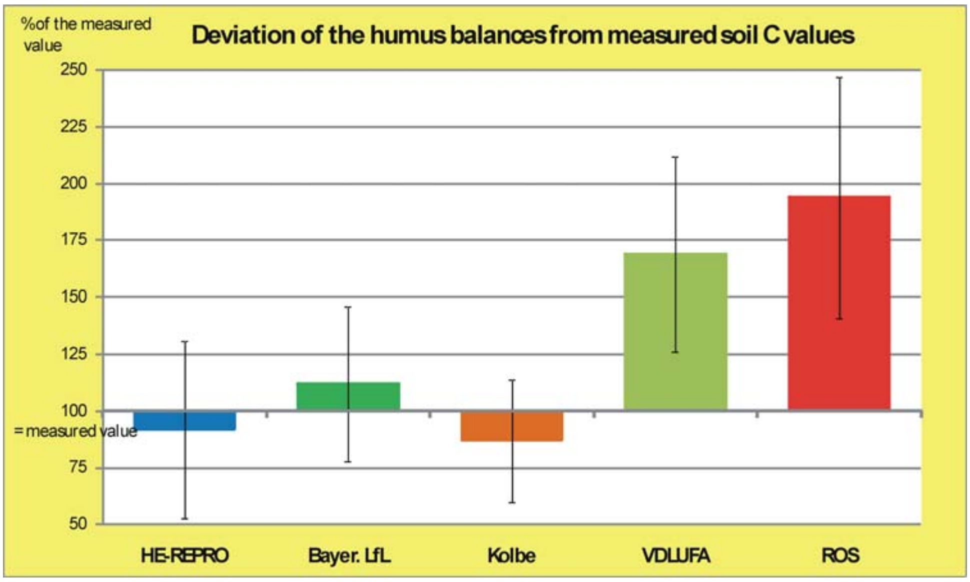


Fig. 9 : Deviation in the organic carbon assays calculated with five different humus assay methods from the organic carbon values measured in the compost-fertilised soil in the STIKO study.

Fig. 10 : Soil profile with humus-rich A horizon and with cover crop.

Subsequent tests of the Kolbe method using working farm data were successful. This method will therefore be used in future in BFA's regular workshops for farmers.

The changes in soil carbon stocks computed in this project ranged from +370 to +1100 kg C/ha/year in the field experiment with compost fertilisation and from -300 to +480 kg C/ha/year on farmers' fields. The assay of +480 kg C/ha/year was achieved by compost fertilisation and growing fodder and cover crops.

Assuming (optimistically) that by promoting management methods that increase soil carbon, 500 kg C/ha/year could be sequestered on all of Austrian cropland (1.39 million hectares), a total of 0.7 million tons of carbon per year, corresponding to 2.55 million tons of carbon dioxide per year stored in the soil. Austria's total carbon dioxide emissions were 73.6 million tons in 2008, while the total greenhouse gas emissions amounted to 86.6 million tons of carbon dioxide equivalents. In order to achieve our Kyoto target, emissions will have to be reduced by 17.8 million tons of carbon dioxide equivalents per year.

This comparison shows that carbon sequestration in agricultural soils could make an appreciable contribution to a reduction in greenhouse gas emissions. This contribution could come into effect quickly as the techniques to be used are well known. The humus accumulation achievable in practice will not suffice, however, to compensate for all of the carbon dioxide emissions from fossil fuels. The sequestered carbon will nevertheless improve soil functions such as water-holding capacity, which is valuable particularly with a view to adaptation to climate change.

6 StartClim2009.E: Adapting office buildings to climate change: optimisation of thermal comfort

The reduction of cooling energy demand in office buildings while maintaining comfortable indoor thermal conditions is an important consideration in the light of global warming and an imminent shortage of energy. The effectiveness of various cooling strategies was compared using model calculations. The study also investigated optimisation strategies in buildings using models to calculate heat balances in buildings and evaluated the effectiveness of innovative cooling technologies.

Improving the energy efficiency of electronic devices and artificial lighting significantly lowers the internal heat loads and the demand for cooling energy. The achievable annual savings are commensurate with increases in demand to be expected due to climate change.

It is likely that the theoretical improvement in the energy efficiency of appliances could be taken advantage of in the next few years since the additional cost of more efficient appliances is decreasing. It should be ensured, however, that the gains in efficiency are not cancelled out by the use of additional appliances. Reduced internal heat loads result in increased heating requirements in winter particularly in poorly insulated buildings. In such cases, it is advisable to improve the building insulation.

