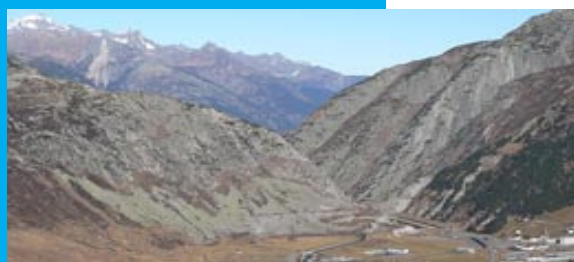
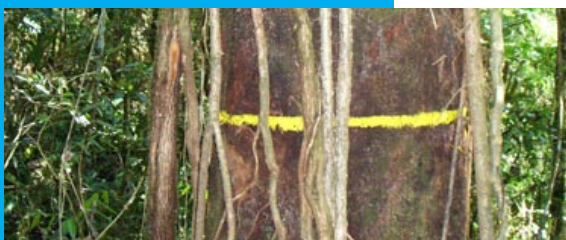
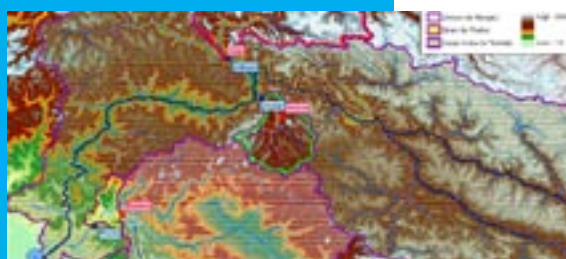


Newsletter of the Mountain Research Initiative

# MRI NEWS

no. 2 • April 2009



Global Change in Mountain Regions  
**The Mountain Research Initiative**



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### Impressum

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Dear Reader,

This second MRI Newsletter covers a wide range of subjects, activities, and scientific communications. As a hydrologist I am struck by the crucial role of water in many of the articles, which recalls an Uzbek saying: „Wherever the water ends, the earth ends as well“.

The Newsletter is thus proof that MRI's community of global change mountain researchers is alive and well, a good thing for a project that aims at building that community!

Still, I am moved to ask if mountain research is doing what it should? The problems and challenges of mountain regions require problem- centric, and even better, solution-centric research.

While we certainly still need basic research to improve our understanding of underlying processes, we also need more and better applied research. By this I mean research that goes beyond publication in journals to include extension and application of the results, as a matter of course. Transdisciplinarity in its proper sense is what we need.

There are many reasons why we fail to arrive at this destination:

- We still lack basic data. As noted unequivocally by the World Water Development Report 3 of the United Nations we lack sufficient data for the planning of sustainable management of the water resources, especially in developing nations. We must convince our funding agencies that field work and basic measurements are indeed a crucial component of excellent research.
- While the rhetoric of academia usually endorses interdisciplinarity, the daily practice of academic life often discourages it. A researcher's career is nearly always predicated on disciplinary excellence, and therefore, interdisciplinarity, however desirable, is usually a lower priority.
- Shorter duration and more narrowly focussed projects offer little scope for application. More and more projects are of short duration so they end before there is even a chance to consider how the results relate to practical implementation.
- A nearly exclusive reliance within academia on scientific assessment via publication in peer-reviewed journals tends to discourage work that considers implementation of the results.

Furthermore scientific conferences often remain without concrete results, and without messages to decision makers or society. There is often a lack of intention and readiness to pass on the insights

gained and to build on them in follow-up events. We keep repeating ourselves! Personal conversations with you, the readers, show me again and again that many scientists share these opinions, but are limited in their actions by the basic conditions of the scientific environment.

Let's improve our scientific system together in order to achieve an applicable and credible mountain science. The mountains of the world and their inhabitants need us to take this responsibility!

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# Progress Report



**In MRI's News N° 1, I described the four main headings in MRI's current workplan. In this edition, I would like to give you some details on our progress.**

**The objective of the Key Players** theme is to evangelize MRI's core vision of interdisciplinary research to important researchers in hopes that they will carry this vision forward in their programs and into national research funding agencies. MRI took the first step down this road with a workshop held in Berkeley, California on 14 December 2008, just before the American Geophysical Union Fall Meeting in San Francisco.

While the idea of evangelizing evokes an image of exhorting followers, in fact, the workshop was quite the opposite. The workshop consisted of multiple sequential panels of four researchers, each of whom described in five minutes their current and desired future research programs, followed by intense small group discussions around each panel participant. Audience members were assigned to discussions with individual panelists in order to maximize the diversity of disciplines in each discussion. The workshop report, available in pdf format on the MRI website, contains the summaries of research programs of each participant.

Follow up with participants indicated real satisfaction with the workshop format. The workshop allowed several

participants to meet each other for the first time and to elaborate future collaborations. For others, the workshop provided a venue to meet with small sets of people whom they had already targeted for conversations during the AGU week, and so simplified their task.

As the AGU workshop was a success, MRI has decided to move ahead with a similar workshop at the Austrian Academy of Science scheduled on 18 April 2009, the day before the start of the EGU meeting in Vienna. Over 80 researchers have expressed an interest in the workshop. Depending on the success of the EGU workshop (and the MRI budget), MRI may extend the workshop idea to other major meetings.

**The objective of the Peer-Reviewed Publications** theme is to develop substantive synthesis and review papers on key global change research themes in mountain regions. MRI is working with Daniel Viroli of the Hydrology Group at the University of Bern to examine how climate change research can be rendered more useful for managers of water resources around the world. Together, we have assembled a team of experts from North America, Europe, the Middle East, South Africa, Central Asia, China and Oceania who will develop summary papers on the relationship between climate change research and water management in their regions. This group will then meet in Göschenen, Switzerland from 16-18 September 2009 to develop a synthesis paper. Dr. Viroli has submitted a conference grant proposal to the Swiss National Science Foundation to complement the resources of MRI, and is in discussion with several journals regarding the publication of these papers in a special issue.

MRI continues to pursue papers on forest dynamics in the American Cordillera by CORFOR, the state of the art of global change research in the Carpathians with MRI-Carpathians, and food security in

mountain regions with CDE.

**The key objective of the Proposals theme** is the submission of proposals to funding agencies that advance the cause of global change research in mountain regions. MRI collaborated with Swiss, Austrian and German colleagues on the submission of the Net-DYNAMO project in October 2007, which was subsequently recommended for funding by the European Science Foundation (ESF). However, despite commitments of funds from nine European countries, total contributions by December 2008 equaled only 45% of the requested budget. In the absence of contributions from larger member countries, ESF declined to launch Net-DYNAMO in 2009. The group mobilized around Net-DYNAMO is currently considering how to move forward with the proposal.

As part of Global Change Research Network for African Mountains (GCRN\_AM), MRI brokered the submission in November 2008 of a proposal to the Swiss National Science Foundation and the National Research Foundation of South Africa for a joint scientific conference on mountain observatories. If successful, this conference will occur in Switzerland in Fall 2009, with perhaps a follow up conference the following year in South Africa.

**In collaboration with IGF and four other partners**, MRI participated in the development of a proposal, submitted in January 2009 for an FP7 Support Action, entitled Mountain.TRIP (Transferring Research Into Practice), to improve the use of EU research in the practice of sustainable mountain development. The project proposes to establish a dialogue via a dedicated social network between practitioners (decision-makers, administrators, consultants, entrepreneurs) of mountain development and research institutions that will be locating and summarizing all relevant EU research.

Finally, among the many products generated by MRI since October 2007, I would like to highlight the IHDP Update of October 2008, Mountain Regions: Laboratories for Adaptation, of which MRI was a co-editor. This excellent publication brought together articles submitted by mountain researchers around the world, indicating the breadth of our community.

Greg Greenwood  
Executive Director, MRI  
[green@giub.unibe.ch](mailto:green@giub.unibe.ch)

## Upcoming MRI Events

<http://mri.scnatweb.ch/events/mri-events/>

**Securing the Sustainable Provision of Ecosystem Services in the Alps and the Carpathians**, 9 June 2009, Bratislava, Slovakia

**Second Planning Meeting of Science for the Carpathians (S4C)**

10 June 2009, Bratislava, Slovakia

**Climate Change and Water Resources Management in Mountains**

16 - 18 September 2009, Göschenen, Switzerland (by invitation only)

Contact: Daniel Viviroli, [viviroli@giub.unibe.ch](mailto:viviroli@giub.unibe.ch)

**Global Change and the World's Mountains**

Perth II - Five Years Later

27 September - 1 October 2010, Perth, UK

To propose sessions please contact [Martin.Price@perth.uhi.ac.uk](mailto:Martin.Price@perth.uhi.ac.uk)

[www.perth.uhi.ac.uk/mountainstudies/2010](http://www.perth.uhi.ac.uk/mountainstudies/2010)

## Past MRI Events

<http://mri.scnatweb.ch/events/mri-events/>

MRI convened sessions on global change research in mountains as side events of both the AGU Fall Meeting in Dec. 2008 and the EGU Meeting in April 2009. The Research Summaries of the Dec. 2008 workshop are available from the MRI website (see link above). The Research Summaries of the April 2009 workshop will be available in May 2009.



Participants of the October 2007 meeting of MRI Europe in Innsbruck, Austria

## Find more information in the four regional Newsflashes of MRI

**Newsflash of the Global Change Research Network for African Mountains**

[http://mri.scnatweb.ch/index.php?option=com\\_docman&Itemid=57](http://mri.scnatweb.ch/index.php?option=com_docman&Itemid=57)

**Newsflash of the American Cordillera Transect**

[http://mri.scnatweb.ch/index.php?option=com\\_docman&Itemid=58](http://mri.scnatweb.ch/index.php?option=com_docman&Itemid=58)

**Newsflash of MRI Europe**

[http://mri.scnatweb.ch/index.php?option=com\\_docman&Itemid=73](http://mri.scnatweb.ch/index.php?option=com_docman&Itemid=73)

**Newsflash of Science for the Carpathians, S4C**

[http://mri.scnatweb.ch/index.php?option=com\\_docman&Itemid=72](http://mri.scnatweb.ch/index.php?option=com_docman&Itemid=72)





# ACQWA - Assessing the Future of Water Resources in Vulnerable Mountain Regions

**MRI Interview with Martin Beniston, Project Director,  
University of Geneva, Switzerland**



**What is new about ACQWA? Will it come up with new datasets that have never existed before, or will it explain relations that we have never understood before?**

It is the first time that we are trying to really integrate! The models themselves and the input, the datasets, will not be much different from what has been done in other projects. But the results of the models will be integrated: instead of having sector-by-sector work where people just look at glaciers, or at hydrology, or at regional climate models separately, we are actually putting all this information together to go from the global climate change down to the Alpine scale and then down to the different components of the hydrological cycle. An end-to-end pipeline, if you like.

And then the other major part is the impacts side. Again, impacts have been looked at in disciplinary ways. Even if you look at the IPCC report: you have chapters on ecosystems, agriculture, and numerous other sectors, but in ACQWA we are also trying to integrate the consequences on the hydrological regime. This is important for the different actors in the resources and agriculture sector, we can already start to think of strategies of how to avoid conflicts of interest as water becomes rarer and will need to be shared among these actors.

**How will you be able to make accurate statements or predictions on adaptation strategies and governance issues? What are the methods you are using on the level of the economic and political system?**

In terms of physically based data - especially if you look at the Alps - there is plenty of information out there. As we go into the socio-economic, policy relevant data, it is more difficult. Even just talking about data with people from different backgrounds, e.g. natural science or political science, data means different things to different people.

We are starting work in the Alps, in the Rhone valley, because there is a lot of data available. And there is also to some extent political good-will. In Valais the authorities are very interested in the objectives of ACQWA, for obvious reasons, since the Rhone is part of the study region. It goes beyond an academic interest because they see the added value of this integration of the disciplines, and they are even thinking about setting up a local government competence center on water management. Under one roof we would have people looking at the energy sector, at water supply, agriculture and other topics, a regrouping of the official local governance around water issues! At the moment they are subdivided into several cantonal departments - with sometimes a lack of communication. So ACQWA has been a catalyst for people to talk together, whereas before there hasn't been the institutional basis to do so.

**You said that in Chile the mining, agriculture, and energy industries were the stakeholders of water issues - what is their role in the project? Are they just the recipients of the results, or do they tell you, what kind of**

**questions they have? How are they integrated in the project, and what are your tools for this interaction.**

In the non-European countries we have not yet identified many key stakeholders, what we have are the scientific contacts. As the results start coming in the partners in Argentina and Chile will actually do their own communication to their own stakeholders and local policy makers, this is not up to us from the ACQWA coordination group.

In the European context, however, we do have some responsibility of feeding back into existing databases, like the European Water Directive. What takes place in the Alps can have large-scale repercussions downstream, in Europe. The Rhone feeding into France, the Po in Italy. We will extrapolate the information to other rivers like the Rhine, and the Inn which feeds into the Danube, and then into Eastern Europe. So there are more formal links established with the European Commission, and we are planning stakeholder- or policy-relevant workshops towards the end of the project, from the third year onward. They will highlight the burning issues regarding water resources originating in the Alps, and with this we might have some direct impact on the future strategies of the European Water Directive. You can solve water quality problems for today's climate, but they might creep up again when the seasonality or the quantity changes.

The European Commission has not come back to us with specific requests, though. Maybe they are happy with the way the project has been designed, and they are going to wait for the results.

**In the project description you have used the expression of a "data ware-**



**house” where all the base-line datasets are stored. What do you do with the results of meetings with the local governments in Kyrgyzstan? And what with meeting notes from Valais? Where are all the bits and pieces stored which are not the final results, but which are important for the progress of the project?**

Well they would actually be stored on our internet site, which can be accessed by members and affiliate members, so there we would have documents that report on, e.g. the state of discussions with local governments. The Steering Committee members have access to these documents on the internet. There is nothing extremely exciting at the moment, just the official contract documents. As time goes by we will be putting information, including non-numerical information, on the internet. And all the quantitative information will be accessible via the warehouse.

You have mentioned integration to be what makes ACQWA special. What tools are you using for the integration? Are these tools that you are developing in the process of the project? Or are they existing tools?

