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**UNIVERSITÄT
BERN**

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

THE OESCHGER CENTRE

for Climate and
Climate Change Research



GLOBAL AND REGIONAL CLIMATE DYNAMICS

CLIMATE RISKS AND NATURAL HAZARDS

ECONOMIC AND SOCIAL CONSEQUENCES OF CLIMATE CHANGE

HOLISTIC CLIMATE RESEARCH

EDITORIAL: Climate change affects us all. As an alpine country, Switzerland is directly affected by flooding, landslides and melting glaciers. Moreover, images of hurricanes in the Caribbean and droughts in Africa increasingly reach us in our homes through the media – are these also caused by climate change? Science is not yet able to give us definitive answers to these questions.

It is understandable, then, that the University of Bern has increased its activities in the field of climate research. But this interest is not new: already in the 19th Century, pioneers sought answers to questions about climate and glacial changes as well as the sun's activity. In the 20th Century, both at our University and also internationally, physicist Hans Oeschger promoted a holistic understanding of the earth's climate system and warned of the consequences of the unchecked use of fossil fuels.

To honour his foresight, the University of Bern named its centre for climate research after him. The Oeschger Centre, founded in 2007, draws upon all relevant scientific areas, such as natural sciences, humanities, social sciences, economics and law in its challenging research programme. It includes a Graduate School and conducts public relations and outreach activities. In all these ways we try to meet the high expectations of society in relation to climate change research.

Martin Grosjean Wanner.

MARTIN GROSJEAN (left) is Professor of Geography und Director of the Oeschger Centre. **HEINZ WANNER** (right) is Professor of Climatology and Meteorology and Founding President of the Oeschger Centre.



MEASUREMENT AND OBSERVATION

Whether climate researchers are interested in processes in the atmosphere or in changes in biodiversity, measurement and observation are often at the centre of their work. At the Oeschger Centre, this includes determining the water vapour content in the atmosphere. An exact measurement is obtained for this important greenhouse gas using microwave technology. In another area, field sites at different altitudes are observed in order to understand how grassland reacts to droughts which will increase in Switzerland in future. Measuring technology and analysis methods used for this work are in many cases developed at the University of Bern, for example, the continuous flow analysis used for polar ice cores by climate scientist Daiana Leuenberger. She is participating in an international project in northern Greenland in which an ice core is being drilled in order to obtain climate information from the past 150 000 years. The data stored in the ice core will be deciphered at the Oeschger Centre. Daiana Leuenberger's work focuses on aerosols. Her aim is to reconstruct past aerosol concentration in the northern hemisphere to an as yet never achieved degree of temporal resolution. Of special interest is the frequency of volcanic eruptions. Such eruptions release large amounts of ash particles and gases into the atmosphere, which reflect solar energy back into space – a process which is one of the important natural causes of climate change.

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DAIANA LEUENBERGER is a doctoral student at the University of Bern: "I'm thrilled by the use of sophisticated analysis methods and am very motivated by the fact that I am contributing to a better understanding of the climate system."
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COOPERATION

Successful climate research is only possible in international networks. The Oeschger Centre is a hub in the international network of leading research institutes and works with researchers worldwide. Members of the Oeschger Centre have a high status in the research community and perform important national and international functions. For example, the climate and environmental physicist Thomas Stocker, who holds one of the top posts in the Intergovernmental Panel on Climate Change (IPCC) and, together with a Chinese colleague, leads the IPCC working group "The Physical Science Basis". Thomas Stocker and his team coordinate the work of hundreds of international experts, who, as IPCC authors, evaluate worldwide knowledge on climate change in order to summarise it in a report. As a researcher, Thomas Stocker is active in two areas in particular: the development of simplified climate models and the reconstruction of the climate of the past. Together with his team, he proved by analysing ice cores from Antarctica that the concentration of the most important greenhouse gases has never in the past 800 000 years been as high as it is today.

The Oeschger Centre works closely with a number of different organisations (see "Bern – a climate centre" on p.15).

