StartClim2015

Additional Contributions to the Implementation of the Austrian Adaptation Strategy

Final Report

Project Leader
Institute of Meteorology
Department of Water - Atmosphere – Environment
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 Science, Research and Economy
Federal State of Upper Austria
Austrian Federal Forests
Federal Environment Agency

Administrative Coordination

Federal Environment Agency

Vienna, November 2016

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Contributions to StartClim2015

StartClim2015.A: Re-inventing prevention? - An analysis and evaluation of approaches and tools for flood and heavy precipitation self-provision and private prevention (RE-Invent)
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Wegener Center für Klima und Globalen Wandel, Universität Graz: Philipp Babcicky, Sebastian Seebauer
Landesfeuerwehrverband Vorarlberg: Clemens Pfurtscheller

StartClim2015.B: RELOCATE – Relocation of flood-prone households in the Eferding basin: Accompanying research on social impacts
Wegener Center für Klima und Globalen Wandel, Universität Graz: Philipp Babcicky, Sebastian Seebauer

StartClim2015.C: Monitoring the effects of climate change on the Austrian bird fauna
BirdLife Österreich: Erwin Nemeth, Norbert Teufelbauer
Zentralanstalt für Meteorologie und Geodynamik (ZAMG): Ingeborg Auer, Brigitta Hollòsi

StartClim2015.D: Maintaining the protective services in Austrian forests under conditions of climate change
Institut für Waldbau, BOKU: Manfred Lexer, Florian Irauschek, Werner Rammer

StartClim2015.E: Risk assessments for selected protection forest types of the Eastern Alps (Austria and Southern Tyrol) with reference to the disturbance regimes storm/snow damage/drought - bark beetle– forest fire and climate change
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Abstract

StartClim has been studying the topic of adaptation to climate change since 2008. The projects in StartClim2015 addressed various research questions and provided scientific support for implementation of the Austrian Adaptation Strategy. Two projects examined different aspects of social transformation, one project developed a monitoring programme to analyse the influence of climate change on local bird fauna, and two projects focused on protection forests, their functionality, maintenance and risk assessment.

Increases in flood disasters and heavy rainfall events have caused considerable damage in the last few years, resulting in a large demand for disaster management and risk prevention. Climate change is expected to exacerbate this development. While procedures and strategies for flood protection, regional planning and public disaster management are continuously revised in order to cope with flood risks, public awareness raising has been haphazard and unsystematic. Changing behaviour is a gradual process, evolving from precontemplation to a desire to act, then to planning, implementation and finally consolidation of the changed behaviour. In terms of individual preparedness, most Austrians are still at the level of precontemplation. Individual preparedness is a vital component of risk management, however, and it is thus essential to strengthen this dimension.

The RE-Invent project reviewed established approaches and methods for promoting individual preparedness, focusing on German-speaking areas. Expert workshops served to identify the measures best suited to promote adaptation and protection of property. This study focuses on flood events only.

If risk awareness is low, effective individual preparedness is also limited. Measures should therefore focus on ways of heightening awareness, for example by including the subject of natural hazards and individual preparedness in school curricula. As soon as basic awareness of potential risks has been established, residents at risk need to be approached before and during a flood event. Accessible, standardised and proactively communicated information plays an important role in this regard, particularly concerning early warning and hazard information. At the next stage, when residents at risk have already stated an intention to make individual preparations, measures should not only assist residents in their intentions but also provide incentives for implementation, such as financial support or counselling by qualified personnel.

Apart from specific measures, the overarching framework for strengthening individual preparedness calls for a clear distribution of the legal and operational tasks among the various institutional bodies promoting individual preparedness. However, the current fragmentation of competences and responsibilities prevents a clear assignment of roles to the federal state, provinces, municipalities, and other institutions.

Flood risk management faces major challenges because of the expected increase in the intensity and frequency of extreme weather events caused by climate change. Against this background, the relocation of flood-prone households is being increasingly discussed as an alternative to conventional flood protection measures. So far, however, there has been a lack of research on how relocation processes can be designed to reduce negative social impacts and increase political acceptance.

In Eferding Basin (Upper Austria), 146 private households had to decide to either accept or reject a relocation offer by the end of 2015. Prior to this deadline, we conducted interviews with 78 relocation households to identify their individual decision-making processes, perceived fairness and risk perception. In a follow-up project, these households will be observed in yearly interviews to record and analyse long-term social impacts.

Relocation households take risk judgments, economic consequences and emotional aspects into account when deciding to accept or reject a relocation offer. Often, these households call on their experience with the most recent flood event to determine future flood risks in their own houses. As far as the economic consequences are concerned, households take the offered compensation amount and the housing market situation into account (e.g. current land and property prices; possibility of selling their properties). Also, personal circumstances, such as recent family foundation, employment, retirement or children's prospects, are considered. This emotionally driven appraisal is also shaped by the personal attachment to a specific place, house or farm and by the extent to which the available options (relocate or stay) threaten personal ideas about life and an ideal housing situation. Throughout the relocation project, politicians and public authorities have led a primarily rational debate that only marginally touches on households' risk perceptions and economic considerations, let alone emotional aspects.

More personal contact would give relocation households the opportunity to better express their individual perspectives and considerations with respect to the relocation and regional flood hazards. Future relocation projects should therefore consider engaging a person or institution to moderate the relocation process in an empathic, neutral and trustworthy manner. Nevertheless, all parties need to take responsibility for the realisation of specific parts of the process – such as expectations, participation, transparency and empowerment to make individually favourable decisions.

One project within StartClim2015 used the results of the Austrian Breeding Bird Survey (1998–2015) to evaluate the influence of climate change on the populations of 76 bird species. The majority of these species belong to the group of 'climate winners' and only 17 to 'climate losers'. If we exclude species affected by the ongoing intensification of farming, the Climate Impact Index (CII) shows a significant effect of climate warming. The timeframe was relatively short and fell in a period of no temperature rise. For both of these reasons, the results have to be treated with caution. Nevertheless the CII appears to be a useful tool for assessing the influence of climate change on breeding birds of Austria, provided that other factors, such as land use practice, are taken into account. Existing results indicate that most species outside of farmland benefit from climate change. The nightingale, for example, has been able to expand its breeding grounds to higher elevations.

Scenario simulations were performed for a set of representative Austrian forest types to explore the likely future range of stand development trajectories under climate change conditions until 2100. It was designed in particular to investigate the extent to which forests can be protected in future against rock fall, snow avalanches and landslides. Six management regimes were analysed and scenarios with combinations of bark beetle infestation and browsing by game species tested additionally for each scenario. Fifteen regions and up to five elevational zones were considered to determine the ecological conditions in Austrian forests. Poor and rich site types in each region and zone were also defined.

In the scenario without stand management, stock increased in most cases quite densely but without structure. Under climate change conditions damage by bark beetles increased strongly, particularly in montane spruce stands. Damage also occurred in a warmer climate in the lower subalpine zone. The strip and strip-shelterwood management approach does not allow permanent effective protection. Slit and patch cut systems can sustain sufficient levels of protection.

Overall, the results confirmed that under climate change conditions disturbances will be the decisive factor for ecosystem service provisioning in spruce-dominated forests. High

browsing pressure will result in lower tree-species diversity and lack of regeneration in general in future stands. This will have negative implications for susceptibility to bark beetle infestation and the resilience of forests.

Protection forest experts rated storms, bark beetles and browsing as the most important factors reducing the protective effect of forests. Management was considered important, affecting protective services negatively as well as positively. There is thus a demand for forestry expertise on the management of protection forests.

