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Climate impact research in Berchtesgaden National Park
Reflections on a workshop held on 18 and 19 February 2010

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Abstract

Climate impact research in Berchtesgaden National Park (NP) complies with the provisions of its management plan and is supported by a wide range of scientists working for several institutes in Germany, Austria and Switzerland. To promote the exchange of project ideas in the shared study area and discover synergy effects, the park administration initiated a two day workshop in Berchtesgaden. The main topics covered climate impacts on the water balance and snow cover dynamics, species composition and spatial distribution of alpine ecosystems as well as climate adaptation strategies. Workshop results were given an expert assessment by the recently retired director of the Max Plank Institute of Meteorology, Hartmut Graßl.

Profile

National Park

Berchtesgaden National Park

Mountain range

Alps

Country

Germany

Background and objectives

In many parts of Berchtesgaden NP, natural dynamics are allowed to evolve freely. The park administration is obliged to observe long-term environmental conditions and their changes as caused, for example, by climate impact. However, the main challenge for investigating climate impact on ecosystems is the spatial and temporal distribution of meteorological input data. Great efforts were put into establishing a dense climate station network within the park area. For 20 years, Berchtesgaden NP and the German Meteorological Service have been maintaining mechanical and automatic stations at different altitudes and are able to provide long-time series of climate parameters. Moreover, in cooperation with Research Studio iSPACE, Salzburg, Berchtesgaden NP is developing standardized inquiries of station data with real time realization of the interpolated data on the internet.

Due to a comprehensive database – including botanical and zoological topics as well as aerial images and derived land-use data – and low human impact, documented environmental changes can serve as reference data for climate impacts.

The research department of the park coordinates the projects, provides input data and logistics and in return receives results to enlarge the local information systems. The main objective of the workshop was to bring together the community of external scientists focusing on climate issues in Berchtesgaden NP and to exchange current ideas. Contributions by park staff were scheduled to give detailed insight into the scientific background work and information system maintenance. Finally, the workshop should receive an expert assessment by Prof. Hartmut Graßl.

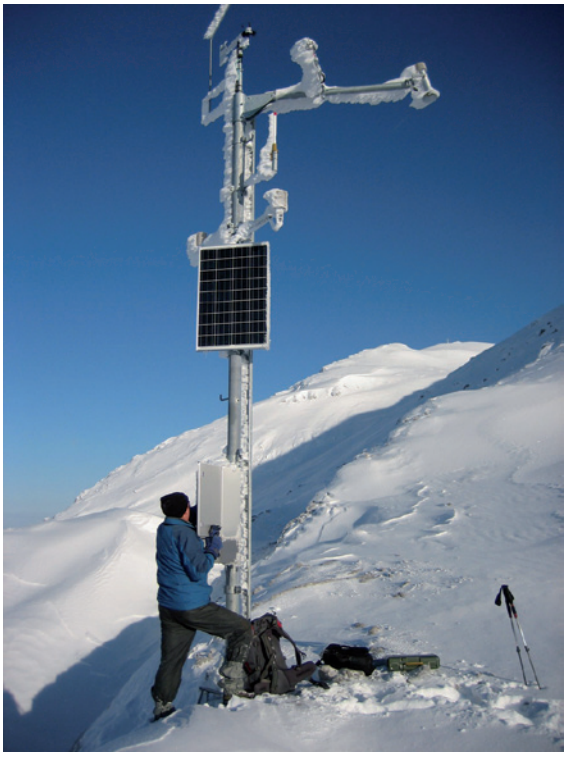
Berchtesgaden National Park. © NPV Berchtesgaden

Overview of current projects in Berchtesgaden NP

Impacts on water balance and snow cover dynamics

Modelling the water balance[1]

The water balance in Alpine regions is characterized by a strong variability of meteorological parameters in time and space, complex hydrogeological conditions and a heterogeneous snow cover. The deterministic spatially distributed hydrological model WaSiM-ETH is implemented in Berchtesgaden NP to analyse the Alpine water balance on a regional scale. To enhance the reproduction of snow deposition and ablation processes, the original WaSiM-ETH has been extend-



Berchtesgaden NP in winter. © NPV Berchtesgaden

ed by principles of the specific snow model AMUNDSEN. The deterministic approach allows describing the groundwater movement and storage in Alpine catchments on different scales. Analyses of comprehensive tracer experiments and of a regional spring database are supportive field data. The new model system will be forced with scenario data of a regional climate model to assess possible climate impacts on the regional water balance.