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THOMAS STOCKER is Professor of Climate and Environmental Physics at the University of Bern: "What fascinates me is that by combining experiments with classical physics, it is possible to reconstruct where the climate has been and estimate where it is going."
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PAST CLIMATE

Predicting the climate of the future presupposes knowledge of the climate of the past. To this end, researchers at the Oeschger Centre study natural climate archives such as ice, lake sediments and tree rings. They also analyse historical records on weather events. Or, like geologist Dominik Fleitmann, they use stalagmites to reconstruct climate over thousands of years. Compared to other climate archives, these have the advantage that climate information stored in the layers of carbonate can be dated very precisely. Stalagmites which Dominik Fleitmann has brought back from caves in Turkey and Oman are sawn open in the laboratory and bombarded with a laser beam in a process called laser ablation. As water trapped in the fine pores of the stone evaporates, the temperature can be reconstructed. Dominik Fleitmann has a specific interest in doing climate reconstruction: he is attempting to understand the interplay between climate changes in the North Atlantic and the strength of the monsoon which sweeps over the tropics each year. The living conditions of a large part of the world's population depend largely on how the monsoon will react to the global warming of the future.

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DOMINIK FLEITMANN is Professor of Geology at the University of Bern: "I became a geologist and climate researcher because this profession is so incredibly fascinating, challenging and diverse."
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PROMOTION OF YOUNG TALENT

At the Oeschger Centre, education is one of our main priorities. The Graduate School of Climate Sciences offers a Master's and a Doctoral programme in which future climate researchers and specialists are trained to work on climate change issues in business and administration. For example, Patrizia Imhof, who holds a BA in Geography from the University of Fribourg and chose the MSc in Climate Sciences in Bern due to its broad course content. Lecture topics range from atmosphere and plant sciences to climate economics and international environmental law. Patrizia Imhof has attended lectures in geography, physics, geology, biology and statistics. She is currently writing her master's dissertation on the historic reconstruction of glacial variations on the south side of Mont Blanc. For this, Patrizia Imhof mapped moraines in Italy, combining the data with an analysis of historic paintings and early photographic material. For the next step, Patrizia Imhof wants to investigate the climatological reasons for the growth and shrinkage of glaciers. To accomplish this she is analysing data on precipitation and temperature from the uninterrupted records which monks from the Grand St Bernard pass have kept since 1818. Patrizia Imhof sees her future in private industry, for example in an environmental consultancy firm, rather than in research.

• www.climatestudies.unibe.ch

PATRIZIA IMHOF is an MSc student in Climate Sciences at the University of Bern: "I grew up near the Aletsch Glacier and already saw the glacier melting as a child. As a climate researcher, I want to understand how this has come about."

EFFECTS OF CLIMATE CHANGE

There have always been climate variations over time. Whether it be through natural causes as in the distant past or today through combination with human activity, climate change has far-reaching consequences. The Oeschger Centre investigates the effects of climate change on water supply, snow, ice, and natural hazards, but also on natural and managed ecosystems such as agriculture. Past and present contain valuable insights for the future, for example in Willy Tinner's work. He studied geography, geobotanics and archaeology and is Professor of Palaeoecology. His research group focuses on the spread of certain types of tree species and other plant communities as a reaction to climate change. Have certain species increased, decreased, or even become extinct over time? In order to find answers to these questions, Willy Tinner studies lake sediments. These contain pollen, charcoal particles and other microfossils. The analysis of these findings reveals information about the long-term interplay between climate, the biosphere and human activity. The palaeoecological data are compared to models which can simulate the dynamics of vegetation over a period of decades or even thousands of years. In this way, Willy Tinner can test hypotheses on which factors affect which type of ecosystem in the long term. This combined method of data reconstruction and computer modelling enables predictions as to how certain species of tree will react to climate change in future. For example, which trees will spread from southern to northern Europe and within what time frame?

WILLY TINNER is Professor of Geobotanics und Palaeoecology: "I worry about the effects of drastic climate change and want to understand how animals and plants react to changes in the climate in which they live."



CLIMATE CHANGE – A CHALLENGE



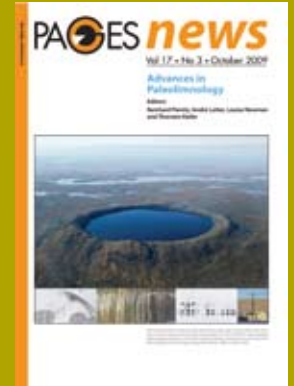
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 Hans Oeschger (1927–1998), after whom the Oeschger Centre is named, taught and researched at the University of Bern. His great achievement was to combine the methodology of modern physics with the study of the systems of planet Earth. He was one of the first to publicly draw attention to the already noticeable consequences of changes in the greenhouse effect.