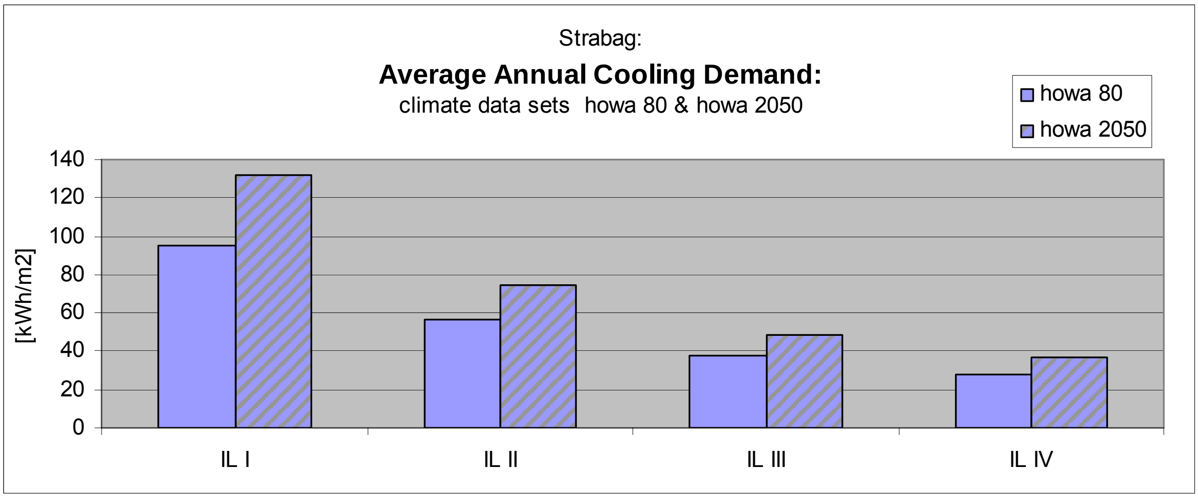
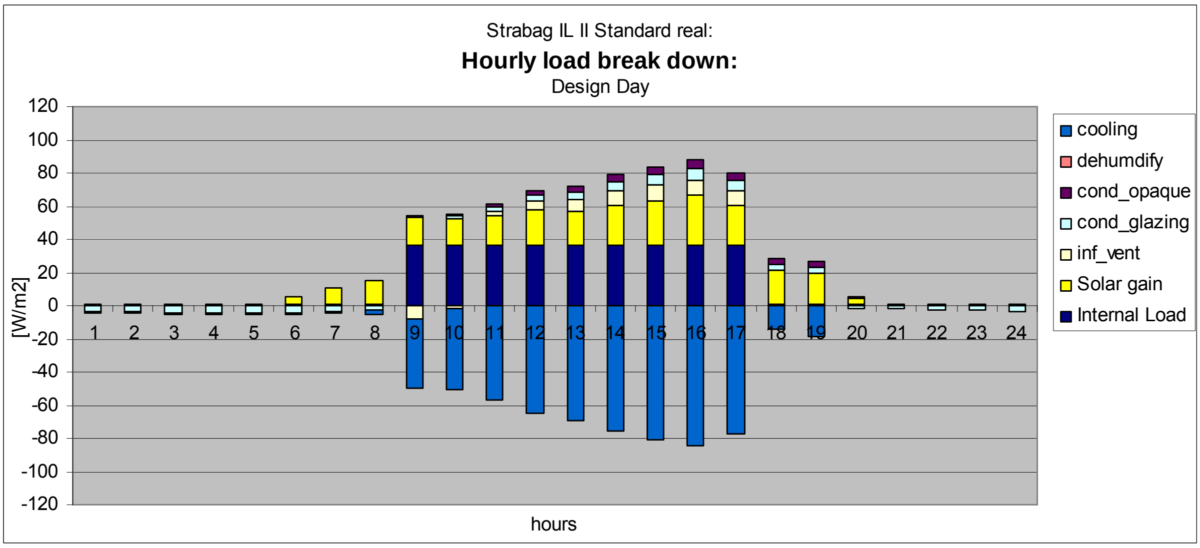


Fig. 11 : Average annual cooling demand of a double office room under present (howa 80) and future (howa 2050) climatic conditions using electronic devices and lighting with different energy efficiency, IL I represents a worst-case scenario while IL IV incorporates the most efficient products currently available on the market.