Permafrost in Bavaria – first results of PermaNET-BY[2]

Frozen subsurface water which occurs in a soil or rock layer with long-time temperature values below 0°C is important for rock stability in Alpine regions. Climate impact is assumed to be the main cause of melting for this so-called permafrost. PermaNet-BY will examine and model permafrost occurrence within the Alps and in special study sites. In Berchtesgaden NP, seven logger and 15 iButtons were put into steep and shaded rock terrain at three sites. The project also aims to predict how permafrost occurrence may change in size and distribution with future climate conditions. Field work will take place in 2010 and 2011. After data validation, a permafrost map of Bavaria including the special study site Berchtesgaden NP will be created.

Geophysical investigation of glaciers and perennial ice fields[3]

In Berchtesgaden NP, two glaciers (Watzmann and Blaueis) and one perennial ice field (Eiskapelle) are situated below the climatic snow line. The project aimed to identify the reasons for their persistence as well as mass decrease or increase. Methods of investigation were tachymetry, kinematic GPS and ground penetrating radar. Results show that shading effects and avalanche snow accumulation are the main causes for the existence of ice in Berchtesgaden NP. The annual mass exchange of the Eiskapelle is lower than the mass exchange of the glaciers. It mainly depends on winter accumulation and is therefore more persistent. The glaciers, however, may not outlast longer warmer periods.

The outcome of GLOWA-Danube[4]

GLOWA-Danube investigates the impact of changes in climate, population and land use on the Upper Danube water resources. In addition, it develops and evaluates regional adaptation strategies. Applied methods are scientific modelling, data preparation and stakeholder interviews. Berchtesgaden NP is considered a "super test site" of the GLOWA-Danube. Scenarios for the Berchtesgaden NP area indicate that snow and ice melt may decrease in future and influence discharge regimes in the lowlands.

Impacts on the species composition of alpine ecosystems

Bark beetle and climate change: hypothesis and certainties[5]

Due to historical forest cultivation, the dominant tree species in today's Berchtesgaden NP management zone is spruce. Spruce monocultures, in particular if harmed by storm events, facilitate bark beetle invasions. Measures to re-establish natural mixed mountain forests have been taken ever since the park was first established. Due to its ecological demands, the bark beetle will profit from the effects of climate change: extreme weather events increase the risk for bark beetle damages in forest ecosystems, especially spruce monocultures. The bark beetle may appear earlier after the winter and the number of bark beetle generations will increase in warm years. Warmer late summers promote maturation grub and therefore decrease winter mortality of the population. Forest ecosystems under drought stress are more difficult to locate than storm-damaged timber and thus present a greater management challenge.

Alpine vegetation and climate change[6]

Two research initiatives in Berchtesgaden NP investigated climate impacts on alpine vegetation. In the first one, the effect of temperature rise on alpine calcareous grassland was studied. Species compositions of 48 reference sites were compared with 1988 census data. In addition, 32 open-top chambers causing an artificial temperature increase were installed. Species composition of manipulated sites was compared with reference sites. The approach shows that plant individuals experience more fitness due to temperature rise, leading to population growth and higher species

numbers. These plant population shifts are observable in Berchtesgaden NP as well as in other alpine regions. Secondly, Berchtesgaden NP is part of the worldwide GLORIA network of long-term field observation sites at mountain summits. The project aims to identify climate-induced vegetation changes and biodiversity shifts in alpine ecosystems.