The Oeschger Centre for Climate Change Research is an interdisciplinary centre at the University of Bern. It comprises two dozen research groups, is run by a management centre and led by a scientific board. All research and education follows an interdisciplinary and holistic approach, with research groups based in the faculties of science, law, economics, the social sciences and humanities. Research at the Oeschger Centre is focused on the following four areas:

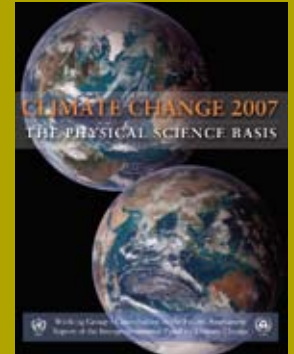
- global climate dynamics and diagnostics
- regional climate dynamics: Europe and the Alps
- climate risks and natural disasters
- economic and social dimensions of climate change

The Oeschger Centre manages the Graduate School of Climate Sciences at the University of Bern. Both Bologna-compatible courses “MSc in Climate Sciences” and “PhD in Climate Sciences” are international in outlook and allow students to specialise in a number of subject areas. The Oeschger Centre conducts public relations and outreach work and participates in dialogue with policymakers, thus contributing to forward-looking, sustainable and knowledge-based decision-making. An example is the Professorship in the Effects of Climate Change in Alpine Areas, financed by the Swiss insurance company Mobiliar.

BERN – A CLIMATE CENTRE



A number of climate research organisations which are extraordinarily well networked both nationally and internationally have chosen to be based close to the University of Bern. An important section of the Intergovernmental Panel on Climate Change (IPCC) and PAGES (Past Global Changes – an international programme of past climate research) are located next door to the management centre of the Oeschger Centre. All this makes Bern an international hub for climate research with its finger on the pulse of science. In addition, the canton of Bern is home to the High Alpine Research Station Jungfrauoch which is of great international importance as the only reference station for ground-based observations of the free troposphere. The University of Bern is the headquarters of the National Centre of Competence in Research, Climate (NCCR Climate), a research and education network of Swiss Universities, the ETH Zurich and national research institutes. Last but not least, its proximity in the Swiss capital, Bern, to the federal government, parliament and academies of sciences contributes to this unique setting for climate and climate change research.



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 Bern is a centre of international climate research, not least because of international research organisations and programmes such as IPCC and PAGES. Their publications have become reference works for the current climate debate.

LEARNING WITH AMBITION

The Master of Climate Sciences at the University of Bern offers a tailor-made programme leading to a specialisation in Climate and Earth System Science, Atmospheric Sciences, Statistics, Economics or Economic, Social and Environmental History.



The specialised "MSc in Climate Sciences" makes great demands on students, so there is a rigorous application procedure.



The Oeschger Centre provides a high-level academic education. There is a rigorous application procedure for the specialised Master's Degree "MSc in Climate Sciences" (120 ECTS). The curriculum is tailor made: students can choose from several faculties to put together their own programme. Their selection can lead to one of five specialisations. Teaching at the Oeschger Centre is international in outlook and takes place in close cooperation with the ETH Zurich. More than one-third of the students are from abroad and all courses are held in English.

The doctoral programme is strongly research-oriented and takes 3–4 years. Career choices of alumni of the Graduate School of Climate Sciences include academia, private industry (e.g. banking and insurance) or the environmental sector (government and NGOs).

- www.climatestudies.unibe.ch

PUBLIC RELATIONS AND OUTREACH



The "Jungfrau Climate Guide" offers on-the-spot scientific information in places where the consequences of climate change are already being felt, e.g. in the Jungfrau region of the Bernese Oberland.

Be it melting glaciers, heatwaves or severe flooding, public interest in climate research is significant. Researchers from the Oeschger Centre are regularly interviewed by journalists or invited to speak to decision-makers from various important sectors of society. The expertise of our climate researchers is in demand at local, regional and global levels. But the Oeschger Centre is also proactive in public relations and outreach. One example is the "Jungfrau Climate Guide". The aim of this project is to make information on climate change accessible to people in areas in which the effects are already being felt. The guide, which was developed at the Oeschger Centre, is an open-air audio guide. On seven walks in various parts of the Jungfrau region, iPhones using GPS technology give users up-to-date climate-related information.