For the modeling part most of the models do exist. The regional climate models have been used, for example, for the last IPCC report. Of course as we come close to the end of the project there will certainly be a need for refinements, maybe for some of the glaciological models, or the hydrological models. That might be the case for the specific case study areas, but not for the ones we are using now. The idea was not to develop a new set of models, but to use existing techniques, and, if necessary maybe refine the techniques. Actually, you also see this taking place in the climate mo-

deling community: there has been relatively little profound development of the models themselves taking place in recent years. People are looking at the results of the runs, more than developing, or improving the models.

**I am not a technical expert: where exactly does the integration take place technically? Are people modeling hydrological and climatological values at the same time, or does the integration occur afterwards?**

It is more the integration of the results, because a single model cannot handle at the same time larger scale climate and glaciological data. You need to feed one into the other, for the integration to function. Because otherwise one single earth system model would use up so much computer space, that it is would not be a useful exercise. The idea of the modeling within ACQWA is to have a consistent flow of information from the regional climate models, down to the snow and ice models, which then feed into the water models, and the water models give us information that can be used for the impacts assessments and policy. So it's a bit like a mini IPCC, if you like, except that the integration is of finer scale and of better quality, I would say.

**What products can the scientific community expect, and when? And what would be the first product of ACQWA in 2009?**

Well, in the first couple of years there won't be many spectacular results. Each year we have a general assembly, where preliminary results will be shown. But from year three onward we would actually organize science plus stakeholder workshops for information exchange, for example in the locations where we

had been doing work, this might be in Valais, or in Chile. We do plan to have newsletters, not only for the scientific community, but also for anybody else who might be interested in some of the issues. The first newsletter has come out in March and is simply a general description of the project, so people do not have to read the whole description of work. Future newsletters will then focus on various applied aspects, such as the implications of our research for local policy making, or for the thinking about risk reduction.

And then publications, also beyond the scientific publications. One of the final products will be an edited volume, which highlights some of the results, based on what we had promised at the start. It would discuss if there are deviations from the original objectives, and why. Was it a scientific problem, was it a problem of access to data, or was it a problem that things have changed in terms of policy? You never know in advance, surprises can happen; for example, since Barak Obama came into power the US have suddenly become a new partner once again, in the climate negotiations. You don't know what might happen over five years, there will be elections in various parts of the European Community. I am not sure about the consequences of the current financial crisis: are people going to care about this, which way are they going to go, will climate and water be at the top of the list of preoccupations in the minds of the general public?

Interview Claudia Drexler, MRI

<http://www.acqwa.ch>

# A High Altitude Interdisciplinary Field Campaign - The Storm Peak Aerosol and Cloud Characterization Study (SPACCS08)

## Introduction

Bioaerosols are defined as organic aerosols that are alive, carry living organisms, or are released from living organisms. Examples of bioaerosols include bacteria, fungi, virus, pollen, cell debris, and biofilms and range in sizes between 10 nm and 100  $\mu\text{m}$  (Ariya and Amyot, 2004). Current work in progress globally is investigating the role of bioaerosols as acting as ice nuclei (IN), cloud condensation nuclei (CCN), and implicating them as potentially altering cloud coverage and thus global climate (Sun and Ariya, 2006 and references herein).

Recent studies also suggest that bioaerosols may significantly contribute to the mass of organic compounds observed in atmospheric particles (e.g. Bauer et al., 2002). This organic aerosol (OA) accounts for a large, often dominant fraction of fine particulate matter in the atmosphere. Despite significant advances in recent years, our present understanding of OA composition, physical and chemical properties, sources, and transformation processes is still limited (Fuzzi et al., 2005). OA influences physical and chemical properties of fine particulate matter and thus affects visibility, human and biosphere health, and ultimately global climate. OA originates from direct emissions (primary organic aerosol, including bioaerosols) as well as from chemical reactions and gas-to-particle conversion in the atmosphere (secondary organic aerosol, SOA). Bioaerosols are a small fraction of the total particle numbers in the atmosphere, yet their numbers are approximately the same order of magnitude as that of IN ( $10^3 - 10^4$  per  $\text{m}^3$ ), indicating their potential significant role. Due to the lack of understanding regarding bioaerosol, further study is needed (Sun and Ariya, 2006). To better constrain our under-

standing of OA and the role of bioaerosols in the atmosphere, Storm Peak Aerosol and Cloud Characterization Study (SPACCS08) was conducted in March 24 through April 15 2008 at the Storm Peak Laboratory (SPL; see photo in figure 1).

## The Desert Research Institute's Storm Peak Laboratory

The Desert Research Institute's Storm Peak Laboratory is located on the west summit of Mt. Werner in the Park Range near the town of Steamboat Springs in northwestern Colorado at an elevation of 3210 m ASL (shown on map in figure 2). This site has been used in cloud and aerosol studies for more than 20 years and a considerable depth of knowledge has been acquired on the aerosols and interaction of aerosols with clouds (Borrs and Wetzel, 1997). SPL includes a laboratory for instrumentation with ac-

cess to the large roof deck, a cold room for snow and cloud rime ice handling, a full kitchen and overnight living accommodations for nine. SPL is also part of several climate networks including the Western Regional Climate Center, the Regional Atmospheric Continuous  $\text{CO}_2$  Network in the Rocky Mountains, and the US Department of Agriculture Ultraviolet-B center. SPL is in cloud 30% of the time during winter. The ridge-top location produces almost daily transition from free-troposphere to boundary layer air which occurs near midday in both summer and winter seasons. Long-term observations at SPL document the effect of orographically-induced mixing and convection on vertical pollutant transport and dispersion. SPL experiences transport from distant continental sources including urban areas, power plants, and natural fires.

At SPL, we expect the aerosol to be highly aged, with characteristically



Figure 1: Storm Peak Laboratory, 2006 (photo by Dave Simeral)



different size distributions, chemistry, and hygroscopic properties than fresher boundary layer aerosols. SPL has a multitude of continuous measurements including meteorological parameters, atmospheric trace gases, and aerosol properties. Combining this existing equipment with measurements of bioaerosols and mercury species, SPACCS08 was able to provide new understanding from this interdisciplinary collaboration.

## The Storm Peak Aerosol and Cloud Characterization Study (SPACCS08)

Participants of SPACCS08 included a multitude of universities and researchers. Atmospheric, chemical, and biological scientists involved with this campaign include: Drs. Anna Gannet Hallar, Daniel Obrist, and Xavier Fain, Desert Research Institute; Dr. Christine Wiedinmyer, National Center for Atmospheric Research; Dr. Marianne Glasius, University of Aarhus, Denmark; Dr. Mike Hannigan, Kelly Baustian, Eszter Horayni, University of Colorado; and Dr. Lynn Mazzoleni, Michigan Technological University. The microbiologist involved in this campaign included: Dr. Noah Fierer and Robert Bower, University of Colorado; Dr. Duane Moser, Desert Research Institute; and Dr. Brent Christner, Louisiana State University.

Results from SPACCS08 produced valuable insights about biological particles (bacteria, fungal spores, and pollen) in the remote, continental atmosphere. During the two-week SPACC study, total microbial abundance, diversity and composition of airborne bacteria and fungi, and total ice nuclei measurements were performed and correlated to the meteorological conditions at the time of sampling. Results from Bowers et al. (to be submitted) show the consistency of bacteria and fungal species across all atmospheric samples. There have been few comprehensive studies using culture-independent techniques (i.e. eliminated the requirement of studying only the species that grow to needed mass

concentrations) to describe the diversity and temporal dynamics of airborne bacteria and fungi. During this sampling campaign, the microbial communities were surprisingly stable in terms of microbial abundance, diversity, and community composition, while the total number of ice nuclei was significantly higher during times of high relative humidity, which was used to distinguish between cloudy and clear skies (Bowers et al., to be submitted). These species distributions, although highly consistent in the atmosphere, were also significantly different from the distributions observed in snow (Bowers et al, to be submitted). Captured cloud water also demonstrated sensitivity to heat denaturation and protease digestion, indicators of IN protein (Christner et al., to be submitted). Airborne microbial life may be strongly influenced by atmospheric conditions. The number of ice nucleators within those particles identified as having intact DNA was on the order of 1 in 10,000; typical of atmospheric concentrations (Bowers et al, to be submitted). Wiedinmyer et al. (to be submitted) show that, although uncertain, the contribution of bacteria and fungal spores to particulate organic carbon in the atmosphere is substantial and warrants more detailed investigation.

As part as the SPACC campaign, continuous monitoring of gaseous elemental mercury (GEM, Hg<sup>0</sup>), reactive gaseous mercury (RGM) and particulate mercury (PM) was initiated. In the lower atmosphere, RGM and PM (the oxidized forms of mercury) represent only a few percent of the total mercury. However, we observed multi-day events of enhanced RGM at Storm Peak Laboratory, which could not be related to local pollution as no relation was found between RGM and CO, ozone or aerosol concentrations. On the contrary, RGM and GEM appeared to be anti-correlated, demonstrating in situ production of RGM. Similar to the airborne microbial life, the local meteorology is key to mercury concentrations: drops in atmospheric RGM levels were related to high humidity and air saturation. High humidity promotes RGM scavenging and consequently deposition on the snowpack (Fain et al., to be submitted).

## Future Work

Several of the SPACC participants are currently continuing this work at SPL with improved methodologies, instrumentation and scientific direction. A field campaign is currently planned for January 2010, which will include an additional ice nucleation instrument.



Figure 2: Map of Colorado with Storm Peak Laboratory denoted.

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# A new Peruvian-Swiss Program on Climate Change Adaptation: Advancing towards Integrated Climate Change Research, Implementation and Science-Policy Dialogue

## The Andes: highly vulnerable to climate change

Mountain regions in developing countries are particularly vulnerable to climate change. These regions need readily available base lines of expected impacts on the regional and local level to plan and implement effective and socially consistent adaptation measures. However, the field of climate change impacts and adaptation is highly complex on both scientific and implementation levels. Main reasons include impacts on different ecological services and socio-economic systems, related feedback effects, and a multi-actor environment within different levels of social and political systems.

The Peruvian Andes are among the most vulnerable areas to climate change (Bradley et al., 2006, Magrin et al., 2007). In collaboration with the Peruvian Ministry of Environment, the Swiss Agency for Development and Cooperation (SDC) recently initiated a program on climate change adaptation (PACC – Programa de Adaptación al Cambio Climático) in two regions of the Peruvian Andes.

## Key parameters of PACC

The PACC is implemented by a NGO consortium led by Intercooperation. Scientific support is provided by several scientific institutions in Peru, and a scientific consortium in Switzerland, which includes Meteoswiss, Meteodat, Agroscope Reckenholz-Tänikon ART, the Swiss Federal Institute for Forest, Snow and Landscape Research WSL-SLF, the University of Geneva and is led by the University of Zurich.

The programme focuses on three major thematic lines: (i) disaster risk reduction; (ii) water resource management; and (iii) food security.

Geographically, it focuses on the Cusco and Apurímac regions in the south of Peru between about 3000 and more than 4000 m asl, with mountain peaks rising to over 6000 m asl. The total population of the regions is around 1.5 million, with about 40% suffering from malnutrition and over 75% lacking basic needs. Poverty-related problems are particularly pronounced in rural areas. As a consequence, the regions have limited adaptive capacity to adverse effects of climate change (Lagos, 2007).

The Andean regions of Peru have two distinct seasons, a rainy period in austral summer and a dry period in austral winter. During the dry season, many parts

of these regions rely on water resources from glaciers, and rural indigenous people are in fact observing with increasing concern the glacier retreat of the past years and decades (Orlove, 2008).

Glacier retreat and changing water resources are not the only relevant climate change impacts. Extreme climatic events such as cold waves have struck more severely in recent years. The rural population is especially affected by loss of crops and cattle caused by cold waves and droughts. In addition to slow-onset climatic disasters (e.g. droughts) the magnitude and recurrence of rapid geomorphic hazards such as landslides may be altered due to climate change.

We need to improve the prediction of the type and magnitude of climate change on the local and regional level using adapted downscaling methods. Past



Figure 1: Meteorological and hydrological stations in the Andes are often maintained by local people. Here a campesina explains 'her' station in Sicuani, near Cusco (photo by Mario Rohrer).



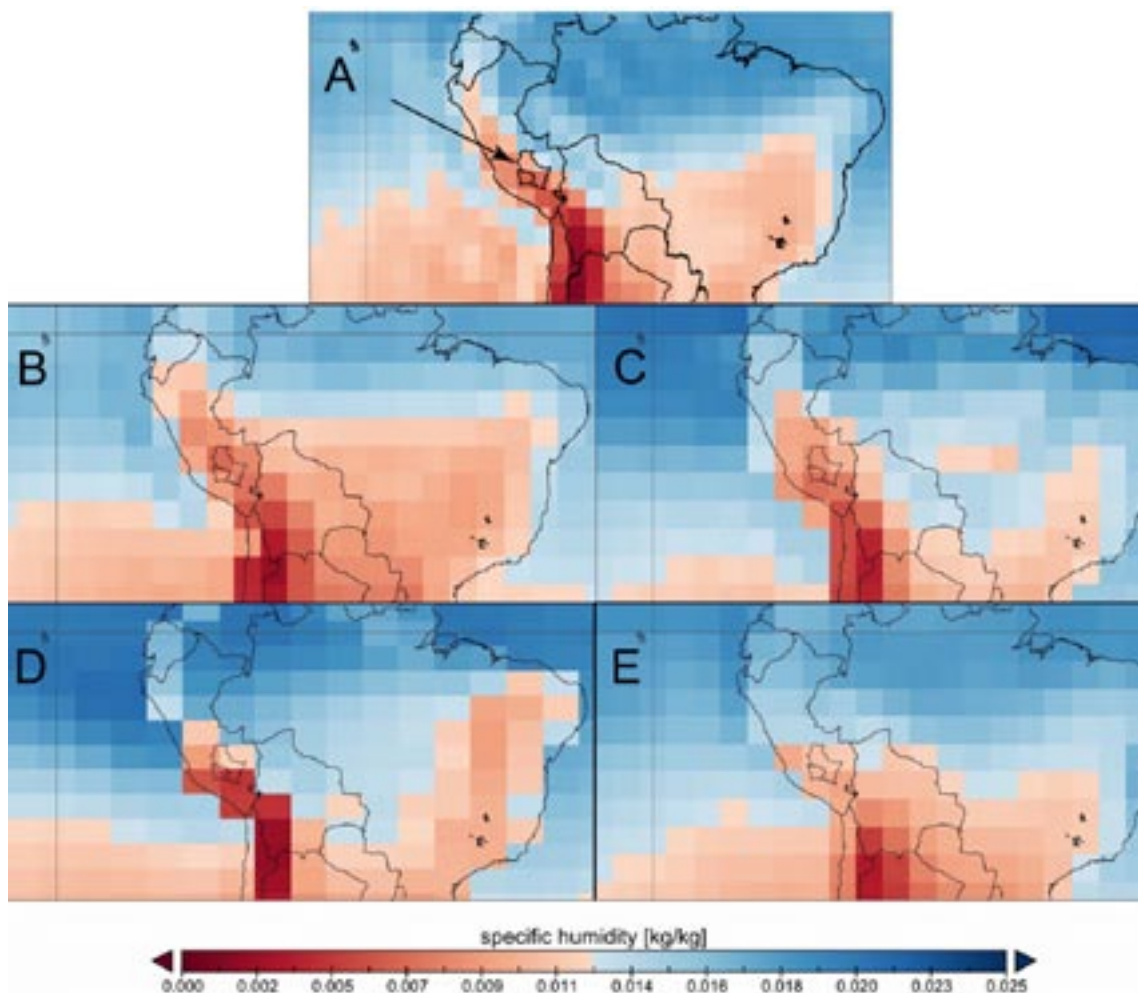


Figure 2: As an example of climate projections, mean specific humidities are shown for June 1980-1999 based on NCEP Reanalysis (A), and for June 2046-2065 for SRES-scenario A1B as modelled in the Global Circulation Models for the central part of South America: Bjerknes Center BCM2 (B), Canadian Center CGHR (C), Hadley Center CM3 (D) and Meteorological Institute of Japan MRI-MRCGCM (E). These IPCC-AR4 based results do not provide sufficient detail and clarity as to whether the dry austral winters in the regions of Cusco and Apurímac (geographic limits indicated) will even be drier in future than at present (data courtesy IPCC).