Changes in the times when rooms are used could also alter the heat loads in office buildings, since heat loads depend not only on occupancy but also on the appliances and lighting the occupants use. Cooling demand could be reduced by shifting occupancy from the hottest hours of the day and by means such as teleworking. As measures of this nature have an impact on working habits, however, the relevant discussion needs to look beyond the thermal energy considerations.

The study demonstrated that in naturally ventilated office rooms, thermal comfort can be optimised to a limited extent through window ventilation. The exact extent of the improvement is largely dependent on the prevailing wind situation and its local impact. Moreover, the increase in warm nights also reduces the effectiveness of nocturnal cooling.

The possibility of improving comfort through external air flows and desktop cooling fans was also studied. Both are possible and often useful. In the first case, however, workable tools for calculating the possible flow rates indoors as a function of the outside wind velocity and direction need to be developed.



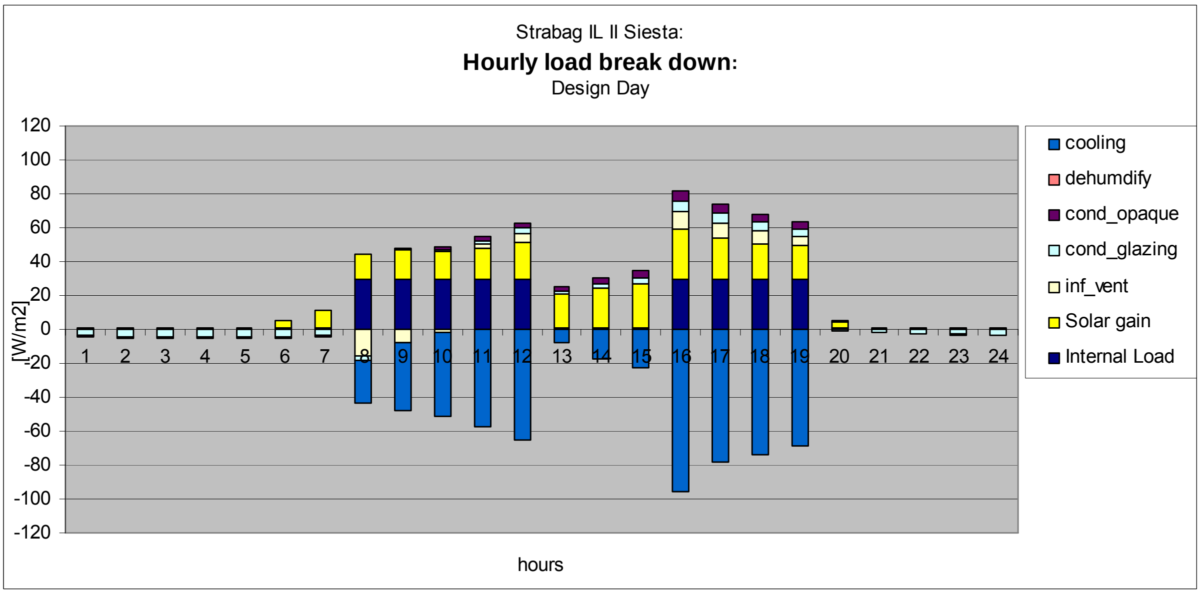


Fig. 12 : Comparison of hourly heat gains and losses in a double office room with a standard design day (above) and a siesta model (below), The absence of users during the siesta period considerable reduces the cooling requirement during this time.

The study also investigated the efficiency and suitability for office buildings of innovative cooling technologies, most of which are not yet available on the market. Radiative systems used heat radiation against the cold night sky to generate cooling energy, while evaporative systems extract heat from the room air through evaporation.

A combination of radiative and evaporative systems in addition to conventional cooling technologies proves to be the most effective way of covering the cooling energy demand in office buildings. The inclusion of building or water storage to combine supply (mostly at night) and demand (during the day) is feasible and in some cases necessary.

7 StartClim2009.F: AlpinRiskGP – Estimation of present and future risk potential for Alpine tourists and infrastructure caused by glacier retreat and permafrost changes in the Grossglockner-Pasterze glacier area (Hohe Tauern, Austria)

As a result of climate change, numerous natural processes in high mountain areas are becoming more intense. In particular, these are processes that reshape the land surface by erosion, transport and deposit of rocks. Such processes have always represented a risk for people and/or infrastructure in high mountain areas. But if the frequency, magnitude and range of hazardous events increases as a result of climate change and there is also an increase in the number of people staying in range at the same time, it is likely that the risk potential will rise in the future at least on a regional scale.