- www.jungfrau-klimaguide.ch

GLOBAL CLIMATE DYNAMICS



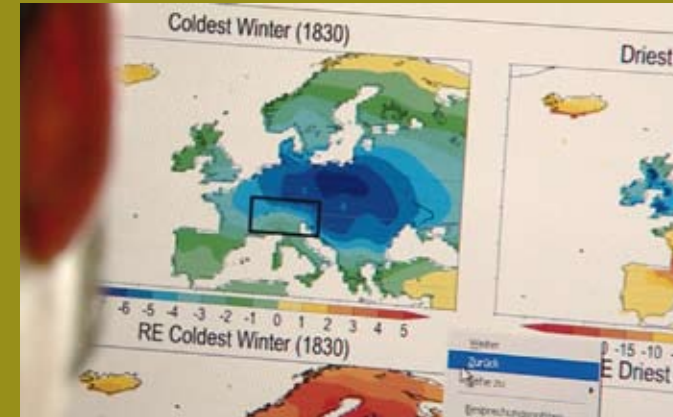
The climate has always been undergoing change. Whether in earlier times solely because of natural factors or nowadays in combination with human activity, climate change has far-reaching consequences. The Oeschger Centre is investigating the causes and effects of this change.



The aim of our first research focus is to understand how the earth's system with its three main components "atmosphere", "terrestrial ecosystems" and "oceans" reacts to natural and anthropogenic disturbances. Only by understanding these processes can quantitative predictions be made for the future, the causes of climate change identified and uncertainties estimated. This will make it possible to make statements about the present and the future which are relevant to society.

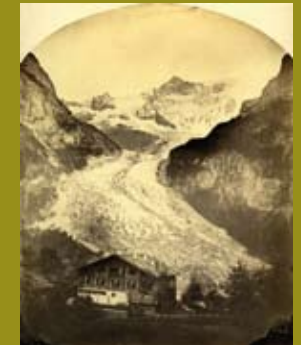
We are looking for answers to questions such as: Do climate changes happen faster today than in the past? How have large terrestrial ecosystems as well as animals and plants adapted to the changes? How stable is the oceans' circulation? Does the water vapour content of the global atmosphere change as a result of climate change? Using natural climate archives such as ice cores, lake sediments, stalagmites and tree rings, but also historical documents, we look back several thousand years and investigate how natural driving factors (the sun and volcanoes) and anthropogenic disturbances (greenhouse gases, land use, aerosols) have changed the climate and how ecosystems react to such changes. The comprehensive reconstruction of the climate of the past is a core competency of the Oeschger Centre. The long proxy data and measurements series in Europe and in Switzerland allow climate reconstructions of a quality unique in the world. They provide detailed input into the long-term diagnosis of atmospheric dynamics (pressure, precipitation and temperature), the causes of variations in climate and the statistics of extreme events.

REGIONAL CLIMATE DYNAMICS



Our second research focus deals with climate variability and climate changes at local and regional levels. The Alps are particularly sensitive to such changes. In order to estimate the effects of climate change in Switzerland, it is necessary to understand processes at a very high degree of temporal and spatial resolution. The North Atlantic European area determines weather conditions above the Alps, but climate changes and the extreme weather events they cause have a considerably greater impact at a local and regional level than globally. Research in the "Regional Climate Dynamics" focus is therefore central to the analysis of climate risks and the effects of climate change in the Alpine area, the subject of the Oeschger Centre's third focus.

The Alps are particularly sensitive to climate change. The best-known example of its dramatic consequences is glacial shrinkage.



The Lower Grindelwald Glacier in 1904 and 2005

CLIMATE RISKS AND NATURAL HAZARDS

For Switzerland, climate change may mean more extreme events like flooding, droughts and storms. In the mountains there will also be an increasing possibility of dangerous landslides and debris flows caused, amongst other things, by the thawing of the permafrost.



Our third research focus is concerned with the effects of climate change on Switzerland and the Alpine region. The main emphasis is on climate risks, that is, the impact of climate change on natural and managed ecosystems, on infrastructure and also on supplies of water, food and energy. Last but not least, we are interested in the effects of climate change on human health. We help to identify risks, to evaluate them and in this way to lay the foundations for sustainable, socially and economically compatible ways of dealing with the dangers of climate change. Our research takes a long-term view.