and present climate trends and future projections are not understood in sufficient detail for the Peruvian Andes. In general, a temperature increase of up to  $0.3^{\circ}\text{C}/\text{decade}$  has been observed but this pattern is not homogeneous (Vuille et al., 2003). For the Urubamba catchment in Cusco the temperature has increased up to  $0.4^{\circ}\text{C}/\text{decade}$  (Rosas et al., 2007). Similarly, climate projections for this region are still uncertain (Urrutia and Vuille, in press).

## Regional scientific basis

Thorough analysis of existing long-term climate series forms one basis for further impacts assessments (Fig.1). While most studies on climate change in the Andean region have used monthly climate variables, studies within PACC will include analyses of daily variables. This analysis is particularly necessary for an improved assessment of climatic extreme events and is being done by the Servicio

Nacional de Meteorología e Hidrología del Perú (SENAMHI) in collaboration with the Swiss scientific consortium. Long-term climate series date back to the 1960s. However, the scarcity of data in the Andes is challenging, though typical for mountain regions, particularly in developing countries. On the one hand this scarcity emphasizes the importance of improving current monitoring networks and on the other hand calls for integrating additional data sources. Satellite data are a primary choice and may include rainfall data from the Tropical Rainfall Measurement Mission (TRMM) or high-resolution optical satellite data for deriving land-cover and glacier information.

Downscaling of future climate projections based on global circulation models (GCM) provides a basis for further impacts analyses (Fig. 2). In the PACC both dynamic and statistical downscaling is applied, the former in collaboration with different climate centers.

The three major thematic lines require different methodologies. For water resources, for example, a distributed hydrological model (PREVAH) is adapted and calibrated for application on a regional level. The extreme scarcity of gauging station data is thereby a major challenge. For local water resource studies, inventories of existing surface and subsurface water systems are carried out in collaboration with local people.

## Science and decision-making dialogue for adaptation measures

PACC emphasizes the analysis of cross-sector effects through the thematic lines of water resources, food security and natural disasters. For instance, changes in water resources impact agriculture, forestry, natural hazards, biodiversity, industry, sanitation, and other sectors. The program cannot thoroughly study the effects across all the sectors but



must choose some key impact sectors for adaptation. The human dimension, particularly the people's perception, is necessarily integrated in this concept to allow for a more complete view on vulnerabilities to climate change. A better understanding of people's perception of climate change and risks, and of the perspectives of different local, regional and national actors will enable an improved design of adaptation mechanisms.

PACC promotes an integrated framework for the assessment of potential impacts, damages and costs. Corresponding methodologies developed in integrated assessment studies (Carter et al., 2007), however, are relatively poorly developed on the local level and therefore need to be advanced. The PACC has a major opportunity to improve the dialogue between the scientific community, implementing agencies, and the political sphere to find more sustainable mechanisms of climate change adaptation. PACC involves all political levels in the program, from the local community to the regional and national governments. This close integration of the political level is a strength of the program but also a difficulty for the scientific communi-

ty, which is not familiar with political discourse. In this context uncertainties related to natural and social aspects of climate change prevailing in scientific assessments are often difficult to communicate to decision-makers. While uncertainties have been an important issue in climate science, they have only recently been systematically approached in the field of climate change adaptation (Dessai and Hulme, 2007). The key for adaptation projects such as the PACC is to find adaptation measures that are robust against uncertainties but yet feasible to implement.

### The global perspective

The lack of scientific base lines for adaptation projects at a local to regional level is a serious problem in view of ongoing climate change and the highly debated adaptation funds through the United Nations Framework Convention on Climate Change (UNFCCC). The need for scientific base lines on the one hand, and scarce data and observation on the other, is a typical problem found in countries in development and in mountain regions. The PACC should

therefore serve as a catalyst for the development of adapted methods applicable in other regions as well.

Collaboration with initiatives and projects in this field is important. In the Andes, the PACC collaborates and seeks synergies with other ongoing programs such as the Adaptation to the Impact of Rapid Glacier Retreat in the Tropical Andes Project (PRAA) of the World Bank/Comunidad Andina, the American Cordillera Transect for Global Change Research and others.

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# The Cordillera Forest Dynamics Network (CORFOR)

**CORFOR is a network of scientists and institutions, focussed on understanding forest responses to global changes in mountainous ecosystems along the American Cordillera.**

## Background

How climate change affects forests is still strongly debated (Phillips et al. 2004, Wright 2005, van Mantgem and Stephenson 2007, Chave et al. 2008). The Cordillera Forest Dynamics Network (CORFOR) will provide key data to answer that question for the mountain backbone of the Americas.

CORFOR was born in Argentina in 2006 as a working group of the larger America Cordillera Transect for global change research. CORFOR is a collaborative group of scientist who maintain hundreds of Permanent Forest Plots (PFP) monitoring thousands of individual trees. These plots cover a wide latitudinal range from temperate to tropical forests, and provide an opportunity for detecting patterns of change at large scales. Mountain systems also are characterized by steep environmental variation over very short distances, offering an opportunity to develop ecological experiments over small spatial scales as well. Empirical and theoretical results from CORFOR, covering studies on forest maintenance and functioning from local to continental scales, will shed new light on forest responses to climate change and other global changes. This information is of tremendous value to policy makers, land managers, environmental agencies and stakeholders all over the world.

## Objectives of the network

- Improving the understanding of tree species dynamics and distribution, carbon fluxes, and other environmental services such as water supply and regulation provided by forested moun-

tain ecosystems.

- Improving the mechanistic understanding of forest responses to global changes (in particularly to climate change), and therefore our capability of forecasting and modeling expected future changes in terms of composition and function (Stephenson and Duque 2008).

## CORFOR membership

CORFOR held its first workshop in June 2008 as part of the MTNCLIM 2008 meeting held in Silverton, Colorado, USA. Twelve people attended the CORFOR workshop representing eight institutions in five countries, and consisting a quorum for the establishment of basic principles for CORFOR operation.

CORFOR does not intend to be the

data manager for other research teams. Rather, it provides metadata about CORFOR plot networks through its webpage ([www.corfor.com](http://www.corfor.com)). The first step of a member is to supply appropriate metadata. We encourage all those interested in joining the CORFOR initiative to meet the following minimum and desirable criteria:

- Scientists conducting monitoring agree to their work being included in the metadata directory and are willing to share data with other members of the network.
- The people or institutions conducting monitoring are dedicated to seeing it continue in the future.
- The monitoring is conducted in the



Figure 1: View of a tree within a plot in the colombian Andean mountains (photo by Alvaro Duque)

Topic	Person/Institution	Other partners	Location	No. of plots
Old-growth forest dynamics	Lori Daniels, University of British Columbia		Coastal Range of south-western British Columbia, Canada	7 0.49-ha plots
Patterns of forest dynamics in space and time	Nate Stephenson, USGS Western Ecological Research Center	Many other partners	Central and southern Sierra Nevada of California, USA	28 1-ha plots
Diversity and dynamics of lower montane forests	James Dalling, University of Illinois at Urbana-Champaign	Pedro Caballero, Arturo Morris Universidad Autónoma de Chiriqui (UNACHI)	Continental Divide, Western Panama	6 1-ha plots
Red de de monitoreo bosques Colombia	Esteban Alvarez, /Interconexión Eléctrica S.A. ISA	Alvaro Cogollo /Jardín Botánico de Medellín JB MED	Mountain ranges of Colombia	18 1-ha plots
Forest dynamics	Julieta Carilla, Universidad Nacional de Tucumán	Agustina Malizia UNT	NW Argentina	12 1-ha and 10 0.24-ha plots

Table 1 provides a brief summary of the current interests and data of some of the members of CORFOR.

mountainous American Cordillera. While the foothills of the Andes would be included, the broad flatlands of the Amazon basin would not.

(d) The monitoring tracks individually-identified trees. Rationale: To make our task manageable, we propose that we limit our directory to plot-based monitoring of individually-identified trees, because these are the studies that will give us both (a) change detection, and (b) the information needed to develop a mechanistic understanding of forest responses to environmental changes thereby improving our ability to predict future changes.

e) Within a defined area (plot or sub-plot), all trees greater than the minimum dbh (diameter at breast height, that is, 1.3 or 1.4 m from the soil surface) are sampled. Rationale: Both change detection and development of a mechanistic understanding of forest dynamics are best served by sampling all trees including less common species, suppressed trees, damaged trees, etc..

(f) Recommended minimum dbh to be sampled is 1 cm. However, inventories focusing on a minimum dbh up to 30 cm could be included. Rationale: Small trees are usually both the most abundant and the most dynamic, and represent the possible future of a forest. Projection of possible future stand conditions requires an understanding of all age and

size classes of trees.

(g) The monitoring records tree recruitment, death, and growth (at dbh). Rationale: Information on all of these measures is needed to develop a mechanistic understanding of forest dynamics.

(h) Ideally, more than 500 individual trees are monitored. A minimum plot-area of 0.25 ha (50 x 50 m) is desirable. However, existing plot networks based on 0.1 ha plots are also included. Rationale: Large samples are needed for change detection and development of mechanistic understanding.

(i) The interval between censuses is <10 years (preferably from 1 to 5 years). Rationale: Long intervals between censuses are associated with a number of problems, perhaps most notably including bias in estimating demographic rates, losses of tree tags, and reduced ability to assign observed changes to specific environmental events (see, for example, Sheil 1995, For. Ecol. Manage. 77:11-34).

### Topics for exploration and analysis

In the second part of the workshop, participants defined priority topics. In order to build CORFOR on a scientific basis we aim at writing one or more pa-

pers to be submitted to peer reviewed journals in the coming year. In this first stage of the network large scale patterns will be our main interest. Our current data will enable us to compare processes and patterns among temperate forest of North America, subtropical forests in Argentina, and tropical forests in Colombia and Panamá.

The main subjects being explored are:

1. Changes in species turnover at different latitudes.
2. Mortality and recruitment along elevation gradients at different latitudes.
3. Large-scale comparison of disturbance and mortality.
4. Growth rates and biomass dynamics.
5. Point pattern analysis of dead trees using stem maps.

### Future Activities

CORFOR members will have a conference call in January to present the preliminary advances on each one of the subjects described above. Then, a second workshop supported by the Mountain Research Initiative (MRI) will be potentially organized later in 2009 at the University of British Columbia, Canada, to work on final contents and writing of the manuscripts which will then be submitted to peer-reviewed journals. We hope that with this launch CORFOR will make a



major contribution to global discussions about forest ecology and climate change. All researchers running permanent plots in the mountains of America are very welcome to join us.



Figure 2: Field workers in an Andean plot (photo by Alvaro Duque)

## Contact

If you want to join the network please go to the CORFOR website <http://www.corfor.com> or contact Nate Stephenson ([nstephenson@usgs.gov](mailto:nstephenson@usgs.gov)) or Álvaro Duque ([ajduque@unal.edu.co](mailto:ajduque@unal.edu.co)).

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# Ongoing and Future Vegetation Changes in the Western Swiss Alps

The ECOSPAT group at the University of Lausanne has been investigating observed and potential vegetation changes in the Western Swiss Alps since 2002. In this context, two research directions have been developed: (i) assessing ongoing vegetation changes during the 20th and 21st centuries, using existing and newly established permanent plots along a model-based monitoring design, under the lead of Dr. Pascal Vittoz, and (ii) predicting the future geographic distribution of plant species and diversity by the end of the 21st century, under the lead of Prof. Antoine Guisan.

## The PERMANENT.PLOT.CH project

Dr. Pascal Vittoz has been leading the PERMANENT.PLOT.CH project (Vittoz & Guisan 2003) since 2003. The project aims at centralizing data on permanent vegetation plots in Switzerland in a unique database. The primary objective of the PP.CH database is to conserve highly valuable historic data gathered in permanent plots, or in well-identifiable and circumscribed sites such as summits or specific communities (e.g. ponds or bogs). This project ensures that data are safely stored and made available to the entire scientific community for future research projects on the past, current and future vegetation in Switzerland.