For residential areas and transport routes an elaborate system of permanent and temporary/active and passive protective measures was developed in the late nineteenth century and for areas highly frequented by tourists (e.g. ski slopes) measures were introduced in the twentieth century. These measures are embedded in an integral risk management concept and are implemented consistently throughout most of Austria. However, this is not always the case for marked Alpine trails and unmarked high Alpine routes. For this reason more and more people are considering ways of ensuring the safety for people walking on trails and routes. AlpinRiskGP aims to develop a tool that is able to identify dangerous spots exactly, extensively and in an easily comprehensible manner and thus facilitate the implementation of targeted measures.

One of the most highly frequented high mountain areas in Austria served as a study area, where dangerous processes are mainly caused by glacier retreat and permafrost degradation. The project modelled rock fall and denudation processes. For this purpose, the first step was to model the susceptibility of an area to trigger a process. It was obtained by combining various types of information (e.g. slope, geology). The second step was the process modelling, so that erosion, transport and rock deposit could be determined over the whole study area. Finally, the processes were assessed and served as a basis for the generation of a geomorphological hazard map that subdivided the study area into four hazard classes. This process was repeated using additional climate data to create a scenario for 2030 and generate another geomorphological hazard map.

By overlaying the hazard maps with trail and route network information, vulnerability maps (see figures) were created. These maps make it easier to recognise how severely certain trail or route segments will be affected by dangerous processes. The results show clearly that an increase is likely by 2030 in both the area and number of trails and routes in classes with a high risk potential.

In a final step local stakeholders reviewed the maps and considered possible measures. These include local strategies (e.g. closing or marking new trails) and organiasational measures (e.g. installation of a trail information system) and improved training of people who spend their leisure time in high mountain areas. The developed method is easily transferable to other study sites.