Bark beetle outbreaks can have a far-reaching impact on forest dynamics. They especially endanger the sustainable functioning of protective forests. Management of these forests should focus in future on the sustained maintenance of protective functions. Risk profiles for selected protective forest types have been established to assess the present and future threats from abiotic/biotic disturbances.

The risk profile was based on existing risk models for Norway spruce and the extension of these models to other conifer species in montane subalpine protection forests (larch, stone pine, Scots pine, black pine). The phenology and development of the bark beetle species *Ips cembrae*, *Ips amitinus* and *Ips acuminatus* was modelled on the basis of empirical data, literature reviews, and existing knowledge-based susceptibility assessment models for the Norway spruce – *Ips typographus* combination. Past, present and future hazards were assessed using different regional climate models.

The modelling of the development for the different bark beetle species showed that projected climatic change will increase the number of potential generations for all bark beetle species and for all regions. Spring swarming and the establishment of sister broods and filial generations will occur much earlier. Therefore, bark beetle infestations is likely to occur more frequently, especially at high altitudes.

The derived risk profiles with interactions between the different bark beetle species, abiotic disturbances and subsequent hazards can be used for the development of suitable adaptation and preventive mitigation strategies for the management of alpine protective forests.

1 The StartClim research programme

The StartClim climate research programme is a flexible instrument. Because of the short project duration and annual allocation of project topics, it can react quickly to topical aspects of climate and climate change. It is financed by a donor consortium currently consisting of nine institutions:

- Federal Ministry of Agriculture, Forestry, Environment and Water Management (since 2003)
- Federal Ministry of Health (2005, 2006, 2007)
- Federal Ministry of Science, Research and Economy (since 2003)
- Province of Upper Austria (since 2012)
- Austrian Federal Forests (since 2008)
- Oesterreichische Nationalbank (2003, 2004)
- Austrian Hail Insurance (2003, 2004, 2006, 2007, 2008)
- Federal Environment Agency (2003)
- Verbund AG (2004, 2007)

StartClim has been studying adaptation to climate change since 2008. Since StartClim2012, the programme's objective has been to deliver scientific contributions to the implementation of the Austrian National Adaptation Strategy.

The five StartClim2015 projects examined different aspects of relevance to climate change adaptation in Austria. The topics explored were:

- Analysis of the tools for self-provision and individual prevention
- Study of social impacts in flood-prone areas
- Monitoring programme for the effects of climate change on Austrian bird fauna
- Maintenance of protection forests
- Risk assessment for protection forests

The StartClim2015 report consists of an overview of the results in German and English along with separate documentation containing detailed descriptions of the individual projects by the respective project teams. All StartClim2015 reports and documents will be available for download on the StartClim website (www.startclim.at). Furthermore, a limited number of CDs containing all StartClim reports and a folder with a short summary of the results will also be made available.

2 StartClim2015.A: Re-inventing prevention? - An analysis and evaluation of approaches and tools for flood and heavy precipitation self-provision and private prevention (RE-Invent)

Increases in flood disasters and heavy rainfall events have caused considerable damage in the last few years, resulting in a large demand for disaster management and risk prevention. Climate change is expected to exacerbate this development. While flood protection, regional planning and public disaster management are continuously revising their procedures and strategies in order to cope with flood risks, public awareness raising has been haphazard and unsystematic. According to the Transtheoretical Stage Model, the majority of Austrian people are at the first of four stages of behaviour change, the stage of precontemplation. However, individual preparedness is an essential part of risk management, which builds on the interaction between public and private actors. A general risk awareness is required to enable residents at risk to proceed from the first stage to the third and later stages, where people engage in actual protective behaviour.

The RE-Invent project reviewed established approaches and methods for promoting individual preparedness, focusing on German-speaking areas. Expert workshops served to identify the measures best suited to promote adaptation and protection of private property. This study focuses on flood events only.

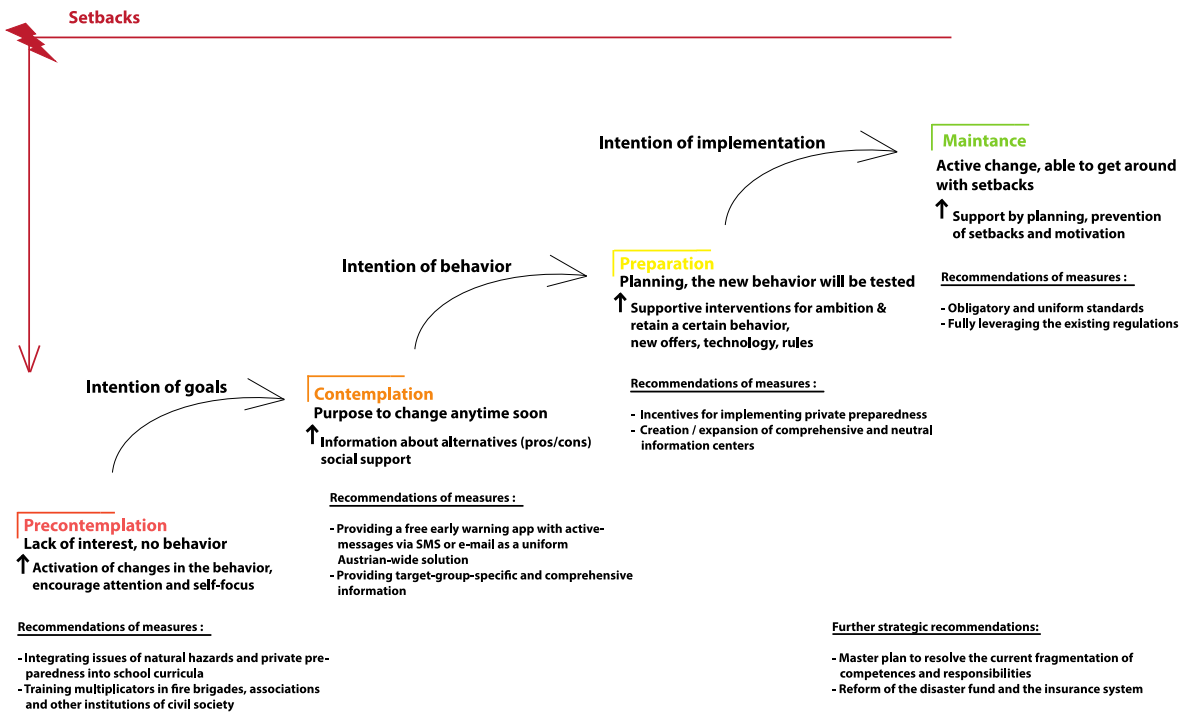

Fig. 1: The recommendations of measures rated by the Transtheoretical (stages-) model

Currently, across all four stages (precontemplation, contemplation, implementation / planning and action / maintenance), the largest deficits can be observed in the first two stages. The reason is the lack of awareness, which inhibits measures at later stages and the intention to act. Therefore, the greatest need for action is at the lowest stages.

Recommended measures for the precontemplation stage

If risk awareness is low, effective individual preparedness is also limited. Measures should therefore focus on ways of heightening awareness, for example by including the subject of

natural hazards and individual preparedness in school curricula. The next generation of residents should be made aware of and prepared for impending risks. Those affected should be empowered to become involved so as to strengthen their individual adaptive capacities. Moreover, multipliers should be trained to heighten public awareness. Inter-agency training of key employees in authorities and emergency services should be encouraged.