A main use of the PP.CH database is to study vegetation dynamics, assess already observable climate change impacts on vegetation (e.g. Vittoz et al. 2008; Vittoz et al. 2009) and identify possible underlying drivers. However, it can be difficult in some situations to use these data to assess long-term vegetation changes when surveyed plots have been previously altered or are still under a human-disturbance regime. Assessing vegetation change due to climate change is most feasible in ecosystems with

limited human influence, such as found at higher elevations. Due to the high human pressure at low elevations, data on grasslands below treeline for the assessment of climate change impact are scarce. There are three possible reasons for this: (i) Permanent plots of open areas at these elevations are most often under a special management treatment. (ii) Warming experiments were rarely conducted in these mid-elevation systems, but rather at high elevations in the alpine zone or at low elevations on the plateau. (iii) The smaller size of plants in mid-elevation grasslands tends to make trends less visible than in forest trees. For this article we consider an example of permanent plots in grasslands below the treeline at the Schynige Platte (Switzerland, BE; Hegg 1992) and in the Vallon de Nant (Switzerland, VD).

## Change in subalpine grasslands

Vittoz et al. (2009) used 46 years of monitoring data from permanent plots (Schynige Platte) and re-surveys of bo-

tanical censuses after 36 years during the summer 2006 (in Vallon de Nant; Figure 1) to assess the respective importance of climate change and anthropogenic impact on subalpine grasslands. Their results showed changes smaller than reported for the alpine-nival belt, and mainly related to changes in human management, with a decrease of alpine species observed under competitive pressure by taller, subalpine species no longer grazed by cattle. However, in the Vallon de Nant, some species increased in frequency following abandonment and reached a particularly high elevation for the region, and in Schynige Platte, an exchange between two hemiparasite plant species was observed. A decrease in the alpine *Euphrasia minima* was observed as the colline-subalpine *Rhinanthus alectorolophus* increased in frequency across all plots. This suggests that vegetation changes were mainly driven by land management, but the influence of climate change cannot be excluded, as some of the increasing species are close to their highest distribution limit.



Figure 1: Dr. Pascal Vittoz during the re-survey of a botanical census (Vallon de Nant, Switzerland, summer 2006) (photo by Christophe Randin)

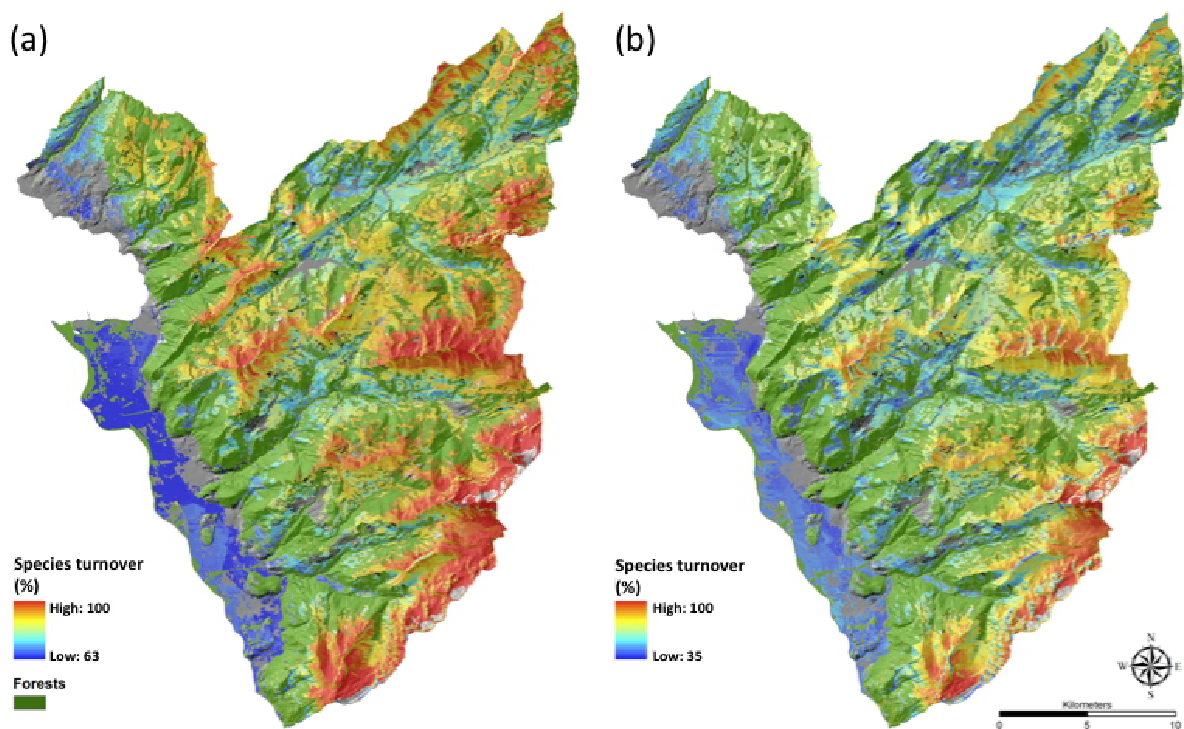


Figure 2: Species turnover under the A1FI scenario (a) and under the B1 scenario (b). Forested areas (in green) and areas unsuitable for plant growth have been removed from the projections. The turnover is calculated for each pixel as  $T = 100 \times (\text{Number of species lost} + \text{Number of species gained}) / (\text{Current predicted species richness} + \text{Number of species gained})$ .

## Modeling the 21st century vegetation

Species distribution models (SDM; Guisan & Zimmermann 2000) can be used to predict the current potential distribution of species on the basis of various environmental predictor variables, mainly climate, topography and substrate. By modifying the input climatic predictors according to socio-economic scenarios (IPCC 2007), SDMs allow forecasting the future potential distribution of species and, consequently, the assessment of extinction risks and possible impacts on biodiversity and ecosystems. Coarse resolution ( $10 \times 10'$ ; ca.  $16 \times 16$  km in our latitudes) models fitted at a continental extent have predicted species losses in the range of 27-42% for Europe (Thuiller et al. 2005).

However, models based on higher spatial resolutions are preferable in the rugged landscapes of mountain areas because plants are more dependent on (micro-) topography to decouple from the harsh climate. Using such finer models, Randin et al. (In press-a) assessed climate-change impact on the distributions of 78 plant species in two alpine areas (Western Swiss Alps and Zermatt) at a

fine resolution ( $25 \times 25$  m grid cells). The greatest prediction discrepancy between fine-scale (i.e. Western Swiss Alps and Zermatt) and coarse-scale (i.e. European scale) occurred in the area with the largest cover of nival vegetation: the authors showed that fine-scale models predict persistence of suitable habitats for up to 100% of species that were predicted by a European-scale model to lose all their suitable habitats in the study area of Zermatt. However, many of these species may nevertheless lose a significant proportion of their habitat in the Western Swiss Alps. These results suggest elevation range as the main driver for those discrepancies. Pixels at the European scale reflect a mean climate at a mean elevation for a  $10 \times 10'$  area whereas pixels at the fine scale are distributed along the entire elevation gradient. Local-scale projections may also better reflect the possibility of climatically suitable microhabitats that enable plants to persist locally. Such microhabitats cannot be represented in coarse resolution projections.

While several modeling studies conducted by different research groups have already forecasted the possible impact of climate change on plant distri-

butions, most of them have ignored how the consideration of dispersal can influence predictions. Instead, most studies simply assume that dispersal is either unlimited or negligible. However, depending on the rate of climatic change, landscape fragmentation and the dispersal capabilities of individual species, these assumptions likely represent two extremes, leading to under- or overestimation of future species distributions and substantial uncertainty.

The MIGCLIM model (MigClim model; Engler & Guisan In press) has been developed to address this issue and incorporates realistic dispersal into projections of future species distributions by including a number of parameters, such as maximum dispersal distance, landscape fragmentation, species generation time and long distance dispersal. In order to quantify the impact of integrating dispersal limitations in projections for mountain environments, the MIGCLIM model was used to project future distributions for 287 mountain plant species over the 21st century in the Western Swiss Alps (Engler et al. In press). Results indicated that when taking dispersal limitations into account, 30-70% of the species, depending on the



chosen climatic scenario, will lose more than 90% of their original distribution and are thus considered at risk of extinction. Most alpine and nival species were predicted to lose part or all suitable habitat by 2100. The change in species composition (species turnover) per cell (i.e. 25 x 25 meters) varied between 63% and 100% under the A1FI (i.e. the most extreme) IPCC scenario (Fig. 2a). Areas above the treeline were especially affected. All summits in the study were projected to experience nearly complete species turnover (Fig. 2a). Under the B1 (least extreme) scenario, predictions changed slightly (Fig. 2b), with mid-elevation summits showing lower turnover values. Nonetheless, high elevation summits were still predicted to undergo nearly 100% turnover. The results suggested that the first extinctions may occur around 2040 under the worst-case A1FI climatic scenario (+7.6°C in 2100), but only around 2090 under the more benign B1 scenario (+3.9°C in 2100).

To further improve predictions of SDMs, other important factors such as interspecific interactions or specific environmental parameters (e.g. soil conditions, geomorphic perturbations of human land use) should be investigated. Currently, such spatially explicit data often remain unavailable. These factors may be facilitators or inhibitors, acting as barriers or corridors for plant dispersal (Randin et al. In press-b; Randin et al. In press-c).

One crucial assumption when using SDMs to project species distribution in the future is that the species' ecological niche remains constant through space and time. The reliability of SDM predictions depends on the veracity of this hypothesis of niche conservatism and it should therefore be tested. In fact, some studies showed that assumptions of niche conservatism may not be justified (Pearman et al. 2008). Generally, one considers that species distribution along a temperature gradient is restricted by abiotic factors (i.e., climatic conditions) at the most stressful limit (higher altitudes in the Alps), and by biotic interactions (i.e., interspecific competition) at the less stressful end of the

distribution range (Normand et al. In press). Consequently, if the competitive species migrate towards higher altitudes at a slower rate than expected from climate warming due, for example, to dispersal limitation (Engler et al. In press), extinctions of the higher elevations species could be delayed. Moreover, some species may rapidly adapt to new climatic conditions, which may reduce future extinction rates from what would be expected under the assumption of an unchanging niche.

### Rare and invasive species

Climate change will impact most species, but understanding the impacts on rare and invasive species requires special investigations because they are not well captured by standard sampling surveys. Field sampling campaigns based on the geographic predictions of SDMs have proven to be useful tools to increase the efficiency of field work on rare species like *Eryngium alpinum* and on invasive species like *Heracleum mantegazzianum*, particularly in mountainous landscapes (i.e. Model-Based Sampling, MBS, Guisan et al. 2006).

In the case of the invasive *H. mantegazzianum*, locations of current populations, population sizes, and genetic analyses (Henry et al. In press) revealed the influence of human activities on population structure and have shown that the species was introduced in multiple sites

and subsequently dispersed to many other locations. A recent study (Dessimoz 2006) highlighted how distribution models of invasive species can be used to anticipate species expansion and support integrated management schemes.

At the opposite end, severe declines of several rare plant species have been documented in the Western Swiss Alps. Although extensive field campaigns directed effort to find additional populations at highly suitable habitats (MBS, Model-Based Sampling), these were unsuccessful and suggest that several rare species appeared to have declined further during the last decades (Le Lay et al. Submitted). Also, the updated habitat suitability maps predicted very small and fragmented suitable areas, suggesting possible difficulties in maintaining effective populations and ensuring the survival of the species. While human activities certainly remain the most important factor of risk for rare species, climate change could further exacerbate extinction risk for rare species.

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# Challenges and Opportunities for Sustainable Development in the Ukrainian Carpathians

After the adoption of Chapter 13 of Agenda 21, "Managing fragile ecosystems: sustainable mountain development", at the UN Earth Summit (UNSED, 1992), the awareness of the importance of mountain ecosystems and communities has increased. For Ukraine, this emphasized the significance of sustainable development within the main objectives of the market reforms. These reforms consist of democratisation and public participation in decision-making; economic liberalisation and privatisation of major productive assets; political, administrative and fiscal decentralisation; and a restructuring of the government (Nijnik and Oskam, 2004). The significance of sustainable development is especially high in remote rural areas of the Carpathians Mountains where the lack of constructive market

reforms negatively affects welfare of local communities and at times damages natural ecosystems. The response to the challenges of global environmental changes and of the market reforms in Ukraine thus lies in the application of the sustainable development concept to socio-economic and environmental conditions of a transitional economy.

## The Carpathians

The Carpathians are remarkable for their biodiversity. They are Europe's last great wilderness area and support large carnivores, with over half of the continent's population of bears, wolves and lynx. They are home to the greatest remaining reserve of old growth forests. Covering a total area of more than 200,000 km<sup>2</sup> the Carpathian Mountains

stretch across seven countries. These mountains are the place of diverse nations and nationalities with rich cultural heritage. The Carpathian forests are highly significant for a densely populated and highly urbanized European continent.

## The pivotal role of forestry in the Ukrainian Carpathians

The Ukrainian Carpathians extend throughout four of the country's administrative regions (called "oblast"), namely Lviv, Ivano-Frankivsk, Chernivtsi and Trans-Carpathian, with a population of nearly 5 millions, of which the inhabitants of remote rural areas comprise 12%. The remaining 88% of the population lives in urban areas. The Carpathians cover 4% of Ukraine's 603,700 km<sup>2</sup> territory, but their forests cover c. 21,000 km<sup>2</sup> of the 71,000 km<sup>2</sup> of the Ukrainian forestland and produce a third of the forest resources of this country (total country's standing volume of timber 17Bln m<sup>3</sup>, annual harvest in 2007 of over 12Mln m<sup>3</sup>). Forests occupy 53.5% of the Carpathian area and play a particularly important role in socio-economic life of the mountain communities. Forest industry and mountain tourism are the major profitable economic motions in the mountain region.

Principally, in Ukraine, all forests are publicly owned and 68% of them are managed by the State Committee of Forestry. The remaining 32% are divided among various stockholders, i.e. the Ministries of Agriculture and of Environmental Protection, other ministries, and around 50 public agencies, including local municipalities and educational organizations. Forestland in Ukraine includes 34,200 km<sup>2</sup> of protected forests handled for environmental needs, e.g. for tourism and recreation, ecosystem protection and conservation of biodiversity, and 36,900 km<sup>2</sup> of forests managed for timber production.