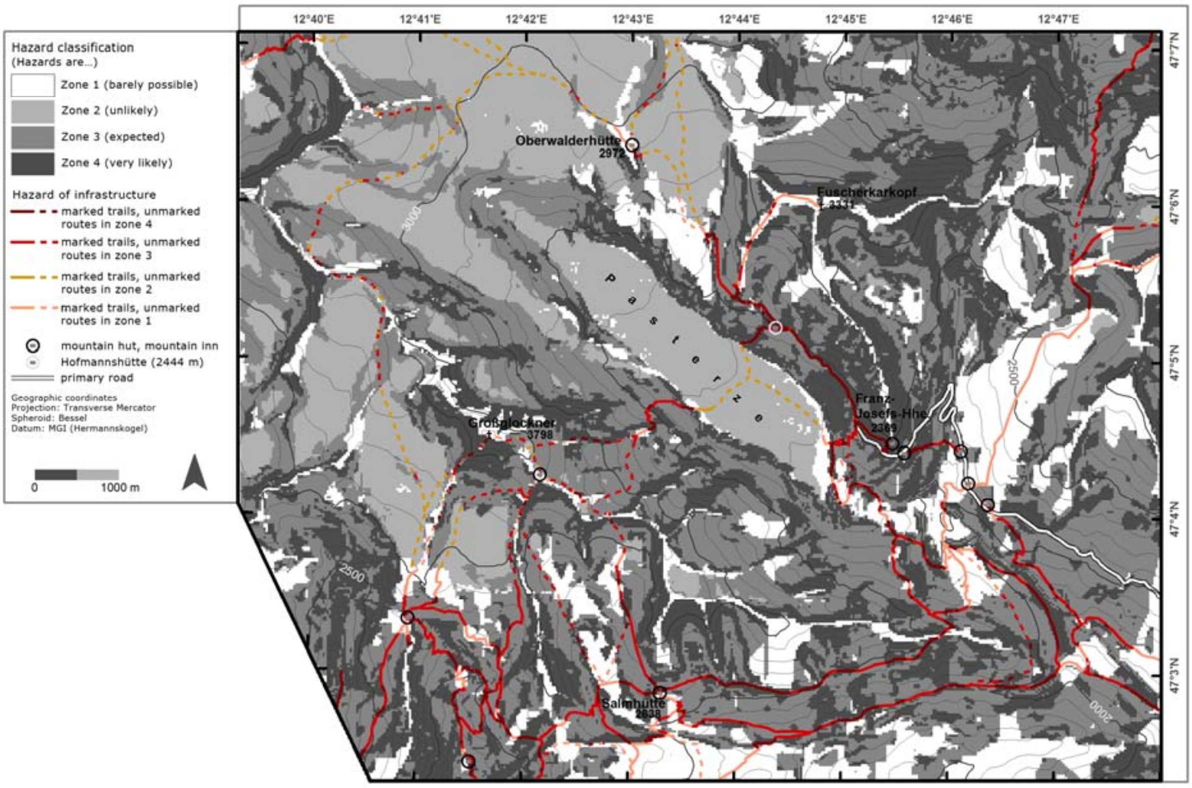


Fig. 13 Vulnerability map 2010

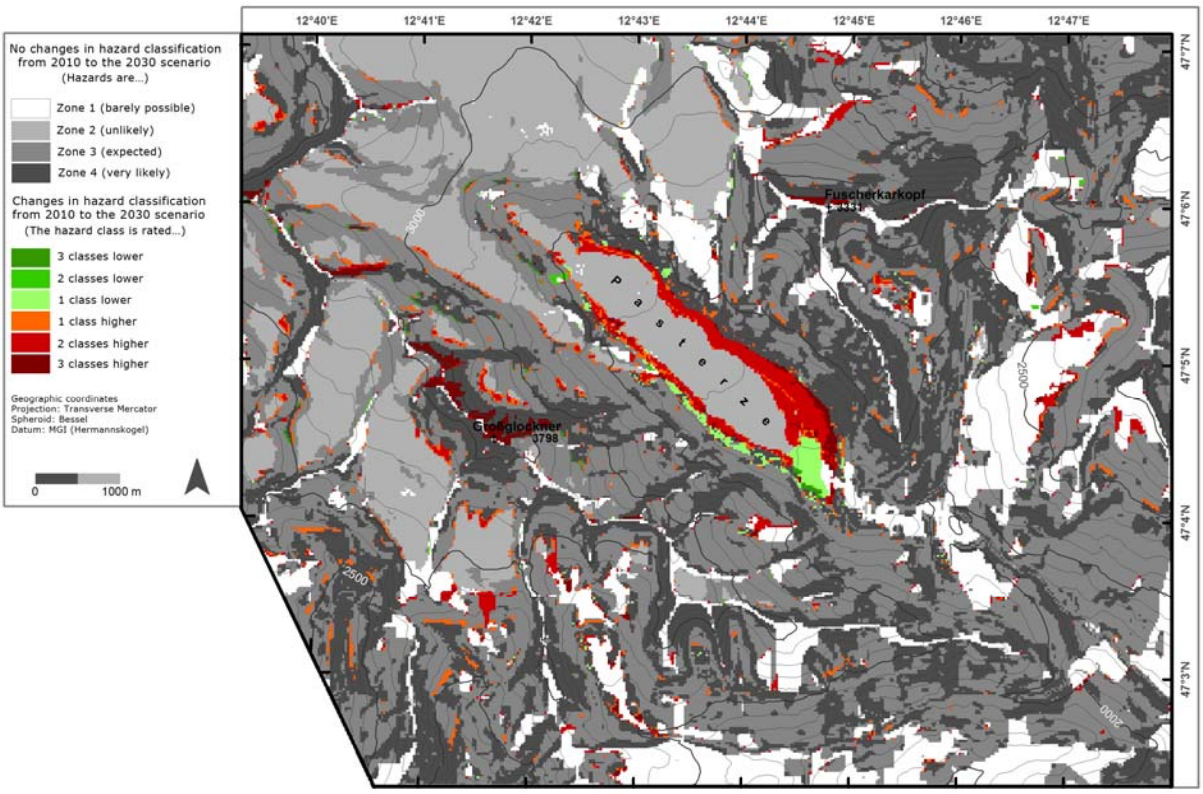


Fig. 14 Differential map of hazard classes 2010-2030

Although the AlpinRiskGP project is just based on a minor climate change scenario with a manageable timeframe of two decades (Scenario 2030), the majority of the expected changes in hazard classes will lead to an increase in hazards (orange to dark red), while the reduction of risk potential will only occur at discrete spots (green).