Recommendations

- Including natural hazards and individual preparedness in school curricula
- Training multipliers in fire brigades, associations and other public services

Recommendations for contemplation stage

As soon as basic awareness of potential risks has been established, measures are required to heighten awareness before and during a flood event and to motivate action in this way. Accessible, standardised and proactively communicated information plays an important role, particularly concerning early warning and hazard information. Information should be adapted to the specific target group and socio-demographic characteristics, such as age, education, gender, experience, risk perception or social class.

Recommendations

- Free early warning app with active messages via SMS or e-mail as a standard Austria-wide solution, similar to the Swiss app “Wetter Alarm”, even if not all segments of the population can be reached.
- Targeted and comprehensive information on the Internet and in brochures about hazards, warnings and measures to protect property

Recommendations for the implementation / planning stage

In the following stage, when residents at risk already intend to engage in individual preparedness, measures should not only assist residents in their intentions but also provide incentives for implementation. It is important that the measures are affordable and within the household budget. Financial incentives from the public and the private sector and specialised counselling on preparedness and property protection for residents at risk should be developed.

Recommendations:

- Promotion and provision of positive and negative incentives for implementing household measures through the disaster fund, insurance companies, provincial and municipal authorities (e.g. financial funding of property protection in risk areas, reduced payments by the disaster fund if a household refuses to invest in protective measures, support by insurance providers for implementing measures after an event has occurred)
- Creation / expansion of comprehensive and neutral information centres for potentially affected households, companies and communities, such as one-stop shops providing information about the technological, legal and organisational aspects of specific preparations without promoting dedicated products.

Recommendations for the action / maintenance stage

In this stage, guidelines and legal regulations play an important role in promoting individual preparedness. Building regulations and land-use planning offer numerous ways of increasing effectiveness, even if the range of existing instruments has already been extensively exploited. Standards and norms for construction in hazardous areas need to be established for the various degrees of exposure. Hazard protection products should also be systematically tested.

Recommendations

- Application of existing regional planning and construction regulations when building and verification of compliance by the authorities;
- Introduction of obligatory and uniform standards for hazard designation and building protection (for example, catalogues of products, inspection procedures, building certificate for hazard protection)

Further strategic recommendations

Apart from specific measures, the overarching framework for strengthening individual preparedness calls for a clear distribution of legal and operational tasks among the various institutional bodies involved in promoting individual preparedness. However, the current fragmentation of competences and responsibilities prevents a clear assignment of roles to the federal state, provinces, municipalities, and other institutions. Resolving this fragmentation would foster good governance in natural hazard management and civil protection. The risk transfer system in Austria should be reformed, in particular through the introduction of compulsory insurance for natural hazards, risk-differentiated insurance premiums and restructuring of the disaster fund.

Recommendations

- Development of a master plan to resolve the current fragmentation of competences and responsibilities in Austria
- Reform of the disaster fund and the insurance system to include compulsory insurance against natural hazards with national reinsurance.

3 StartClim2015.B: RELOCATE - Relocation of flood-prone households in the Eferding Basin: Accompanying research on social impacts

Flood risk management is facing major challenges: flood damage is expected to rise on account of the growing number of economic assets in flood risk zones and an increase in the frequency and intensity of extreme weather events. On top of this, the scope for the construction and maintenance of flood protection installations is decreasing because of shrinking public budgets. The planned relocation of flood-prone households is therefore being increasingly discussed as an alternative to conventional flood protection measures. While the legal basis for relocation is undisputed, public discourse and media reports underscore the conflict potential of relocation projects. So far, however, there has been a lack of research on how relocation processes need to be designed and organised to reduce negative social impacts and increase political acceptance.

In Eferding Basin (Upper Austria), 146 private households had to decide to either accept or reject a relocation offer by the end of 2015. Prior to this deadline, we conducted semi-structured in-depth interviews with 78 relocation households to identify their individual decision-making processes, perceived fairness and flood risk perceptions. We also mapped neighbourhood networks and used standardised questionnaires to improve comparability between municipalities and demographic groups. Based on this methodological approach, RELOCATE identified opinion-forming processes underlying relocation decisions and perceptions of the political process from the perspective of the affected households. RELOCATE has also laid the groundwork for assessing long-term social consequences in a longitudinal study within the ACRP project RELOCATE 2016–2018.

Flood risk perception, economic and emotional factors were found to be the three key dimensions by which households evaluated their decisions whether to relocate or not. They consider a number of aspects – all related to these three dimensions – which ultimately resulted in a positive or negative attitude towards the opportunity to relocate.

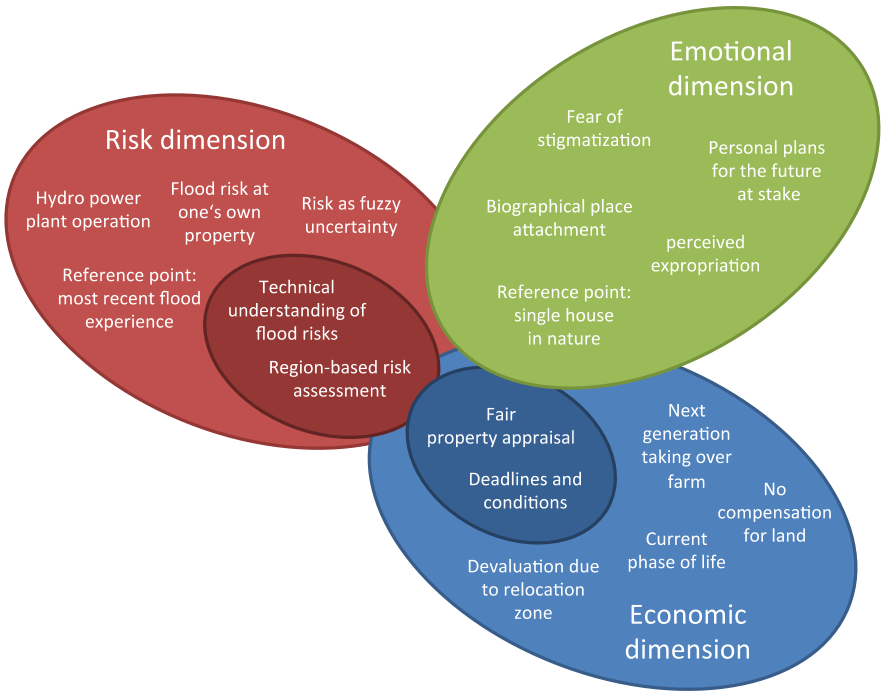

Fig. 2: Key dimensions of relocation decisions

Instead of a technical evaluation of risk in terms of probability and severity, households referred to their most recent flood experience, which they use as a reference point to estimate flood risks in their homes. Risk perceptions were also influenced by speculation and rumours, as in the 2013 flood event, which was considered to have been exacerbated by a deliberate operation by the local hydroelectric power plant to protect the city of Linz and relieve the dam in the Machland region. Unlike households, political actors and experts tended to have a technical, scientific and region-based understanding of flood risk.

With respect to the economic dimension, households considered the compensation offered, current conditions in the regional housing market and their children's interests. They repeatedly criticised the fact that the relocation offer did not include compensation for land and that the building ban in the relocation zone had adversely affected the market value of their properties. The length of the decision period was considered adequate, but households complained that no binding technical flood protection measures for the Eferding Basin had been released before expiry of the decision deadline. Some people therefore had difficulty in assessing how flood risks might change once technical measure were in place.