Springs as indicators of climate change[7]

Springs are locations of groundwater exfiltration and represent unique ecosystems. To examine these habitats and to determine possible climate impacts, a long-term monitoring project was implemented sixteen years ago. Investigation parameters are location, altitude, discharge rates and dynamics, chemical, physical and structural parameters as well as flora and fauna. Several endemic species have been described. To date there is no evidence for climate impact at Berchtesgaden NP spring sites, however, historical reference data are not available. Emerging spring species might be more able to adapt to changing conditions, thus non-emerging species are potentially more endangered by climate change.

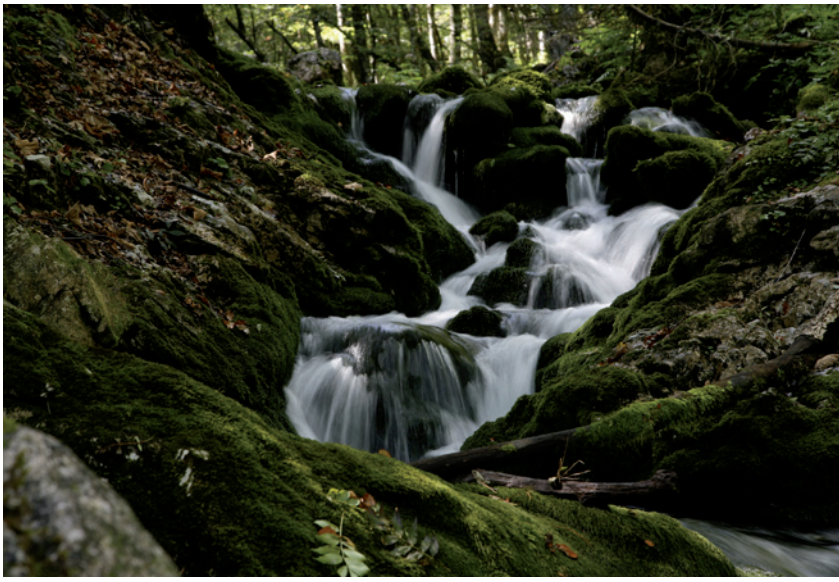
The tree ring project[8]

Tree rings are an ecological indicator for tree growth. Reactions to climate conditions are species-dependent. Fir and beech tree rings mainly reflect late frost periods whereas spruce is drought-sensitive. Dendroecological sampling took place in Berchtesgaden NP in 2009 and again in 2010, with a focus on spruce, fir and beech. In four altitudinal zones, ten tree cores are collected per species at four characteristic sites. Key questions to be answered are: which changes in mountain forests may occur due to climate change? Are there species-dependent changes? Which species may profit from temperature increase, which species may experience a loss in fitness? Is there a trend in location and altitude? How may extreme events affect mountain forests? Which adaptations are necessary?

Impacts on the spatial distribution of alpine ecosystems and climate adaptation strategies (FORKAST projects)

Ecological impacts of climate-induced phenological changes on the Bavarian vegetation[9]

Phenology regulates ecological services like competition, growth, biodiversity and pollination. Historical data indicate earlier vegetation periods and longer flowering seasons. Their analysis, together with manipulative experiments, will show how extreme weather events and climate change influence plant phenology and dependent interactions between organisms. The different reactions of species (e.g. to late frost or pest insects) should allow for species-directed management strategies. In Berchtesgaden NP, phenological records date back to 1994 and are used as supportive data source. In addition, two vertical transects were observed in 2009 and again in 2010 regarding date and duration of the flowering period, its micro-stages and the changes under manipulated conditions.