Figure 1: The Carpathian Mountains (source: TARG, <http://www.e-targ.org/>)

## Major challenges to sustainable development of mountain areas

### Implementation of sustainable forestry

Sustainable forestry is an important part of the National Strategy of Biodiversity Conservation in Ukraine (Ukrainian Parliament, 1997), of the Carpathian Convention “On the protection and sustainable development of the Carpathians” (2003) and of the Forest Code (1994/2006). Despite the government’s efforts to dedicate more resources to economic and social development of the Carpathians, their physical isolation alienates the remote communities from the opportunities accessible in other areas in Ukraine, thus holding back sustainable regional development (Hrycyshyn, 2003). Due to the state monopoly on timber harvesting many mountain communities do not share extensive profits from forestry. They have minor access to legal mechanisms for gaining recognition of their community-based property rights and especially for gaining decision-making power (Lynch and Maggio, 2002).

### Restructuring of property forms

The market reforms concerning restructuring of the forms of property in the wood-processing industry are almost completed (Nijnik and Oskam, 2004). Today, the share of collective and private ownership in the wood-processing industry prevails. This creates more opportunities for public involvement in decision-making in the industry, but without stimulating positive changes in forest management system, for example concerning timber harvesting.

Enterprises by forms of ownership	Forest and wood-processing industry, including	timber harvesting	wood-processing
State ownership	24.5	89.0	7.6
Collective ownership	75.1	11.0	91.8
Private	0.4	-	0.6
Total	100	100	100

Table 1: Types of Property in Forest and Wood-Processing Industry (in % to total timber production) (source: Estimations based on the data from the National Academy of Sciences, 2003)



Figure 2: Carpathian Highlands (source: Riznyk O., <http://www.olexa.com.ua/photos/>)

### Financial crisis and transitional institutions

In 1997, wood product enterprises and those of the cellulose and paper industry became collectively owned by the employees and became the main producers in these sectors. Their labour force currently comprises c. 90% of the labour employed in the industry, with the same share in the total value of production assets. However, as a result of the financial crisis and improper (transitional) institutions the sector is faced with market and governance failures (Nijnik and Oskam, 2004). The weakness of transitional institutions, i.e. of the prevailing societal formal and informal rules and competences, lies in stakeholders’ insufficient knowledge of the market economy, and therefore, in their slow responses to market changes, with the lack of their communication, motivation and trust. Moreover, govern-

mental structures often remain inflexible relying primarily on administrative regulatory policy instruments.

### Short-term financial considerations versus sustainability

On the one hand, the inherited administrative regulatory policy instruments remain in power, but on the other hand, short-term financial considerations govern the forestry practice. Consequently, the considerations to sustain and enlarge forest resources and ecosystem services are not always taken into account. Sustainability in forestry has also been upset by other accompanying transitional problems, e.g. shortage of investments, illegal logging, job losses, depopulation of mountain areas, and locally, by forest degradation (Bihun, 2005).

### Insufficient public involvement

Public involvement in decision-making has to be an important part of policy measures to sustain social, economic and environmental development. However, in mountain regions, it is still undermined (Nijnik et al., 2007). Mechanisms of public access to information concerning environmental and natural resource management have been developed through the parliament laws and legislative rules, but practical procedures are not transparent, restraining the public from being involved in decision-making and policy implementati-



on, at a local level. Insufficient control and often a lack of environmental awareness, both by local stakeholders and governmental agencies, add to the challenges of sustainable development in the Ukrainian Carpathians.

## Policy responses

In 2003, Ukraine together with Hungary, Slovakia, Czech Republic, Romania, Serbia and Montenegro signed the Carpathian Convention focused on the protection and sustainable development of mountain regions. The parties decided to cooperate for the protection of nature and sustainable development of the Carpathians. The goal of the convention was the improvement of the quality of life, a consolidation of local economies and communities, and the protection and enhancement of natural resources and the cultural heritage. They agreed on increasing environmental awareness and on improving public access to information concerning the protection and sustainable development of the Carpathians, and on assisting in educational arrangements and programmes. In 2006, additional measures that stipulate the environmental role of forests, especially in mountain areas, as well as community involvement in decision-making were added by the parliament to the Forest Code of Ukraine.

Despite these advancements on the policy level, the implementation of new measures, such as a well-targeted mechanism to enlarge the efficiency and sustainability of timber production and provide more financial incentives for local communities, is still needed. This mechanism includes: a clearer definition and assurance, on the ground, of property rights on forestland and timber harvesting; an increased commercial role of forests along with the protection of natural ecosystems and of the cultural assets; the promotion of democratic tools in governance, at a local level; an enhancement of institutional capabilities, e.g. abilities of stakeholders to adjust their behaviour, and to combine an individual and common interests and efforts in order to convert economical

and social changes into multiple outcomes that are beneficial for mountain communities, as well as to link scientific and local knowledge to attain a more sustainable forest management.

The strategy of sustainable development outlined in "The Carpathian Convention" (2003) foresees that both the level of production in forestry and its specialization (commercial forestry, agroforestry or forest tourism and recreation etc.) are to match the natural resources in the region and their regeneration potentials. The adaptation of sustainable development concept to the realities of the country in transition requires an adjustment of the complexity of existing institutions (e.g. rules, competences and governance) to the requirements of a market economy and to promote active involvement of local communities in decision-making and policy implementation.

A comprehensive, scientifically grounded strategy of long term development of the Ukraine's mountain regions calls for a mountain-specific research to target specific regional policy issues and the problems that concern imperfect market reforms in forestry, with the prevalence of the state monopoly on forestland and on timber harvesting, the dominance of

administrative regulatory instruments in forestry governance, short-term economic considerations in forest management practice, the shortage of financial investment in forestry, the lack environmental awareness among local people and of public involvement in decision making.

A new holistic vision and a participatory and interdisciplinary approach to the research are needed to successfully combine the protection, restoration and enhancement of natural resources with the raising welfare of mountain communities. Such problems, for instance, as unemployment and depopulation of mountain localities are to be addressed. More attention is to be given to multifunctional forestry, to evaluation of multiple forest resources and introduction of payments for ecosystem services, to the development of market conditions and setting-up economic incentives in forestry, particularly pertaining to timber harvesting, to initiation of environmentally sound economic and social activities in forests, and compensation of forest owners for ecological restrictions on timber harvesting, and to the increasing of forest's environmental role, of its resilience and adaptation to the changing climate.



Figure 3: Carpathian Highlands (source: Riznyk O., <http://www.olexa.com.ua/photos/>)



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## International Research Collaboration for the Development of Flow Forecasting Tools for the Upper Indus Basin in Pakistan

**Ongoing research by David Archer (JBA Consultants, UK) and Dr. Hayley J. Fowler (Newcastle University, UK) focusing on the hydroclimatology of the Upper Indus Basin (UIB) has been awarded a British Council “PMI2 Connect - Research Cooperation” grant.** The British team collaborates with Drs Muhammad Latif and S. M. Saeed Shah of the Centre of Excellence in Water Resources Engineering, CEWRE (Lahore, PK). Central to the upcoming stages of this work is a new PhD project begun in October 2008 by Nathan Forsythe in the School of Civil Engineering and Geosciences (CeG) at Newcastle University, with Archer and Fowler as advisors. The outcomes of this project should provide a greater understanding of the potential impacts of climate change on the Indus Basin water resources.

### Climate and Hydrology of the Upper Indus, including the upper Jhelum

Accurate and reliable forecasting of the Upper Indus Basin (UIB) river flows will be essential in developing effective strategies to minimise harmful impacts of hydrologic variability and optimise physical and economic returns from available water resources, particularly under changed climate conditions. Water from the Indus and its tributaries is the dominant supply source for Pakistan's irrigation, domestic consumption and hydropower demands (Khan et al 2002). Precipitation in the high mountains of the Karakoram and the contiguous Hindu Kush and Western Himalayas generates much of the runoff in the Indus Basin. Given the dependence of Pakistan's economy on flow in the Indus, this sensitivity has important consequences for the wealth and wellbeing of millions of people (Archer and Fow-

ler 2004). Good to excellent forecasting ability has been developed for flows in the Jhelum (Indus Tributary) using an empirical methodology requiring only locally measured observations as inputs (Archer and Fowler 2008). Development of significantly skilled forecasting tools is the practical, long term objective of the present work, which thus seeks to reduce remaining gaps in characterisation of local hydroclimatology.

### Scientific background

The previous findings serve as the foundation for the current project which will further develop empirical and physically-based (precipitation-melt-runoff) models intended for operational forecasting use.

### Hydrosphere: Hydrological regimes in the UIB including the upper Jhelum

Runoff in the UIB is composed of melt-water from both ephemeral snow and perennial glacial masses as well as direct winter or monsoon rainfall (Archer 2001). The contribution from these three sources of runoff (direct rainfall, seasonal snow and perennial ice) define three observed hydrological regimes characterising the sub-catchments within the Upper Indus Basin (UIB) (Archer 2003).

- Catchments with a regime dominated by direct runoff from rainfall have a flow regime that largely mirrors the precipitation regime except that any snow accumulated during the winter melts in early spring
- Catchments dominated by melt of an ephemeral snow cover accumulated during autumn, winter and early spring experience almost complete melt during late spring and summer. Peak flows thus correlate with prece-

ding winter and spring precipitation.

- High elevation catchments (mean elevation above 4400 meters asl) are dominated by runoff from melting glaciers and perennial snow where both the volume of summer runoff and the peak flow is correlated with summer temperature which controls the proportion of the catchment contributing to runoff.

These three regimes are exemplified respectively by the Siran (Phulra), Astore (Doyian) and Hunza (Dainyor Bridge) UIB sub-catchments shown on Figure 1. The percentage of annual runoff and rainfall occurring in each month for each of these sub-catchments is shown in Figure 2. Significant correlations between gauged river flows and observed climate variables – concurrent temperature or preceding season precipitation - indicate the sensitivity of UIB hydrology to both climate variability and gradually developing trends.

### Climatic patterns and trends in the UIB

There are highly significant spatial correlations in precipitation and temperature between valley stations across the UIB. For example, correlations coefficients between Astore and Balakot which are approximately 170km apart and separated by the Nanga Parbat peak (8125m) are 0.65 for monthly minimum temperature and 0.63 for winter (Oct-Mar) precipitation (Archer and Fowler 2004). This regional consistency supports the use of observations at key valley stations to characterise conditions across extremely large topographically varied sub-catchments, simplifying the data requirements for skilled empirical forecasting. In addition to correlation between different, distant valley systems, work is on-going to characterise the degree of correlation in climatic ob-

servations between stations at varying elevations within subcatchments. This work will quantify the relationships implicitly indicated by the success of the Jhelum forecasting exercise.

Regional trends (across the UIB) in temperature vary in direction and magnitude by season. Observed trends include significant winter warming, limited summer cooling and increased daily temperature range in all seasons (Fowler and Archer 2006). Declining summer temperatures are reflected in declining summer runoff between 1966 and 1997 on the Hunza catchment.

## Cryosphere

Given the importance of runoff from ephemeral snow and perennial ice to river flows in the UIB, a thorough understanding of physical processes in high elevation catchment areas is essential to improving flow forecasting

tools. Amongst previous work on UIB glaciology and snowfall meteorology, the follow points stand out in guiding precipitation-melt-runoff modelling:

- Although the very limited observations show high vertical and horizontal gradients in snow accumulation, snow pack measurements can provide very high correlations with runoff from ephemeral snowmelt dominated sub-catchments such as the Kunhar branch of the Jhelum (De Scally 1994).
- Although winter storms provide the primary annual accumulation volume, almost a third of observed high elevation solid precipitation occurs in summer (Hewitt et al 1989, Hewitt 1998).
- At the basin and sub-catchment scales a variety of remote sensing data (AVHRR, MODIS, LANDSAT-TM) products can be used to derive a spa-

tial time series of areal snow cover which can then be combined with DEM data to create input or calibration data for snowmelt runoff models (Winiger 2005, Immerzeel 2008).

## New Research

The main aims of the study are:

1. Establish links between large-scale atmospheric circulation patterns, local climate and hydrology in the Karakoram.
2. Use these linkages to establish multiple regression relationships between large-scale atmospheric predictors and local climate to allow the forecasting of seasonal flows to major reservoirs, e.g. Tarbela on the River Indus.
3. Calibrate a physically-based runoff model (accounting for winter-accu-

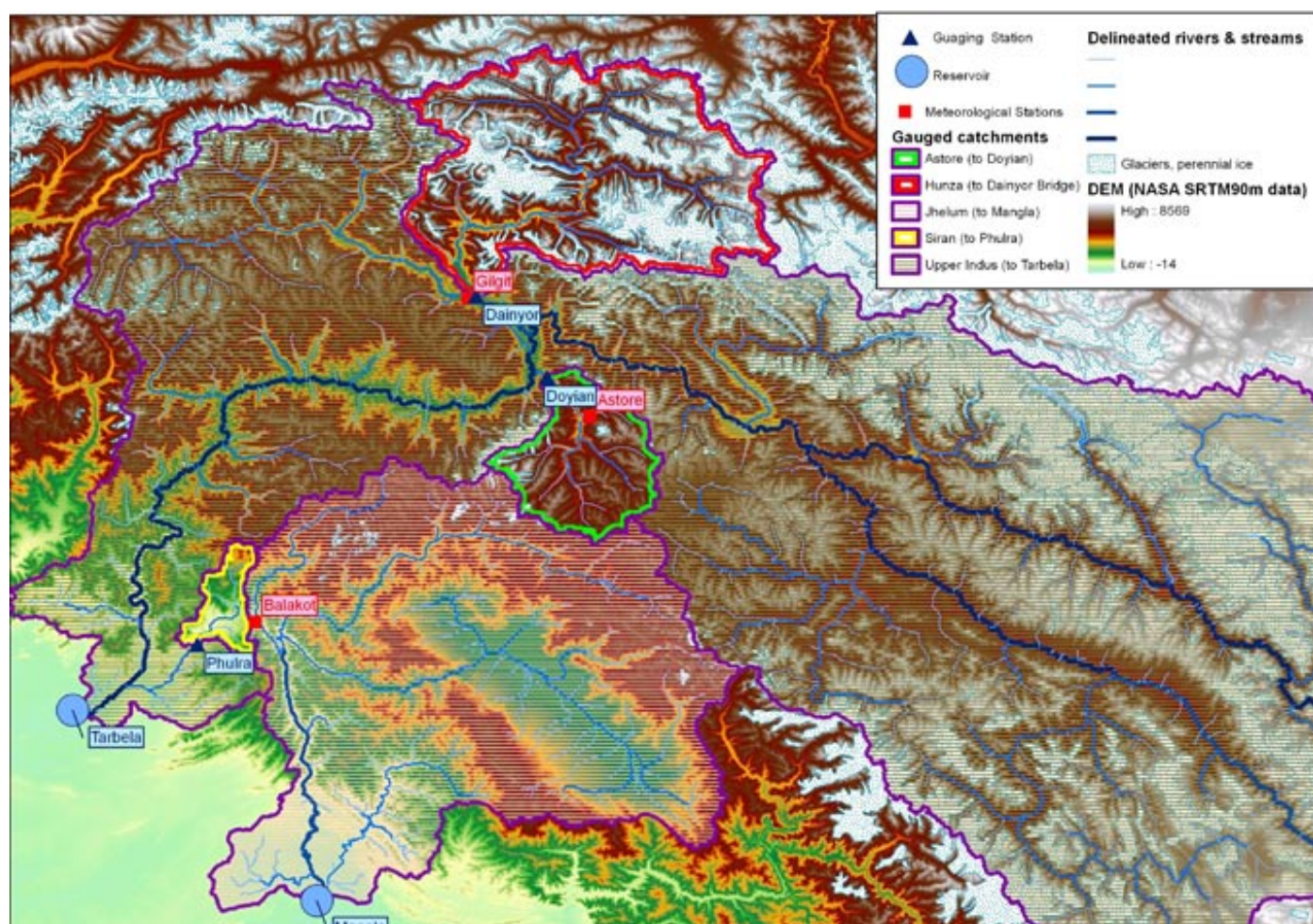


Figure 1: Partial map of Upper Indus Basin (UIB). The Map was produced from NASA SRTM DEM, ESRI Digital Chart of the World and point locations reported by D.R. Archer; it extends approximately from 72°E to 78°E longitude & 32.5°N to 37.5°N longitude



mulated snowpack and concurrent precipitation and energy inputs) of the Indus down to Tarbela reservoir to identify possible improvements in forecasting using a modelling rather than a purely empirical approach.