The emotional dimension was dominated by attachment to the locality and concerns about personal plans for the future and housing ideals. Many households had formed emotional bonds with their surroundings on account of their family history and local social networks. Relocation was experienced as an act of uprooting and as a threat to self-identity. The lack of compensation for land and the devaluation of properties was experienced as hidden expropriation. Some households feared stigmatisation, in the sense that those who remained in the relocation zone might receive significantly less social support during future flood events.

In a discourse primarily driven by rational arguments, political actors only marginally addressed risk and economic dimensions, and almost fully disregarded emotional aspects.

Capacities and processes describe household characteristics that influence the evaluation of risk, economic and emotional dimensions. Social capacities, for instance, comprise the social support that can be mobilised to prepare for and recover from a flood event. They also refer to information sharing and mutual coordination when interacting with public authorities and planning construction activities at new home sites. On the other hand, relocation also imposed a burden on neighbourhood networks, as forgotten conflicts and victimisation were sometimes recalled and previously untroubled social relations were overshadowed by relocation to become the dominant subject of conversations.

Personal capacities describe a household's ability to act in an anticipatory, proactive and strategic manner in order to mobilise additional resources or create new courses of action. Relocation-affected households with high psychological resilience were able to handle relocation issues in a more considerate and goal-oriented manner. Families who had been living in the Eferding Basin for many generations were used to passing on practical flood-coping knowledge to the next generation and therefore expected fewer difficulties if they remained in the relocation zone.

Financial and legal capacities encompass a household's income and savings, right of residence, property ownership and knowledge regarding legal options.

The recommendations developed in this project focus particularly on the design of relocation schemes and communication processes in relocation projects. The success of these projects depends on the willingness of political actors, public authorities, appraisers, hydroelectric power plant operators, citizens and NGOs to take their share of responsibility for accomplishing certain parts of the discourse.

More personal contact between public authorities and relocation households would give households the opportunity to better express their individual perspectives and considerations. Future relocation projects should therefore consider engaging a person or institution to moderate the relocation process in an empathic, neutral and trustworthy manner. Information should be communicated in a timely, clear and binding manner to avoid raising unreasonable expectations through rash promises. By integrating affected households and their experiences with flood events in a participatory dialogue, small-scale and citizen-oriented concepts could be developed to better manage risk and land use. Political actors and public authorities should disclose decision-making criteria and put them up for discussion. Finally, relocation might be considered more as an alternative flood protection measure if material incentives (e.g. compensation for land, provision of alternative land plots) were improved.

4 StartClim2015.C: Monitoring the effects of climate change on the Austrian bird fauna

Since 1998 hundreds of volunteers in a citizen science project have been counting breeding bird species in Austria. BirdLife Austria coordinates the census in accordance with the Pan-European Common Bird Monitoring Scheme and manages the survey data about species abundance and count locations. By applying a Climate Impact Index (CII), the pan-European survey data shows a clear effect of climate change on the population sizes of breeding bird species. Here we analysed the possible impact of climate warming on bird species in Austria and developed an Austrian Climate Impact Index based on the pan-European CII, with species classified according to their climate suitability trends (CSTs).

Birds that are expected to benefit from temperature rise are classified as 'climate winners', while 'climate losers' are expected to show a negative population trend. The CST is based on significant relationships between species distribution and climate variables in the 1980s. These dependencies make it possible to predict changes in species distribution as a result of climate change. Breeding bird species that show a positive CST are climate winners. They would be expected to expand their breeding grounds and occur in higher numbers. Species with a negative CST should show shrinking breeding ranges and a decline in number. In Austria we have to expect more climate winners than losers because species from the south are expanding their breeding ranges northward and to higher elevations.

In the Austrian dataset we found 57 winner and only 19 loser species. For both groups we calculated composite population trends, and the ratio of winner to loser trends was used to define the CII, which should increase with climate warming. From 1998 to 2015 the Austrian CII increased by 20 per cent but the rise was not continuous or significant. A major reason for these results was significant negative population trends in most of the farmland bird species (e.g. the Eurasian skylark), which were thought to be caused by more intensive farming. After exclusion of farmland birds, population trends corresponded significantly to CSTs, and this relationship demonstrated an impact of climate warming. However, the impact was not as high as in the pan-European dataset. The reasons for a weaker relationship are probably the short time span and the temperature development in our observation period.

From 1998 to 2014 temperatures did not rise significantly, and the increase in the CII was presumably a consequence of the previous dramatic increase in temperature; since the rise in the CII is caused by the decline of climate loser species, we assumed that these species had probably suffered under constant high temperatures. Because of our short timespan at an unfavourable time in terms of temperature impact, caution was required in our interpretation of the effect of climate change on breeding bird species in Austrian with caution. Nevertheless the CII is a useful tool for assessing the influence of climate change on breeding birds of Austria, provided that other factors, such as land use practice, are taken into account. Our data show that most of the breeding bird species of Austria are affected by climate change. Typical examples include the nightingale, a species that is currently expanding its breeding grounds to warmer areas, and the fieldfare, which is decreasing in abundance.

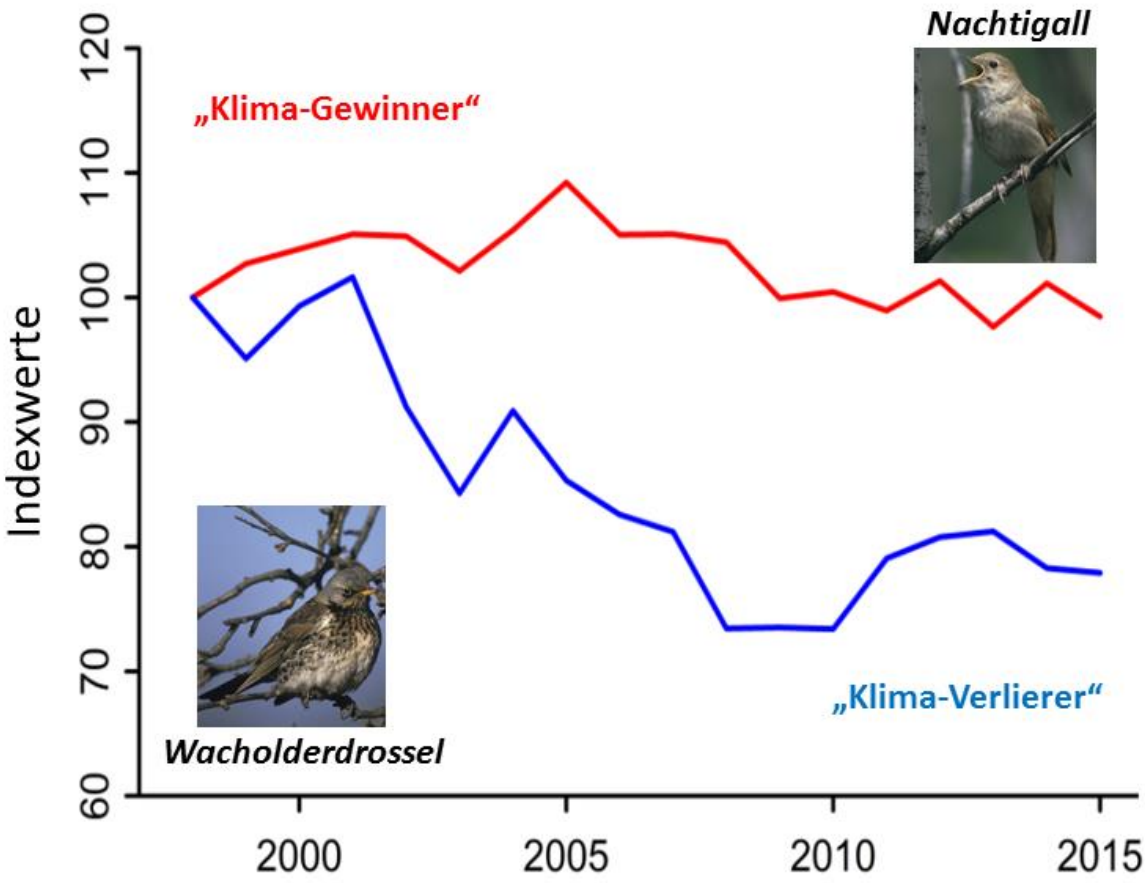

Fig. 3: Composite population trends without farmland species for “winners” (red) and “losers” (blue). The nightingale is a species that benefits from climate warming, while the fieldfare is disadvantaged