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Annex

All following reports can be found on the StartClim2009-CD-ROM and on the StartClim website (www.austoclim.at/startclim/)

Subprojects of StartClim2003

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
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 Andreas Frank, Petra Seibert

StartClim.5: Testing statistical downscaling techniques for their applicability to extreme events in Austria
Institute of Meteorology and Physics, BOKU -
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-flooding 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 programme for Austria Institute of Meteorology and Physics, BOKU:
Helga Kromp-Kolb, Andreas Türk

StartClim.Reference database:
Implementation of a comprehensive literature database 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

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 productivity?" A project at the interface between science and education
Institute of Meteorology, BOKU
Ingeborg Schwarzl, Elisabeth Lang, Erich Mursch-Radlgruber

Subprojects of StartClim2005

StartClim2005.A1a: Impacts of temperature on mortality and morbidity in Vienna
Medical University of Vienna, Centre for Public Health, Institute of Environmental 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 Environmental 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

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]

Subprojects of 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
Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Vienna: Stana Simic
Institute of Medical Physics and Biostatistics, University of Veterinary Medicine Vienna: Alois W. Schmalwieser
Medical University of Vienna, Centre for Public Health, Institute of Environmental Hygiene: Hanns Moshammer

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
Federal Forest Office: Robert Jandl, Andreas Schindlbacher, Sophie Zechmeister-Boltenstern, Michael Pfeffer
Department of Forest and Soil Sciences, University of Natural Resources and Applied Life Sciences, Vienna:
Klaus Katzensteiner
Federal Environment Agency: Sabine Göttlicher
University of Vienna: Hannah Katzensteiner
Tiroler Landesforstdirektion: Dieter Stöhr

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
Christine Kroisleitner, Wolfgang Schöner

StartClim2007.G: Integrated modelling of the economy under climate change in application of the STERN report (STERN.AT)
Wegener Centre for Climate and Global Change, University of Graz:
Olivia Koland, Karl Steininger, Andreas Gobiet, Georg Heinrich, Claudia Kettner, Alexandra Pack, Matthias Themeßl, Christoph Töglhofer, Andreas Türk, Thomas Trink
Joanneum Research, Institut für Technologie- und Regionalpolitik:
Raimund Kurzmann
University of Natural Resources and Applied Life Sciences, Vienna: Erwin Schmid

Subprojects of StartClim2008

StartClim2008.A: Impacts of adaptation measures on the acute mortality risk due to extreme temperature in Vienna
Institute of Environmental Hygiene, Centre for Public Health, MUW: Hanns Moshammer, Hans-Peter Hutter
Institute of Meteorology, BOKU: Thomas Gerersdorfer

StartClim2008.B: Which adaptations of soil erosion protection measures can be recommended for expected climate change impacts?
Institute of Hydraulics and Rural Water Management, BOKU: Andreas Klik
Institute of Meteorology, BOKU: Josef Eitzinger
Institute of Agronomy and Plant Breeding, BOKU: Peter Liebhard

StartClim2008.C: Practical testing of the monitoring concept “Adaptations of insect pests to climate change in crop production of eastern Austria” by investigating the distribution of current cutworm (*Agrotis segetum, Schiff.; Fam. Noctuidae*) damage as a function of site-related and climatic factors
Bio Forschung Austria: Patrick Hann, Claus Trska, Eva Maria Frauenschuh, Bernhard Kromp

StartClim2008.D: Organic agriculture in the mountains of Tyrol—contributions to mitigating climate change and adaptation strategies
Division of Organic Farming, BOKU: Michael Dorninger, Bernhard Freyer

StartClim2008.E: Development and economic valuation of landscape structures to decrease evapotranspiration on agricultural acres with account taken of climate change and biomass production
Institute of Landscape Development, Recreation and Conservation Planning, BOKU: Christiane Brandenburg, Bernhard Ferner, Sonja Völler, Brigitte Allex
Institute of Meteorology, BOKU: Josef Eitzinger, Thomas Gerersdorfer
Division of Organic Farming, BOKU: Bernhard Freyer, Andreas Surböck, Agnes Schweinzer, Markus Heinzinger
Institute of Agricultural and Forestry Economics, BOKU: Enno Bahrs

StartClim2008.F: Perception and evaluation of natural hazards as a consequence of glacier retreat and permafrost degradation in tourism destinations—a case study in the Tux Valley (Zillertaler Alps, Austria)
Institute of Landscape Development, Recreation and Conservation Planning, BOKU: Ulrike Pröbstl
University of Regensburg, University Eichstätt-Ingolstadt: Bodo Damm

StartClim2008.G: Adaptation of forest soils to a changing climate
Federal Research and Training Centre for Forests, Natural Hazards and Landscape: Barbara Kitzler, Verena Stingl, Sophie Zechmeister-Boltenstern
Institute of Meteorology and Climate-Research – Atmospheric Environmental Research, Garmisch: Arjan De Brujin, Ralf Kiese, Klaus Butterbach-Bahl