ECONOMIC AND SOCIAL DIMENSIONS

The focus of our fourth main research area is on the interplay between economics, society and climate and the associated impact and risks of climate change. Within this extremely complex and multifaceted area the Oeschger Centre conducts research in six sub-areas:

- **Political economy of climate change:** we investigate, from a political and strategic point of view, how successful national environmental policy can be applied to international agreements.
- **International trade:** we investigate what kind of role the WTO can play in multilateral agreements on climate protection and measures for adaptation to climate change.
- **Mitigation, adaptation and technological change:** we investigate the interplay between these three elements with the goal of developing an optimal long-term climate policy.
- **Uncertainties, risks and insurance:** with the precautionary principle as a guide, we investigate the effects of events which are fairly unlikely but are capable of causing irreparable high damage.
- **Intergenerational justice:** climate change is a long-term problem. We investigate which economic consequences (cost/benefit) may arise for future generations and what this means for the climate policies of today.
- **Climate change and conflicts:** we examine the hypothesis that climate change and regional resource shortages lead to more frequent conflicts. The results may well be of relevance to security policy.

Whether in a global context or in Switzerland, climate change impinges on many areas of social and economic life. In turn, these affect the future development of the climate. The Oeschger Centre investigates these interactions and develops foundations for political decision-making in the area of climate change.



ADAPTATION

Switzerland will have to learn to deal with the consequences of changes in the climate. For this reason, the Oeschger Centre is investigating adaptation to climate change as well as climate risks. This includes studies on protection against flooding or, for example, the work of Rie Nemoto. She gained a master's degree in agronomy in France and is currently working on a second master's at the Graduate School of Climate Sciences at the University of Bern. Thanks to her background as an agronomist, this climate researcher is investigating the effects of climate change specifically in agriculture. Her master's is focused on finding out whether organic or conventional farming systems adapt better to climate change. Depending on how farmers use land, varying amounts of carbon are set free, contributing to an increase in the concentration of CO₂ in the atmosphere. Rie Nemoto works with data from a long-term field study in Therwil near Basel. Based on these measurements, she uses a carbon model to simulate the long-term soil carbon change in different farming systems, analysing the past and making predictions for the future. The study will show whether intensive farming with mineral fertilisers or extensive organic farming is preferable for proper soil carbon stock when climate change is taken into account.

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RIE NEMOTO is a student at the University of Bern's Climate Sciences Master's programme. "I decided on climate research as it is very topical and as climate is one of the most important research fields for the future of the earth."
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MODELS

Computer models are tools central to climate research and play an important role in the work of many scientists at the Oeschger Centre. Reconstructing the climate of the past would be unthinkable without sophisticated models and statistical procedures. Models can also be used to calculate how the climate will develop in the future, depending on varying scenarios of economic and social development – or, conversely, what effects climate change will have on the economy. Climate economist Oliver Schenker studies the interaction of climate change and international trade. Climate change will cause a shortage of certain goods, making them more expensive and affecting the economic performance of a country.

For his computer simulations, Oliver Schenker has developed a model that depicts trade between 15 world regions and incorporates the climate predictions of the Intergovernmental Panel on Climate Change (IPCC). The model presupposes that each region will adapt its trade so that it can obtain necessary goods at the lowest possible price. His calculations show that, indirectly, the economies of countries such as Switzerland will be affected more strongly by climate change than previously thought. This is information which is important when it comes to cost-benefit analyses relevant to policymaking on climate change issues.

OLIVER SCHENKER is a doctoral student at the University of Bern:
"Climate research fascinates me by its complexity and its interdisciplinarity."





RELEVANCE TO SOCIETY

Concerns about climate change have raised expectations on climate research. It has to explain why climate change has come about and what the effects are on society, politics and economics. It has to show how Switzerland can best act in the face of this change. For this reason, researchers from many different disciplines work together at the Oeschger Centre and whether they are botanical scientists, geographers, chemists, lawyers or historians, their work is of great importance for society. The climate economist Ralph Winkler, for example, is investigating climate change from the point of view of intergenerational justice. The idea behind this is the requirement that the current generation should provide future generations with at least the same level of affluence and quality of life as it has itself enjoyed. How this principle of equality can be applied in climate policy is controversial. Climate change is a long-term problem: while most adaptation costs must be borne now, the benefits will be spread over several centuries. Optimal climate policies should ensure that costs are shared between the generations, but current cost-benefit analyses neglect important aspects of justice in intergenerational distribution. Ralph Winkler uses theoretical models to search for alternatives to a pure cost-benefit approach and tests their conclusions on the basis of empirical data and computer simulations.

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RALPH WINKLER is Professor of Economics at the University of Bern:
"I studied physics and economics, so going into climate economics seemed a logical step. This area of research fascinates me; it's exciting and relevant."
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