5 StartClim2015.D: Maintaining the protective services in Austrian forests under conditions of climate change

Scenario simulations were performed for a set of representative Austrian forest types to explore likely future stand development trajectories and related protection against gravitational hazards (rock fall, avalanche release, landslides) under climate change conditions until 2100. Six management regimes were analysed (no management, strip and strip-shelterwood, slit and patch cut systems, each in low and high intensity variants). For each management regime, scenarios with combinations of bark beetle infestation and browsing by game species were tested as well. Fifteen regions and up to five elevational zones each region were considered to determine the ecological conditions in Austrian forests. Poor and rich site types in each region were also defined. Forests structures were calculated using recent tree and stand data information obtained by the Austrian National Forest Inventory (ÖWI). Simulation results where structured into three time horizons: 2030–2040, 2050–2060 and 2090–2100 to show temporal development.

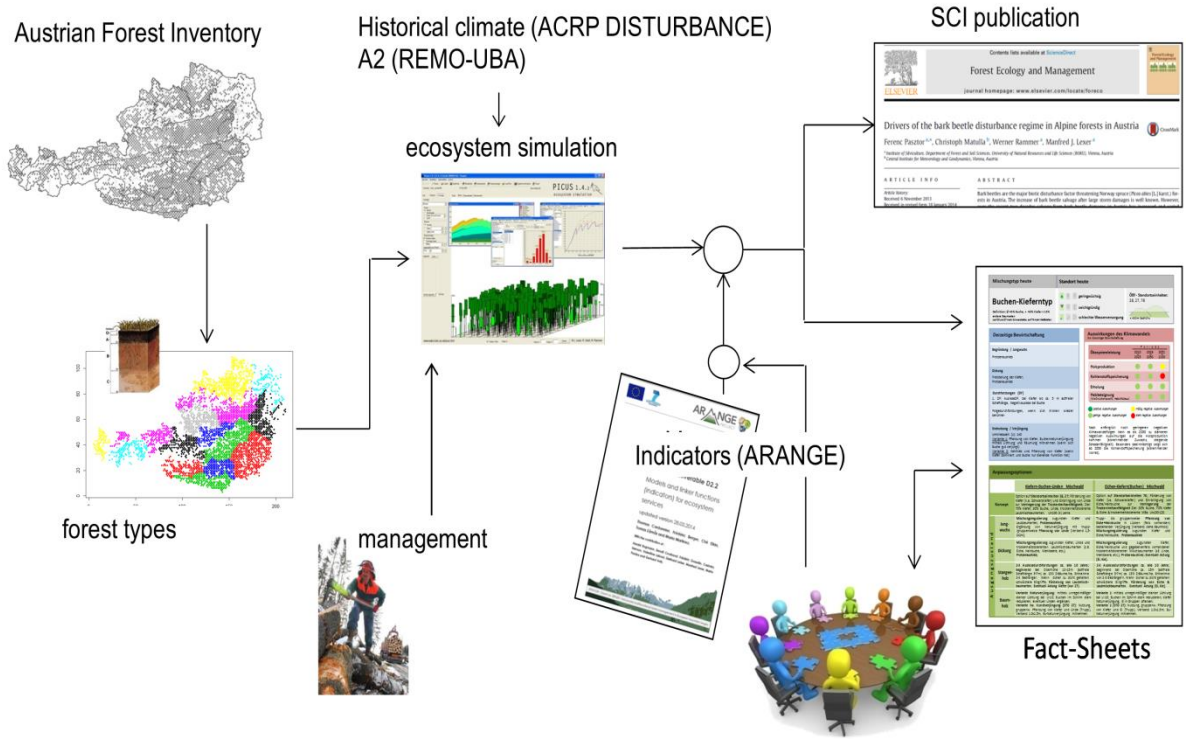

Fig. 4: ProForClim concept

Spruce, spruce-fir-beech and beech stands appear in all 15 regions and can therefore be used to compare management regimes across Austria. The simulation results produced the following trends:

(1) The standwise management approach with strip and strip-shelterwood management results in the highest variation of standing timber and stand density over time. Protective functions are dependent on permanent forest coverage, so slit and patch cut systems are better suited for permanently sustaining sufficient levels of protection.

(2) Without management, standing stock will increase considerably in most stand types, structural diversity will be lost, and stands will become homogeneous and dense. In overmature stands (140 years or more) standing stock volumes will tend to decrease again because of increasing mortality and reduced tree vigour.

(3) Under climate change conditions, damage by bark beetles will increase strongly in the second half of the century, particularly in montane spruce stands. Also in the lower subalpine zone bark beetle damage will occur in a warmer climate. Differences between management regimes are low. Important factors influencing damage are stand density, drought and suitable temperatures for bark beetle development.

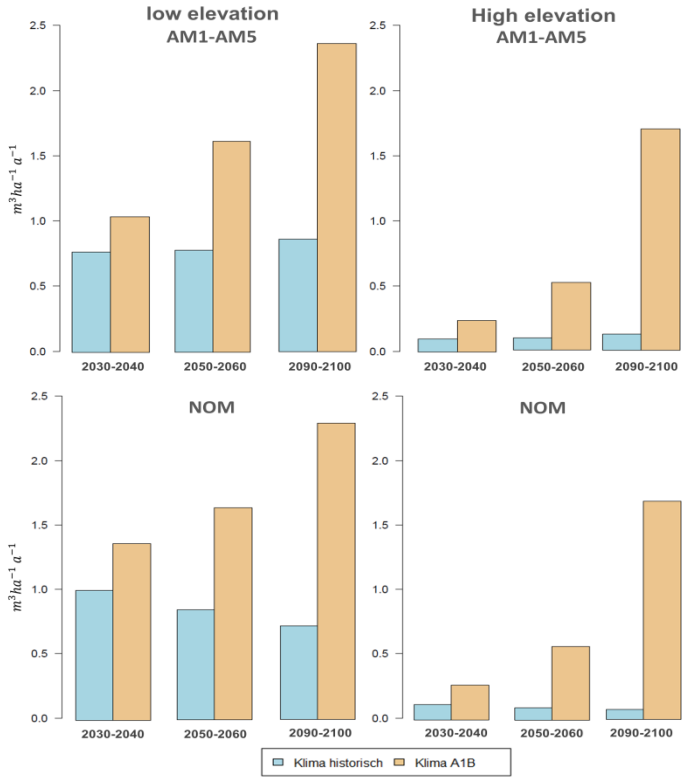

Fig. 5: Simulated bark beetle damage for low elevation (colline to mid-montane) and high elevation sites (high-montane to subalpine) under current climate and climate change conditions of scenario A1B. Includes effects of ungulate browsing. Lower plots: without management (NOM). Upper plots: average for active management scenarios (AM1-AM5)

(4) The simulation scenario without ungulate browsing showed increasing tree diversity under a warmer climate. This indicates the potential for natural regeneration of admixed tree species if browsing pressure can be controlled by regulating game populations.