Karst spring in Berchtesgaden NP. © NPV Berchtesgaden

Endangerment of plant-pollinator networks by climate change and extreme weather events[10]

Interaction between flowering plants and pollinators is extremely important in economic and ecologic respect. Plant-pollinator networks (PPN) might be particularly threatened by climate change since they contain mutually dependent species differing in their responses to projected climatic changes. Of particular concern is the danger of desynchronization of plant flowering and insect activity periods. A deeper understanding of PPNs will allow for strategies to prevent species loss and to preserve the essential ecosystem functions provided by PPNs. A combination of data sources (field data collected along an alpine elevation gradient in Berchtesgaden NP, statistical analysis of existing datasets, related FORKAST projects) will be used to parameterize forecasting models that will help to estimate the consequences of climatic trends and extreme events for PPN stability and to identify threatened species.

Effects of climate change on the timberline and the vegetation of the alpine belt[11]

This project focuses on the analysis of mechanisms behind the present distribution of alpine species along an altitudinal gradient and the current and future climate-related shifts in the calcareous grassland vegetation of the subalpine and alpine levels. This is done by functional and historical analysis of vegetation dynamics. Historical analysis includes the history of land use, past climate changes, glaciations and changes in the timberline. Functional analysis examines traits of plants related to the environment e.g. reproduction rate, generation time and dispersal potential. The vul-

*Black-veined white (*Aporia crataegi*) in Berchtesgaden NP. © Annette Leingärtner*

nerability of species of the alpine grassland communities may be predicted using simple models and a risk assessment implemented. In the study area, 32 plots are spread over an altitudinal gradient from 630 to 2 245 m.

Combined effects of climate change, extreme events and habitat fragmentation on diurnal butterflies and trophic interactions[12]

The long-term survival of animal populations and their adaptability to changing climate conditions highly depends on trophic interactions and genetic diversity. Focusing on diurnal butterflies, this project analyses the combined effects of climate change, habitat fragmentation and extreme events. Differently fragmented grassland habitats along a climate gradient serve as study sites in Berchtesgaden NP. The analysis will also cover the risk of extinction, the impact on population dynamics and trophic plant-herbivore-antagonist interactions, the adaptability of animal populations with different genetic diversity as well as the temporal variance in biodiversity, dispersal and genetic diversity of diurnal butterfly populations. Based on the findings, the project intends to develop adaptation and protection strategies.

Conclusions and outlook

Berchtesgaden NP is characterized by high altitudinal gradients, ridges and plateaus in close proximity and heterogeneous climate conditions. As climate changes are assumed to occur earlier and more intensely in alpine regions than in lowlands, Prof. Hartmut Graßl regards climate impact research in Berchtesgaden NP as mandatory and comments on the current results:
In general, all climate models predict reduced summer precipitation. Water balance models are an accepted tool within climate impact research, but algorithms still need to be improved. Berchtesgaden NP glaciers will disappear even if the climate remains stable.

Species composition and population development of alpine pastures show effects of global warming. Berchtesgaden NP spring research is unique. Bark beetles seem to profit more from water scarcity than from windfalls. Storm damages of spruce are increasing even with moderate wind forces as the species is weakened by the rise in temperature.
As regards future Berchtesgaden NP activities, Prof. Hartmut Graßl suggested that ornithological data should receive more attention and a permanent cross-check with climate data. Drift of climate sensors should be verified regularly to derive correct correlations. Future-oriented research requires a stronger integration of specialists into a more comprehensive transdisciplinary knowledge system. Research areas should extend into both national park and peripheral zone. Climate policies should support species migration and ecological corridors (cf. http://www.econnectproject.eu) to enable adaptations to changing conditions. Permanent research funding has to be ensured, preferably by national and international funds exclusively reserved for protected areas.

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[6] **Thomas Kudernatsch**, Specific field Geobotany, Technical University of Munich, Center of Life and Food Sciences Weihenstephan
[7] **Reinhard Gerecke**, Chair of Systematic Zoology, University of Tübingen
[8] **Christof Dittmar, Andreas Rothe**
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[9] **Christine Cornelius, Annette Menzel**
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