4. Use the modelling framework to examine the likely impacts of future climate change, as predicted by the most recent global and regional circulation models, upon water resources/availability in the region.
5. Examine management strategies with the potential to alleviate climate change impacts.

This research will involve collaboration with researchers at CEWRE (Lahore) and the Global Change Impact Studies Centre (Islamabad) in Pakistan.

Beginning in April 2009, researchers will consult stakeholders at the national and the local level within the UIB itself, the Pakistan Meteorological Department (PMD), and water resources management, and the Water and Power Development Authority of Pakistan (WAPDA). These consultations will present the scientific (hydroclimatological) aims of the project and solicit comment and discussion on the resource sustainability and management concerns of the stakeholders. Specifically decision makers will be encouraged to state what type of forecasting tools would be of most use to them in carrying out their responsibilities. This input will guide the development of empirical forecasting tools that will be the practical output of the project's hydroclimatological characterisation of the UIB.

Areas of scientific uncertainty addressed by the research include the current nature and rates of change in local temperature and precipitation; the state of mass balance for local glaciers and ice-fields; the influence of teleconnections – the influence of large scale air masses and sea surface temperatures – on local climate; the existence of local climate barriers or feedbacks; and the net implications of these phenomena on future water resource availability.

The research will complete and refine the initial analysis of the observed record, thus clarifying current local trends in temperature and precipitation largely through concerted consultation with Pakistan agency scientists. This completed observed record when combined “reanalysis data” (ERA40 by ECMWF)<sup>1</sup> for atmospheric pressure should provide indications of specific teleconnections and their relative strengths.

A variety of remote sensing data (precipitation, snow cover, cloud, etc) will be used to complement analyses of both local climate relationships and large scale teleconnections. Remote sensing data will also be used for construction of a physically based hydrological model. Modelling will be calibrated and validated with existing data, but future simulation will be driven by output from a regional climate model (Hadley

Centre PRECIS RCM) for the area. This program should provide insights into the implications of current and changed climate for water resources availability in near and medium term.

An already substantial body of UIB-specific research by David Archer and Dr. Hayley J. Fowler has led to both the award of a British Council PMI 2 Connect - Research Cooperation grant in collaboration with their colleagues at the Centre of Excellence in Water Resources Engineering (CEWRE) and the initiation of this new PhD project.

This project, undertaken by Nathan Forsythe, with financial support from the US National Science Foundation and Newcastle University as well as the British Council, will help to advance the research aims of better characterizing the hydroclimatology of the UIB, of identifying the probable impacts of climate

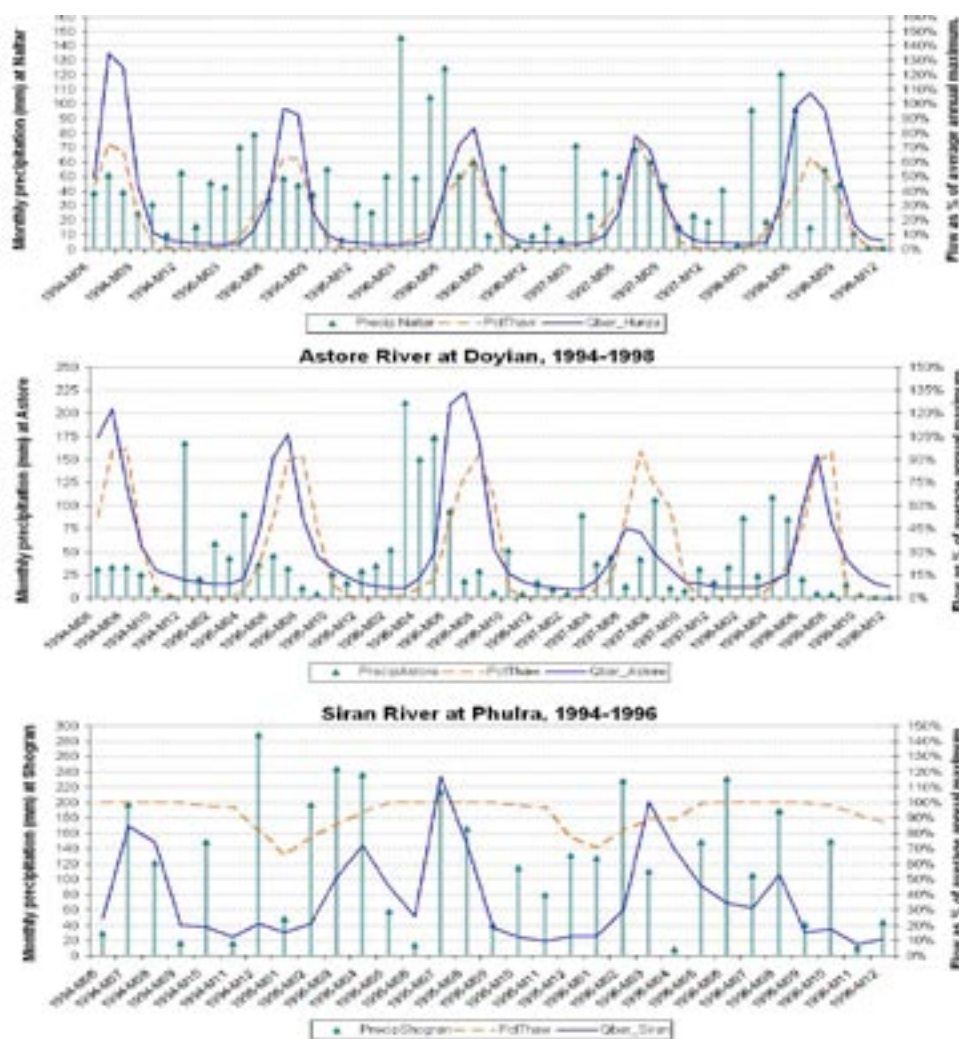


Figure 2: Relationships between flow and melting area and precipitation for 3 UIB sub-catchments



change on Indus Basin water resources and of developing forecasting tools for use by local decision makers.

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**1** ERA40 by ECMWF : ERA40 is reanalysis data for a wide range of atmospheric/climatic variables produced at the daily and sub-daily (specific hour) timescale for a period from 1958 to 2002 on a regular (2.5°x2.5°) global grid by the European Centre for Medium-range Weather Forecasting.

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# Colorado's Roaring Fork River: Incorporating Climate Change Projections into Watershed Management

**In 2008, a unique collaborative effort was undertaken to incorporate climate change into the watershed management and planning process for the Roaring Fork River in central Colorado.**

The nexus of climate change, natural variability, human population growth and development will put unpreceden-

ted pressure on water resources in the Western United States in the 21st century, creating new challenges for water resource managers. This pressure has major significance for resource management: while demand is increasing, supply is projected to decrease. High-elevation major tributaries such as Colorado's Roaring Fork River provide 85 % of the total Colorado River Basin flow (Milly

et al., 2005) – a critical water resource which makes settlement and agriculture in much of the Southwest United States and Mexico's Mexicali Valley possible.

## The Roaring Fork River Watershed

The Roaring Fork Watershed, located just west of the Continental Divide in central Colorado, covers roughly 3756 km<sup>2</sup> and spans multiple jurisdictions. The Roaring Fork River flows northwest from an elevation of 4348 m at Castle Peak to an elevation of 1803 m at Glenwood Springs where it empties into the Colorado River, which flows southwest to the Gulf of California. Because long-standing water rights have over-allocated the Colorado River, tributaries such as the Roaring Fork are now facing increasing water demands from both east of the Continental Divide, to the Denver and Colorado Springs areas (via tunnel diversions), and to the west, to satisfy the needs of growing cities such as Phoenix, Las Vegas and Los Angeles. Additionally, there is growing demand from Colorado's oil and gas industries.

Several mountain resort communities lie within the Roaring Fork Watershed, the most prominent of which is Aspen, Colorado. A key concern for the region, therefore, is whether mountain resort economies will remain stable under warming conditions projected to degrade snowpack/ski conditions and threaten the long-term viability of the local ski industry. Improved understanding of how climate-driven changes in seasonal conditions will affect tourism and associated industries such as hospitality services, recreational outfitters, and the second home real estate market – one of the Roaring Fork Valley's largest industries – is key to developing robust adaptive strategies for these commu-

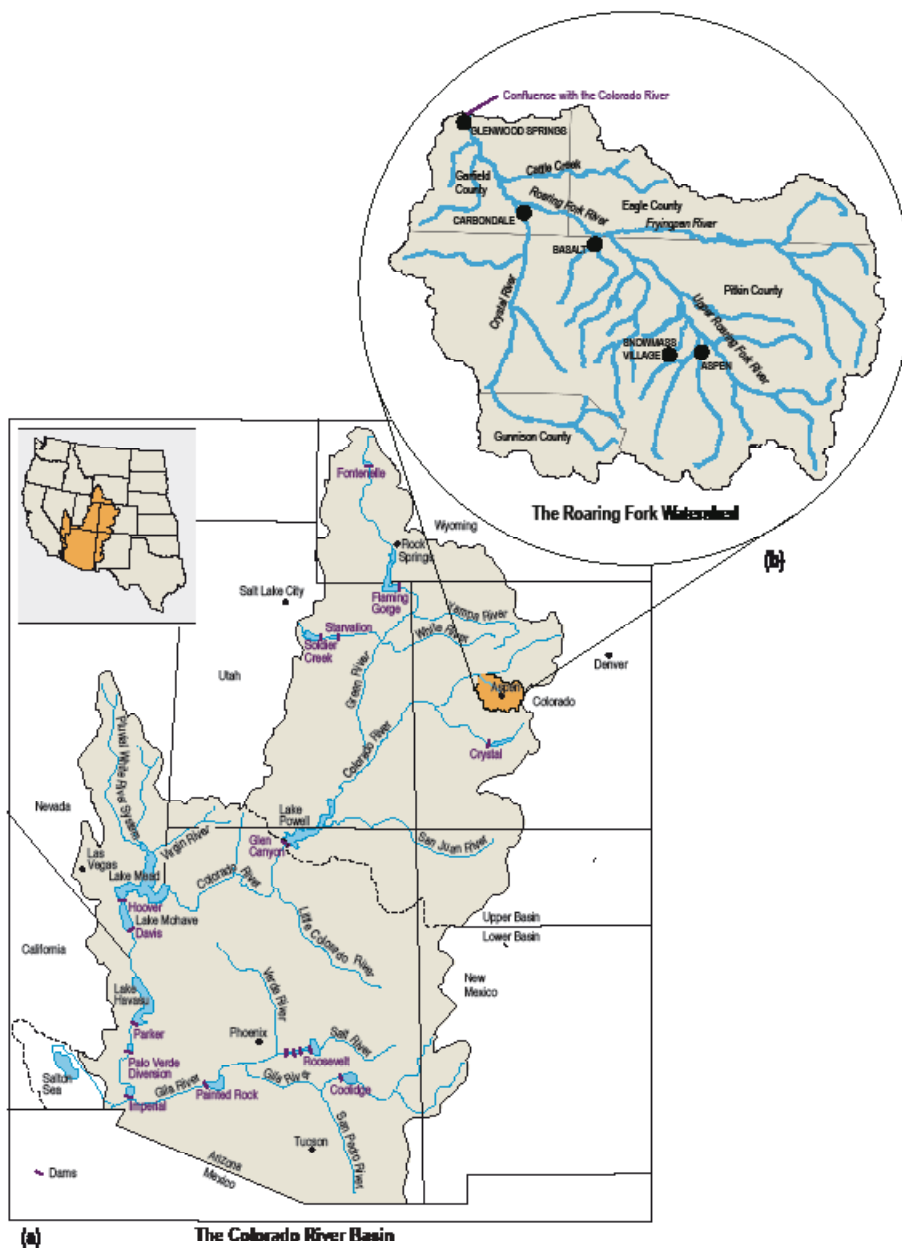


Figure 1: (A) The Colorado River Basin and (B) The Roaring Fork Watershed. (Source: (A) U.S. Department of the Interior, National Biological Service; Modified by Michelle Masone. (B) Clarke et al. 2008; Modified by Michelle Masone.)

nities. These considerations reinforce the crucial need for future watershed management plans and infrastructure to incorporate provisions for climate change-driven alterations to the hydrology, ecosystems, and socioeconomics of the Roaring Fork Watershed.