(5) Protection against rock fall will depend greatly on the end rock size. Protection against smaller rocks is usually well developed, but against big rocks (>1m³) it can be ensured only by means of specialised management concepts. Key elements for rock fall protection are forest structures with sufficient numbers of large trees per hectare.

A large proportion of Austrian protective forest are dominated by spruce. This tree species is particularly vulnerable to climate change. Overall, the results confirm that under climate change conditions disturbances will be the decisive factor for ecosystem service provisioning in spruce-dominated forests. Thus the goal of any management regime should be an increase in tree species diversity and the establishment of a small-scale mosaic of different stand development phases to foster resilience of forests to disturbances. Simulation results show that harvesting regimes based on small-scale areas can maintain continuous protective functions. In forest stands starting from high-montane elevations and with good soil nutrition supply, greater management intensity could be employed to account for better growth rates under climate change and preserve stable stand structure with sufficient regeneration levels.

When considering strategies to increase the resilience of mountain forests, silver fir appears to be a suitable admixed conifer species in future climatic conditions. This species has a high potential for natural regeneration, but with high browsing pressure successful establishment is very unlikely. Simulation results showed that fir does not benefit from specialised small-scale protective forest management strategies where regeneration processes occur continuously but with low intensity, thus increasing the exposure time of fir to browsing. However, on suitable (calcareous) sites, these regimes facilitate regeneration of beech, because this species is less vulnerable to browsing.

Direct climatic impacts on forest growth are usually positive. Sites with low water-holding capacity may be exposed to more drought and show reduced growth. Great emphasis should placed on reducing browsing pressure and additional protective measurements, or artificial regeneration should be considered to ensure regeneration of drought-tolerant tree species.

If direct management activities were abandoned, protective functionality could be maintained in the short and medium term but would lead to increased damage by bark beetles and slower adaptation of tree species composition to changing climatic conditions. In the long term, permanent high browsing pressure will result in lower tree species diversity and lack of regeneration in future mature and overmature stands.

Protection forest experts rated storms, bark beetles and browsing as the most important factors reducing the protective effect of forests. Management was considered important, affecting protective services negatively as well as positively. There is thus a demand for forestry expertise on the management of protection forests for both practitioners on site and for policymakers to enable them to design science-based target-oriented guidelines for management subsidies.

6 StartClim2015.E: Risk assessments for selected protection forest types of the Eastern Alps (Austria and Southern Tyrol) with reference to the disturbance regimes storm/snow damage/drought - bark beetle– forest fire and climate change

Almost one fifth of the forests in Austria are protective forests, i.e. forests that protect settlement areas from natural hazards and other harmful environmental influences. Forest cover and soil of these forests have to be managed in a specific manner in order to maintain the protective function. The “services” of protective forests are increasingly endangered by the incidence of abiotic disturbances (e.g. extreme weather events) and biotic ones (e.g. bark beetle outbreaks). In Austria, storm damage, snow breakage and bark beetle infestation are the most important disturbing agents in spruce-dominated forests for timber production. Protective forests are frequently located in inaccessible, unexplored sites and show a higher tree species diversity than commercial forests. Climate change is expected to cause a higher risk of bark beetle infestation for tree species like larch and pine, which have been less affected by bark beetles in the past.

The aim of this project was to assess the present and future risk of abiotic and biotic disturbance in different protective forest types in selected regions (Northern Limestone Alps, eastern Tyrol, and South Tyrol). Specific bark beetle species are associated with the different protective forest types. Risk assessments were carried out not only for the spruce bark beetle, *Ips typographus*, which is the most important bark beetle species in spruce forests, but also for the small spruce bark beetle (*Ips amitinus*) on Norway spruce and stone pine, and the large larch bark beetle, *Ips cembrae*, and sharp-toothed bark beetle, *Ips acuminatus*, on pine trees.

Hazards were estimated using models taking account of future climatic conditions. The models were compiled to describe the predominantly temperature-dependent development of the different bark beetle species and used to estimate both the temporal progression and the spatial distribution of the onset of swarming and infestation in spring and the number of successful generations per year. The number of generations in particular is an important indicator of the site-specific hazards of bark beetle infestation.

Site- and stand-specific susceptibility to storm damage, snow breakage and bark beetle infestation were assessed using specific indicators. These indicators were weighted according to their relative importance for the different disturbing agents to assess the susceptibility and hence to estimate specific hazard classes.

The results of different regional climate models were used to model bark beetle development and compute site-related susceptibility. Depending on the underlying scenarios (A1B, A2, RCP 8.5), the projected temperature changes were quite different but consistently high for the different study regions and the considered future time periods.

The developmental modelling of the different bark beetle species showed that the number of generations will increase with the projected temperature change for all the regions and for all bark beetle species. At the end of the century, the spruce bark beetle will frequently establish three generations in the lowlands and up to two generations in the high montane/subalpine zone. Areas of higher elevations that do not presently support the development of the spruce bark beetle will almost disappear.

The large larch bark beetle, *Ips cembrae*, which is so far a serious pest only in secondary plantations in warmer lowlands, could have a higher impact in the high mountains as a result of increasing temperatures and associated faster development.

The small spruce bark beetle, *Ips amitinus*, is better adapted to cool conditions in the highlands than *Ips typographus*. With the faster development of *Ips typographus* under warmer conditions in the high elevation zone in the future, *Ips amitinus* could become less important at such sites compared with *Ips typographus*. However, infestations by *Ips amitinus* (and also other pine bark beetles) in stone pine forests could occur more frequently as a consequence of climate change and faster development of the beetles.

Ips acuminatus already possesses high reproductive potential under current climatic conditions (frequently up to three generations in the lowlands and dual generation development in montane sites). Its impact on the complex die-off of pine forests in dry inner alpine valleys could increase in future. In particular, more frequent drought events during the summer months as a result of increasing temperatures and subsequent stress to the host trees, combined with range expansion and widespread epidemics of the pine processionary moth in the Venosta Valley, could increase the susceptibility of the protective pine forests to pine bark beetle damage.

All this shows that the incidence of bark beetle epidemics could increase, especially in high elevation sites. In the future, spruce-dominated forests at higher elevation could have the same high risks of bark beetle outbreaks as spruce forests in the lowlands and the lower montane region nowadays. Model results indicate that reduced precipitation will have a strong impact only by the end of the century. But increased reproductive potential and more favourable swarming conditions as a consequence of temperature change will facilitate rapid changes in bark beetle population densities much earlier after drought or other extreme weather events, so that bark beetle populations will more frequently exceed critical thresholds for successful infestation of standing, living trees.

Improved growth of mountain forests under climate change could create forest stands at high elevation whose structure and composition are prone to disturbances by storms and snow damage. Ultimately, this could contribute to excessive, long-term bark beetle outbreaks in coniferous mountain forests.