## Linking the Scientific, User, and Decision-making Communities

Founded as part of an effort to promote regional collaboration and integrated watershed planning, the Roaring Fork Watershed Collaborative is a public-private partnership involving over 50 local, regional, and state agencies and conservation organizations. A subset of the Collaborative, the Water Committee, serves to address water quality and quantity issues in the region and in 2007 began work on the development of a unified Roaring Fork Watershed Plan. Phase I of this plan, a comprehensive state of the watershed assessment, was led by the Roaring Fork Conservancy and sponsored by the Ruedi Power and Water Authority. The assessment identified and evaluated threats to the watershed such as flow alteration, habitat degradation, and point and nonpoint source pollution. This major underta-

king was published in 2008 (Clarke et al., 2008) and sets the stage for public input and discussion leading to the development of a Phase II management plan in 2009.

## Integrating Climate Change into the Watershed Planning Process

Recognizing the need to identify potential changes and vulnerabilities in advance in order to develop a sound management plan, the State of the Watershed Report devoted a chapter (Chapter 3.5) to assessing the likely climate change-related physical, ecological, and socioeconomic impacts to the watershed – including potentially critical changes to water supply and demand. Additionally, key recommendations were outlined for devising appropriate climate adaptation strategies in the context of other watershed issues.

### Approach

The Aspen Global Change Institute (AGCI) – a nonprofit institute focusing on issues in global environmental change – was approached to develop the climate-related content for the State of the Watershed Report. AGCI had previously conducted a climate impacts assessment

in 2006 for the upper Roaring Fork Watershed area encompassing the Aspen ski resort. The 2006 assessment utilized IPCC high (A1 FI), medium (A1B), and low (B1) emission scenarios and a multimodel approach to develop climate scenarios for the upper Colorado River Basin applied to the Roaring Fork River. Both statistical and dynamical downscaling were combined with snowpack and snowmelt/runoff models (SNTherm and SRM) to simulate future snowpack and upper basin flows (AGCI, 2006). Additionally, the 2006 AGCI report incorporated community involvement in the form of public discussions, stakeholder meetings, presentations, and in-depth interviews with stakeholders including city and county officials, planners, ski mountain managers, water managers, ranchers, and local recreational business owners. Results from this study were summarized in Chapter 3.5 and combined with a comprehensive literature review of other climate studies focusing on the Southern Rocky Mountains and the Western U.S..

### Climate–Watershed Interactions

Climate change drives a complex set of interactions within the Roaring Fork Watershed. These interrelationships are illustrated in Figure 2. Local environmental impacts such as land-use changes from increasing real estate develop-

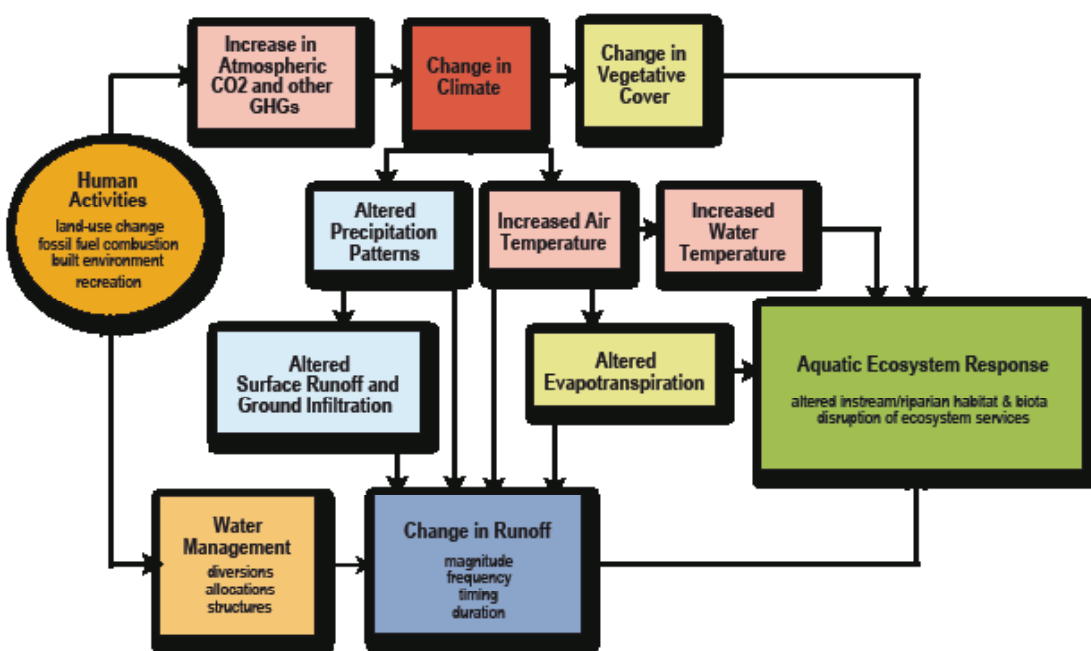


Figure 2: Climate change and watershed interactions. This diagram depicts the complex interactions between human and natural systems in the Roaring Fork Watershed. It serves as a useful conceptual model for engaging with stakeholders and decision-makers. (Illustration by Michelle Masone)

ment, energy prospecting activities, and declining agricultural operations are now being compounded by the regional effects of global-scale climate change. As the 21st century progresses, alpine aquatic and riparian resources will be increasingly impacted by warmer air/water temperatures, earlier spring runoff, shifts in species composition, and altered soil moisture and precipitation patterns (such as more precipitation falling as rain vs. snow). The combination of natural variability with human-induced climate change will likely alter water supply and demand in ways new to existing institutions and legal structures such as the Colorado River Compact (the Compact, originally signed in 1922, is an interstate agreement that allocates the Colorado River's water among the seven southwestern U.S. states). Climate change will additionally impact human uses of local water resources from irrigation and municipal supply to hydroelectricity generation and recreational uses such as snowmaking, boating, and fishing. Traditional management and legal agreements need to be modified to accommodate these new factors.

## Recommendations for Next Steps

Improved understanding of the risks associated with climate change can lead to adaptations that are anticipatory rather than reactive. Apart from the impacts of local change, the Roaring Fork Watershed is now responding to global forces that are external to local jurisdictions and institutions. This creates new challenges for local resource managers and planning efforts, and will likely force a re-evaluation of management practices. Key recommendations from Chapter 3.5 for incorporating climate change into watershed management plans include:

1. The initiation of an integrated assessment incorporating hydrological and regional climate modeling is needed to develop more complete understanding.
2. Water management plans should not be considered complete without provisions for climate change-driven impacts and adaptations.
3. River related infrastructure projects should incorporate future projec-

tions of streamflows based upon climate change research and should not rely solely on interpretation of historical flow/variability.

4. Research to assess the impact that significant global warming may have on present economic trends (real estate, tourism, recreation, and energy) should be undertaken.
5. Site-specific research and monitoring is needed to better understand the complex watershed interactions at work and improve projections of system-wide impacts and adaptive responses.
6. A re-examination of the legal framework of water allocations is needed to identify ways in which existing rights may be legally altered in anticipation of new threats from increased demand and altered streamflow as a result of climate change.

## Developing a Dynamic Implementation Strategy

Although the State of the Watershed report is an important first step, an in-depth integrated climate impacts assessment utilizing recent developments in regional climate and hydrologic modeling could help identify and quantify potential vulnerabilities beyond the more qualitative assessment provided in Chapter 3.5. The many interconnected variables at play in the Roaring Fork Watershed require a systems analysis approach to assess future threats and opportunities for preemptive action, along with active stakeholder involvement to help guide policies and procedures. One innovative example of this type of approach was conducted by Cohen and Neale for the Okanagan region in British Columbia. The approach engages stakeholders with local experts and scientists to develop adaptation strategies. The general framework combines climate change scenarios, hydrological scenarios, and water supply and demand scenarios, along with adaptation studies and dialogue with stakeholders (Cohen and Neale, 2006). A proposal for such an assessment for the Roaring Fork Watershed is currently in the exploratory stage. At the state level, the Colorado

Water Conservation Board has initiated a climate/hydrologic modeling study to provide water managers with future water availability estimates.

Adding human-induced climate change to the list of critical factors addressed in traditional watershed assessments and management plans is essential for devising sound strategies for watershed management in the future. As we move further into the 21st century, the challenge will be to identify and quantify potential vulnerabilities in advance so that adaptations can be built into the planning process, thereby reducing vulnerability and increasing resiliency to the impacts of change.



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## Weblinks

State of the Roaring Fork Watershed Report: <http://www.roaringfork.org/sitepages/pid272.php>

Aspen Global Change Institute: <http://www.agci.org>

# The Hydrological Atlas of Switzerland – Knowledge for Sustainability in the Alps

Almost twenty years ago the foundation stone for the Hydrological Atlas of Switzerland (HADES) was laid. At that time it was a pioneering project in the exploitation of scientific results and, thanks to many innovative measures, it is still of great use today. While the Atlas initially focused on presenting an overview of basic topics, the latest plates deal with single aspects and they contribute to the question of climate change. Thanks to the breadth of the topics included and the marked interdisciplinary approach adopted for the Atlas, it became an essential tool for addressing questions concerning water in the Alps. The Atlas promotes the understanding of hydrological processes in the Alps, and, consequently, plays an important role in the development of mountain regions.

## Structure and organisation of the Atlas

1992 saw the publication of the first set of HADES plates. Since then a total of 57 plates comprising some 200 themed maps, 610 diagrams, over 40 pages of tables and 228 explanatory texts in four languages have been produced. The Atlas is published by the Federal Office for the Environment and the Editor-in-Chief is Prof. Rolf Weingartner of the Institute of Geography at the University of Berne (collaborators: Felix Hauser, Alexander Hermann and Tom Reist). The Hydrological Atlas of Switzerland has served as a model for similar works in Germany and Austria, as well as certain German “Länder”.

The general scale of the Atlas is 1:500'000 for the maps, which allows for a satisfactory degree of detail. Its sections are: Fundamental Maps, Precipitation, Snow and Glaciers, Evaporation, Rivers and Lakes, Water Balance, Material Balance and Soil- and Ground-

water. It contains basic information such as overviews of measuring networks and mean values for the various parameters, but also specialised representation about, for example, more complex subjects such as low flow or extreme precipitation.

Both, basic information, and complex analyses cover the whole of Switzerland. In a country whose topography is dominated by mountains it is natural that one of the focal points of the Atlas should be the hydrologically relevant aspects of Alpine areas. Several plates refer to areas outside the Swiss borders and thus underline the hydrological importance of the Alps for lower lying countries and regions. Three of these plates are described in more detail below.

## Mean precipitation in the European Alps (Plates 2.6 and 2.7)

Plates 2.6 and 2.7 show mean annual, seasonal and monthly precipitation throughout the Alps. The seasonal variation in precipitation influences the composition of the natural vegetation and is partly responsible for discharge patterns in the rivers. Conclusions as to when natural dangers caused by precipitation (avalanches, storms, drought) are likely to occur can, in part, be drawn from the precipitation pattern over the year.

When climatological mapping of the Alpine region started in the 1860's, the representation of precipitation based on information provided by the few observation stations that existed was not very dependable. But as early as 1879 the Alps “from Vienna to Marseille” were divided into four characteristic regimes (Raulin 1879). This division not only distinguished between areas with maximum precipitation in spring and/or autumn and those with a maximum in

summer, but also enabled hydrologists to identify modifications of the regime linked to physical characteristics of the Alps themselves. The analyses were later refined and the results were interpreted in relation to predominant seasonal weather patterns. Today the density of precipitation measuring stations in the Alpine region is greater than in any other mountain range in the world (after Schwarb et al. 2001b).

The annual distribution of precipitation throughout the Alps is characterised by two marked wet bands along the northern and southern flanks of the Alpine chain. These bands represent regions of high precipitation; the southern band can be divided into two main zones (eastern and western). The two bands converge in the vicinity of the Gotthard Pass; otherwise they are separated by an internal drier zone which is particularly extensive in the Tirol (after Schwarb et al. 2001a).

Mean seasonal precipitation patterns for the whole Alpine chain and surrounding areas reveal a minimum in winter, a maximum in summer and intermediate values in spring and autumn (see Fig. 1). As in the case of annual precipitation, spatial distribution shows zones of higher precipitation along the edges of the Alps and in the adjoining mountain areas and a drier area towards the centre of the chain. This pattern is more or less marked depending on the season. In the Alps as a whole, winter precipitation values are below average compared with those for other seasons. The central areas, as well as Lower Austria and Carinthia, are especially dry in winter. In contrast, the adjoining mountain areas (Jura, Vosges, Black Forest) receive more precipitation in winter than in other seasons. These differences are less marked in spring, when particularly high rates of precipitation are observed along the southern edge of the Alps