The derived risk profiles and interactions between the different bark beetle species, abiotic disturbances and subsequent hazards could be used for the development of appropriate adaptations and preventive mitigation strategies for the management of alpine protective forests. Specific hazard assessments and adapted monitoring methods are essential for the optimisation of protective mountain forest management. The modelling of the potential bark beetle development, daily monitoring procedures and susceptibility assessment based on local weather conditions could make a very valuable contribution in this regard.

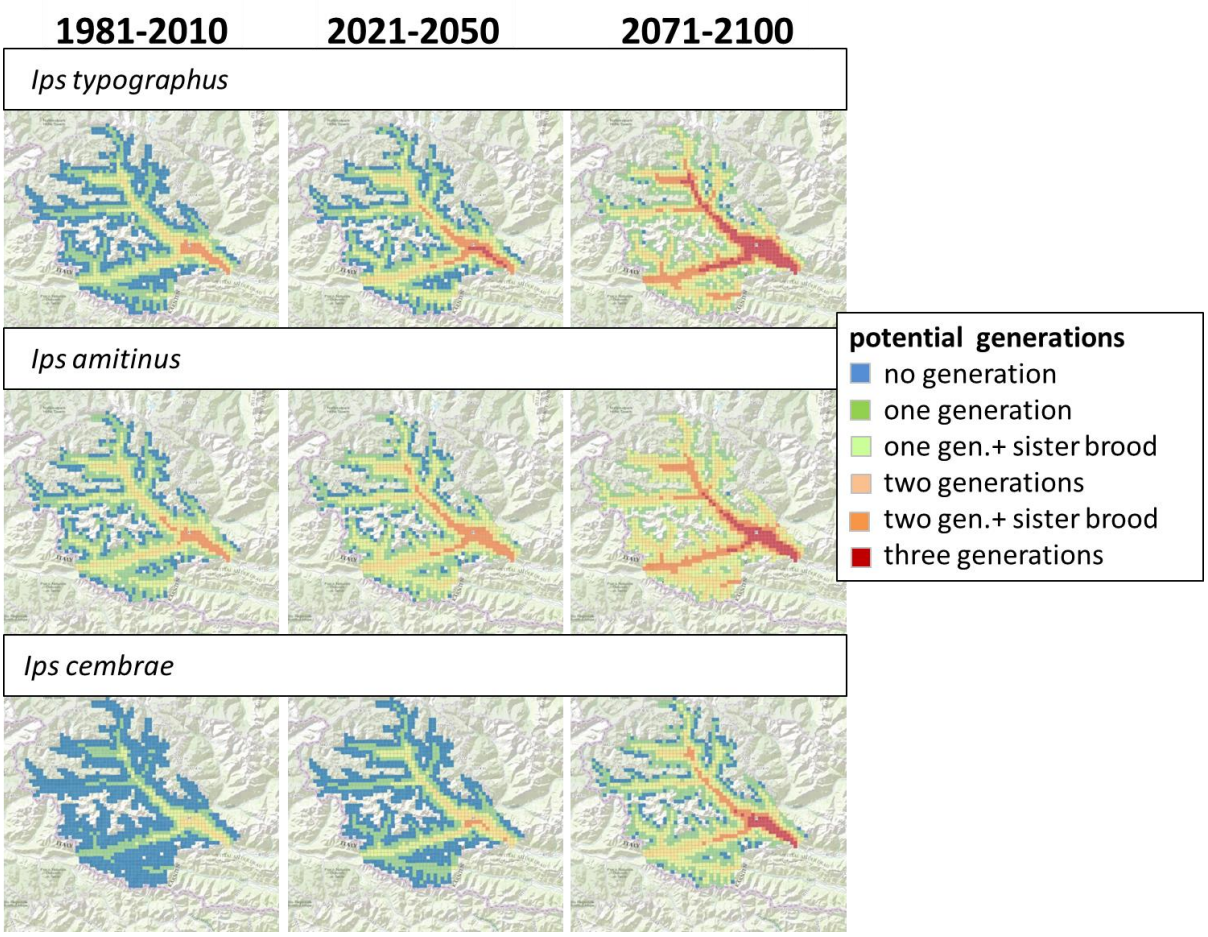

Fig. 6: Number of potential generations for the spruce bark beetle (*Ips typographus*), the small spruce bark beetle (*Ips amitinus*), and the large larch bark beetle (*Ips cembrae*) at forest sites in eastern Tyrol under present and future climatic conditions. Presently unsuitable sites for the insects (blue = no generation) will support up to two generations plus sister brood by the middle and especially at the end of the century

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8 List of Figures

Annex

The following projects were part of StartClim2003 to StartClim2013. All reports can be found on the StartClim2014 CD-ROM or downloaded from the StartClim webpage (www.startclim.at).

Contributions to 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

Centre 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

Contributions to 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: Continuation and further development of the MEDEA event database

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

Contributions to 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 Institute 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

Contributions to 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

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
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

Contributions to 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

Contributions to StartClim2009

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: Gerhard Karl Lieb, Katharina Kern, Gernot Seier, Andreas Kellerer-Pirklbauer-Eulenstein, Ulrich Strasser

Contributions to StartClim2010

StartClim2010.A: Fields of action and responsible actors for climate change adaptation of public parks in cities
Institute of Landscape Development, Recreation and Conservation Planning (ILEN), BOKU: Stephanie Drlik, Andreas Muhar
StartClim2010.B: Recommendations for an adaptation of urban open and green spaces in Austrian cities and city regions
PlanSinn GmbH, Office for Planning and Communication: Erik Meinharter
Federal Environment Agency: Maria Balas
StartClim2010.C: The social costs of adaptation: approaches to an evaluation of adaptation options (SALDO)
Wegener Center for Climate and Global Change, University Graz: Birgit Bednar-Friedl, Olivia Koland, Janine Raab
Federal Environment Agency: Martin König
StartClim2010.D: Integrated precautionary and adaptation measures for the Marchfeld region

Institute for Sustainable Economic Development, BOKU: Christine Heumesser, Mathias Kirchner, Erwin Schmid, Franziska Strauss

StartClim2010.E: Ecological and silvicultural characteristics of European larch (Larix decidua Mill.) – consequences for forest management in Austria in consideration of climate change

Institute of Silviculture, BOKU: Eduard Hochbichler, Gabriele Wolfslehner, Roland Koeck, F. Arbeiter

Federal Research and Training Centre for Forests, Natural Hazards and Landscape: Herfried Steiner, Georg Frank

Institute of Meteorology, BOKU: Herbert Formayer

Startclim2010.F: Hot town, summer in the city – effects of hot days on recreational and leisure behaviour and sightseeing programmes of city tourists as exemplified by the case of Vienna

Institute of Landscape Development, Recreation and Conservation Planning (ILEN), BOKU: Christiane Brandenburg, Brigitte Allex, Ursula Liebl, Christina Czachs

Institute of Meteorology, BOKU: Thomas Gerersdorfer

StartClim2010.G: Knowledge-based platform to optimise operations strategies in handling natural hazards

Austrian Red Cross: Jürgen Högl, Clemens Liehr, Gerry Foitik

Institute of Production and Logistics, BOKU: Manfred Gronalt, Magdalena Schweiger, Patrick Hirsch

Contributions to StartClim2011

StartCim2011.A: Climatic influence on voltinism and spread of the spruce bark beetle, Ips typographus, in alpine areas

Institute of Forest Entomology, Forest Pathology & Forest Protection, BOKU: Axel Schopf, Emma Blackwell, Veronika Wimmer

StartClim2011.B: Analyzing Austria's forest disturbance regime as basis for the development of climate change adaptation strategies

Institute of Silviculture, BOKU: Rupert Seidl, Dominik Thom

Institute of Forest Protection, Federal Research and Training Center for Forests, Natural Hazards, and Landscape (BFW): Hannes Krehan, Gottfried Steyrer

StartClim2011.C: Effects of soil drying on the transpiration of Austrian tree species

University of Innsbruck: Georg Wohlfahrt, Stefan Mayr, Christoph Irschick, Sabrina Obwegeser, Petra Schattanek, Teresa Weber, Dorian Hammerl, Regina Penz

StartClim2011.D: Adapting Austrian forestry to climate change: Assessing the drought tolerance of Austria's autochthonous tree species

Institute of Botany, BOKU: Gerhard Karrer, Gabriele Bassler

Institute of Forest Ecology, BOKU: Helmut Schume, Bradley Matthews

Vienna Institute for Nature Conservation and Analyis, V.I.N.C.A: Wolfgang Willner

Contributions to StartClim2012

StartClim2012.A: Cover crops as a source or sink of soil greenhouse gas emissions?

Division of Agronomy, Department of Crop Sciences, BOKU: Gernot Bodner, Andreas Klik, Sophie Zechmeister-Boltenstern

StartClim2012.B: Effects of climate change on soil functions: metadata analysis

Federal Research and Training Centre for Forests, Natural Hazards, and Landscape (BFW): Michael Englisch, Barbara Kitzler, Kerstin Michel, Michael Tatzber

Federal Agency for Water Management, Institute for Land & Water Management Research (BAW-IKT): Thomas Bauer, Peter Strauss

Austrian Agency for Health and Food Safety (AGES): Andreas Baumgarten, Hans-Peter Haslmayr

Federal Environment Agency: Alexandra Freudenschuß

StartClim2012.C: Disturbance of forest stands and humus loss

Institute of Forest Ecology, BOKU: Douglas Godbold, Mathias Mayer, Boris Rewald

StartClim2012.D: To count with and on wood: adaptations of tools and data (German: Holz BZR)

Kompetenzzentrum Holz GmbH: Tobias Stern, Franziska Hesser, Georg Winner, Sebastian Koch

Institute of Marketing and Innovation, BOKU: Leyla Jazayeri-Thomas, Verena Aspalter, Martin Braun, Wolfgang Huber, Peter Schwarzbauer

Institute of Wood Science and Technology, BOKU: Robert Stingl, Marie Louise Zukal, Alfred Teischinger

Federal Environment Agency: Peter Weiss, Alexandra Freudenschuß

StartClim2012.E: Snow line climatology within the Alpine region, derived from re-analysis data

Institute of Meteorology, BOKU: Herbert Formayer, Imran Nadeem

StartClim2012.F: Values as performance indicators: a path towards a proactive climate protection

Centre for Global Change and Sustainability, BOKU: Maria Miguel Ribeiro, Julia Buchebner

Contributions to StartClim2013

StartClim2013.A: Thermal stress for brown trout in the headwaters of the river Traun during summer

Harald Ficker, M.Sc.

StartClim2013.B: Loss of floodplains and flood risk in the context of climate change

Institute of Water Management, Hydrology and Hydraulic Engineering, BOKU: Helmut Habersack, Bernhard Schober, Daniel Haspel

StartClim2013.C: Runoff scenarios in the Ötztal valley (Tyrol, Austria) considering changes to the cryosphere as a result of climate change

alpS GmbH: Matthias Huttenlau, Katrin Schneider, Kay Helfricht, Klaus Schneeberger

Institute of Meteorology, BOKU: Herbert Formayer

StartClim2013.D: Recommendations for changes to regional development and spatial planning in areas of high flood risk

PlanSinn GmbH - Office for Planning & Communication: Bettina Dreiseitl-Wanschura, Erik Meinharter, Annemarie Sulzberger

Rambøll Group: Herbert Dreiseitl

Federal Environment Agency GmbH: Theresa Stickler, Jochen Bürgel

StartClim2013.E: How and where will Austrian river systems respond to climate change? An interdisciplinary analysis of fish fauna and nutrients

Institute of Hydrobiology and Aquatic Ecosystem Management, BOKU: Thomas Hein, Andreas Melcher, Florian Pletterbauer

Department of Integrative Zoology, University of Vienna: Irene Zweimüller

StartClim2013.F: GIAClim – Gender Impact Assessment in the context of climate change adaptation and natural hazards

Institute of Landscape Planning, BOKU: Doris Damyanovic, Florian Reinwald, Britta Fuchs, Eva Maria Pircher

Institute of Landscape Development, Recreation and Conservation Planning, BOKU: Christiane Brandenburg, Brigitte Allex

Institute of Mountain Risk Engineering, BOKU: Johannes Hübl, Julia Eisl

StartClim2013.G: Validation of the applicability of the SIMAGRIO-W wireworm prognosis model, based on soil temperature and moisture measurements, in Eastern Austrian agriculture

Bio Forschung Austria: Patrick Hann, Katharina Wechselberger, Rudi Schmid, Claus Trska, Birgit Putz, Markus Diethart, Bernhard Kromp

Zentralstelle der Länder für EDV-gestützte Entscheidungshilfen und Programme im Pflanzenschutz (ZEPP): Jeanette Jung
Institute of Meteorology, BOKU: Josef Eitzinger

Contributions to StartClim2014

StartClim2014.A **SNORRE - Screening of remarkable weather**
Zentralanstalt für Meteorologie und Geodynamik (ZAMG): Christoph Matulla, Brigitta Hollosi
Federal Environment Agency: Maria Balas

StartClim2014.B: **Developing a method for assessing climate change effects on productivity and animal welfare as well as adaptation potential of livestock husbandry**
Institute of Livestock Sciences, BOKU: Stefan Hörtenhuber, Werner Zollitsch

StartClim2014.C: **Effects of ambient temperature on performance and health traits in dairy cattle when considering husbandry factors**
Institute of Livestock Sciences, BOKU: Birgit Fürst-Waltl, Verena Auer
ZuchtData EDV-Dienstleistungen GmbH: Christa Egger-Danner, Franz Steininger
Institute of Meteorology, BOKU: Herbert Formayer, David Leidinger
Höhere Bundeslehr- und Forschungsanstalt für Landwirtschaft Raumberg-Gumpenstein: Elfriede Ofner-Schröck, Eduard Zentner
LKV Austria: Karl Zottl

StartClim2014.D: **On the importance of climate change for nutrition and diseases of alpine game**
Gesellschaft für Wildtier und Lebensraum (GWL): Armin Deutz, Gunther Greßmann
Höhere Bundeslehr- und Forschungsanstalt für Landwirtschaft Raumberg-Gumpenstein: Thomas Guggenberger, Albin Blaschka

StartClim2014.E: **Weather-independent tourism offers based on Nature experience offers - relevance and innovative development options**
Institute of Landscape Development, Recreation and Conservation Planning, BOKU: Ulrike Pröbstl-Haider, Verena Melzer

StartClim2014.F: **permAT – Long-term monitoring of permafrost and periglacial processes and its role for natural hazard prevention: Possible strategies for Austria**
Department of Geography and Regional Science, University of Graz: Andreas Kellerer-Pirklbauer, Christoph Gitschthaler, Michael Avian
Zentralanstalt für Meteorologie und Geodynamik (ZAMG): Annett Bartsch, Stefan Reisenhofer, Gernot Weyss, Claudia Riedl