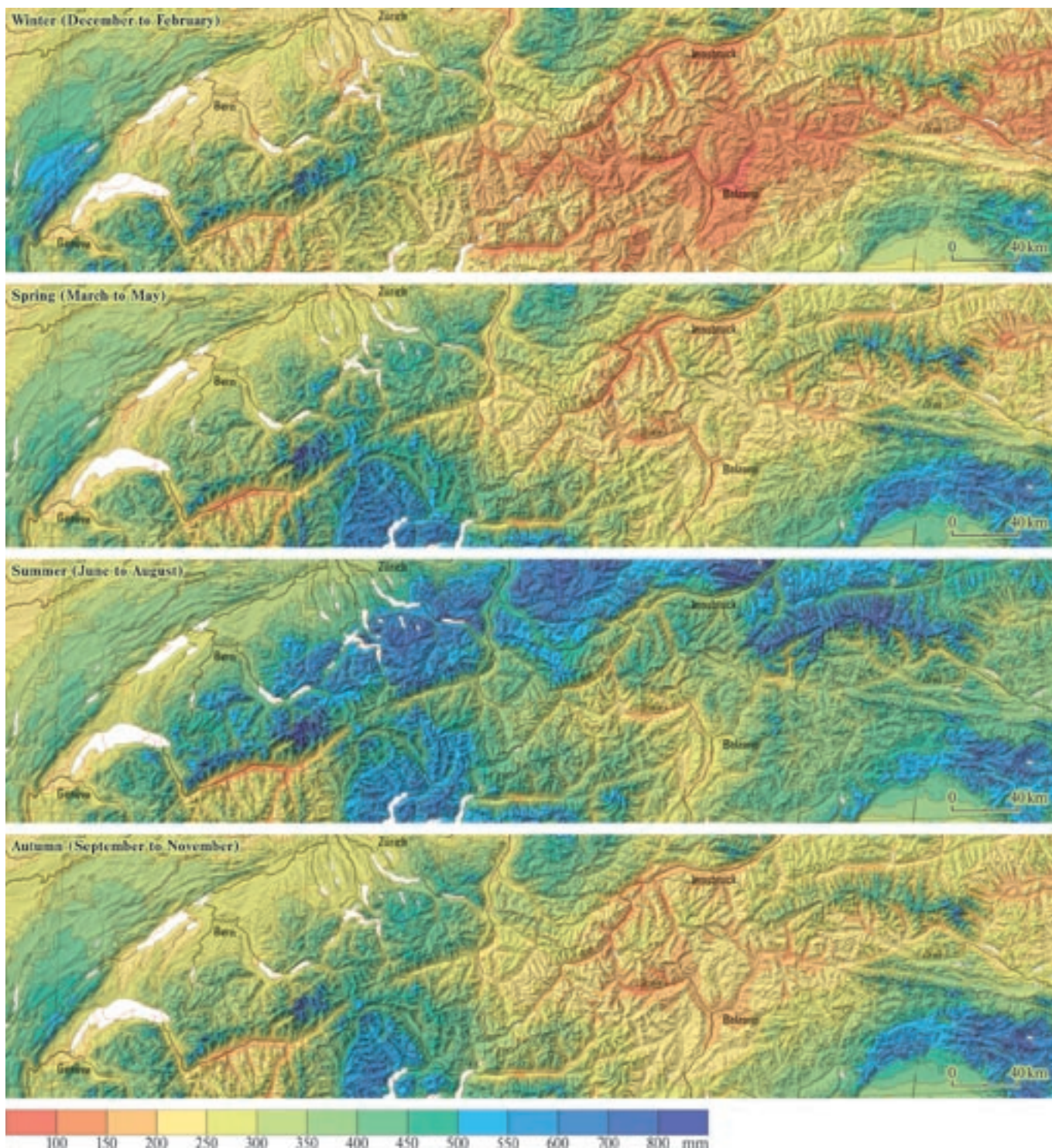


Figure 1: Mean seasonal precipitation throughout the Alps; database: approx. 6000 precipitation measuring stations (after Schwarb et al. 2001b)

(Tessin, Carnic and Julian Alps).

The highest rates of summer precipitation occur along the northern edge of the Alps. At this time precipitation is low on the Mediterranean coast and in the Apennines while the central and eastern Alps receive a lot of rain. This is mainly due to storms in the Alps and the Alpine foothills. Finally, the distribution of precipitation in autumn is similar to that in spring, the Massif Central (in France),

the Julian and Carnic Alps and the Dinaric Alps in particular receiving a lot of rain. Thanks to the high rate of evaporation from the warm surface of the Mediterranean, large quantities of water are driven northwards towards the Alps. For this reason, strong rainfall along the southern Alps is especially common in autumn (after Schwarb et al. 2001b).

### The hydrological significance of the European Alps (Plate 6.4)

As Switzerland is a mountainous country, precipitation is almost twice as high as in the rest of Europe, with a mean of some 1500 mm per year! Around one third of this volume of water evaporates and the remaining two-thirds forms major rivers that flow out of Switzerland



to lower lying countries. Europe's most important river systems are therefore strongly influenced by hydrological condition in the Alps, which is the subject addressed in plate 6.4 of the Atlas (Viviroli, Weingartner 2004).

If one compares the volume of water in the Rhine at Basle with the total discharge of the Rhine in the Netherlands the influence of the Alps becomes clear. The area of the Rhine catchment as far downstream as Basle constitutes only 21% of the total Rhine basin, but contributes on average 47% of the total annual discharge. The alpine region thus generates twice as much water as would be expected on the basis of the catchment area. The hydrological importance of the Alps is especially marked in summer, when in Germany, France and the Netherlands only a small proportion of their total precipitation reaches the river, owing to the high rate of evaporation. In summer, over 60% of the water in the Rhine originates in the Alps! There is a regular seasonal pattern of discharge from the mountains, with the water being stored as ice and snow in the

winter and then released as melt-water in spring and summer. This pattern has an important function in that it balances out the discharge in the Rhine. Similar phenomena can be seen in the case of the R. Rhone (see Fig. 2) and the R. Po.

Without the influence of the mountains the volume of available (blue) water per head of the population per year in Germany would fall from 2170 m<sup>3</sup> to 1305 m<sup>3</sup>, in the Netherlands from 5760 m<sup>3</sup> to only 695 m<sup>3</sup> – values that would cause serious shortages. By comparison, in theory each person in Switzerland has 5800 m<sup>3</sup> of water at their disposal each year, of which only 3% are used (450 litres per inhabitant per day). Thanks to the favourable natural features of the Alps water is abundant in Switzerland and is used to the best advantage through good infrastructure and excellent water management (after Hauser et al. 2005).

### What the future holds

In 2010 a final set of plates will be added to the Hydrological Atlas of Switzerland.

This does not mean that the project will be completed, however. According to the Swiss Geo-Information Act of 2008, the federal authorities are obliged to publish hydrological data in a suitable form. Thanks to technological developments, a large part of the information will be presented via a digital platform, which will involve collaboration with the team responsible for the Atlas of Switzerland at the Institute of Cartography of the Swiss Federal Institute of Technology in Zurich. Furthermore, the currently available data will be expanded to include GIS data. Analogue, printed maps will continue to play an important role as comprehensive, user-friendly working tools, however. In addition, the vast knowledge contained in the HADES about presenting basic and specialised hydrological information will continue to be put to use to offer specific services to meet the needs of various target groups that have one thing in common: a lively interest in water in all its forms (see information box "Teaching material and excursions").

## Teaching material and excursions

**Today HADES is a comprehensive platform** that focuses on the subject of water: apart from the maps, whose information can also be accessed digitally via the internet, there is a selection of teaching material for high schools. This material consists of six work-sheets including text, illustrations and graphs, work projects for pupils and an accompanying commentary for the teacher. Each work-sheet focuses on current hydrological topics such as snow and tourism, glaciers, floods, hydro-electric power, the water balance and the protection of watercourses.

**With its series of excursions under the heading "Discover the world of water"**, the Atlas aims to create public awareness of the uses, changes and dangers surrounding Swiss watercourses. The guides are ideal for individual use, and are aimed at tourists and high schools, as well as people working in the field of hydrology – in fact anyone who is interested in water. All the guides have been written by a team of experienced specialists. They offer excellent insights into the individual topics, and encourage active observation and curiosity. These pocket-size booklets (10.5 x 14.5 cm) include text, illustrations and maps and a list of reference material, plus further useful information for the excursion. These excursions are fun and educational: enjoy your natural surroundings and go home with a new understanding of Switzerland's water and watercourses.

**The guides in this series that have already been published** (in German) include: a set of guides for the Zurich region covering the condition of the watercourses, hydro-engineering projects, ground water, the use of water and urban watercourses; a set for the Brig–Aletsch region covering glaciology, water supply and flooding; a set for the Davos region covering snow, avalanches and Alpine hydrology; and finally, a set for the Lake Geneva–Jura region (in French) covering karst landscape, urban watercourses and catchment hydrology.

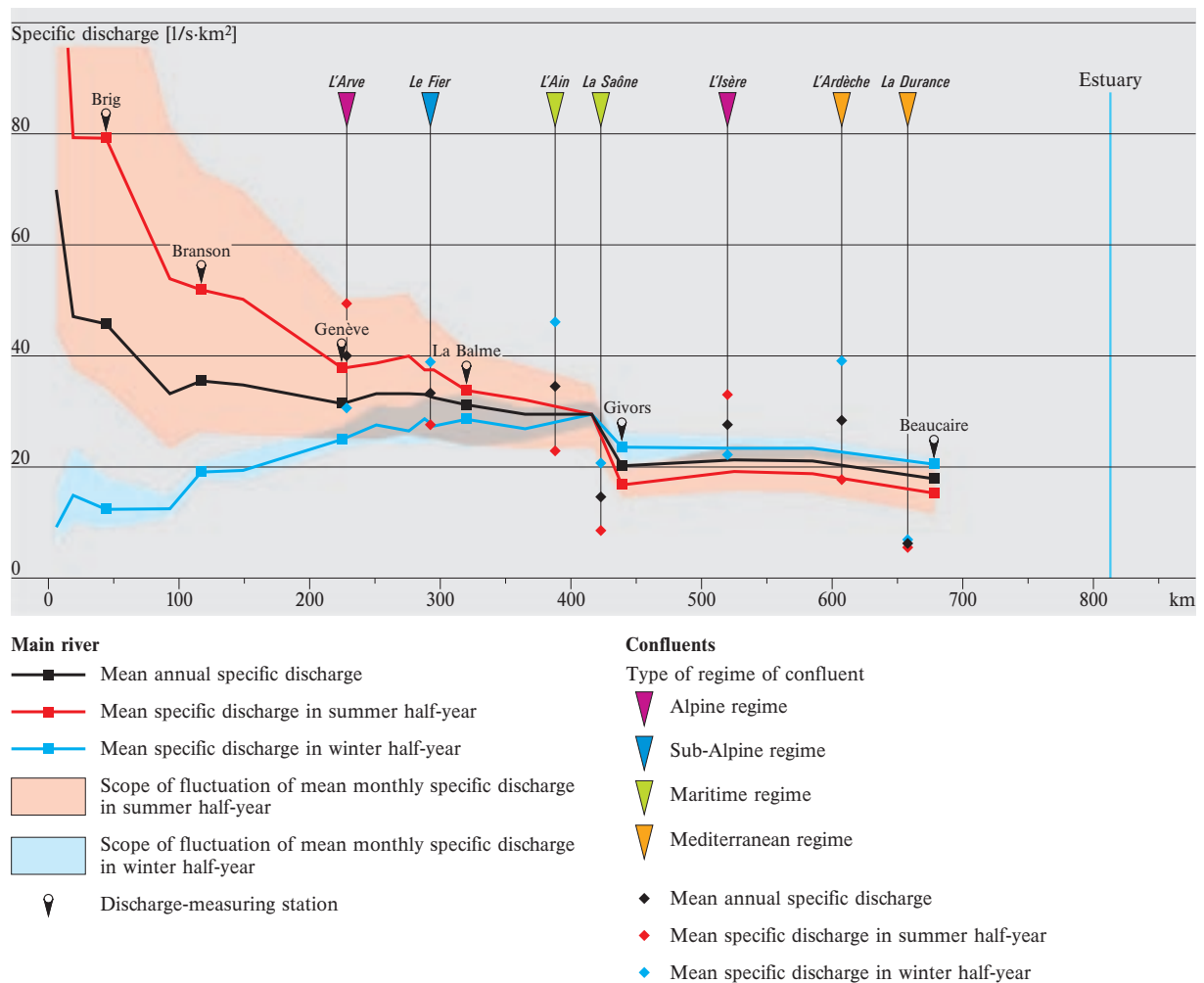


Figure 2: Pattern of specific discharge along the R. Rhone (after Viviroli, Weingartner 2004)

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## Weblinks

Hydrological Atlas of Switzerland  
<http://www.hydrologie.unibe.ch/hades>  
 Federal Office for the Environment  
<http://www.bafu.admin.ch/index.html?lang=en>

# MRI Europe Progress Report



## Editorial

**The stalks of wheat and many other types of grasses produce nodes that temporarily slow down the vertical growth of the plant.** The MRI Europe Program has currently developed such an enlarged node, halting its activities at a lower level in order to define its new identity somewhere between the old MRI Office in Bern and the new affiliation with the “Forschungsstelle für Gebirgsforschung” (IGF) in Innsbruck. The node is also the result of getting settled in a new team, of getting acquainted to new financial procedures, and of bridging the gaps between the Swiss and Austrian administrations.

As with plants, this node makes sense. The temporary halt will contribute to the long-term stability and resilience of the MRI Europe Program, enabling a sustainable growth of the Global Change research community in Euro-

pean mountains and finally, yielding a rewarding harvest!

In fact, the MRI Europe Program reached an extent that not only nourishes inspiration and creativity but also enables high efficiency and smooth operation. Never before the science network offered such fertile ground enabling members to capitalize on existing expertise and experiences, to draw on plentiful resources from 1200 network members interested in Global Change in mountain regions. Obviously, the phase of node formation is going to be completed so that the vertical, thus quantitative growth of the MRI Europe Program can be resumed.

**Associated with quantitative growth is the danger of losing qualitative information** that goes beyond technical data and address books. The MRI Europe Program, but equally other regional MRI networks, always attached great importance to personal contacts with individual network members. This is highly time intensive (e.g. for writing personalized emails) but rewarding in terms of lasting research relationships that ultimately contribute to the success of new research projects and initiatives. Personal contacts create commitment and reliability also in times when projects slow down to produce a “stabilizing node”. Last but not least, personal contacts are vital to the spirit of a science network and mark the difference to net-

works, which are mainly built on databases and internet communication tools.

**Exceeding the 1000 member threshold, however, the MRI Europe Program** might have reached a size where the mere update of the “who’s who” list consumes an unacceptable amount of the program managers’ working time. Has the European MRI network reached the limits of growth? For those who have ever browsed the member list of the MRI Europe Program searching for people with specific expertise with a narrow geographic focus the answer would clearly be “No”. No, since the network has gaps, both geographical and thematic. Certain disciplines, mainly from social sciences, are poorly represented although interdisciplinarity in mountain research is one of the main objectives of the program. Although the network improved its balance regarding membership in the countries of Central and Eastern Europe, the representation of the Southeastern European countries is still very low. Hence, the program must grow although this growth draws from limited financial and human resources.

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## MRI Europe - Focus 2009

In 2009, the MRI Europe Program keeps its focus on mountain systems that have been neglected in the past, namely the Carpathians and the Balkan Mountains, leaving the Alps to the International Scientific Committee on Research on the Alps (ISCAR), with which the Program continues to cooperate.

## Science for the Carpathians

In the wake of the launching workshop of the Science for the Carpathians (S4C) network in Kraków, Poland (28-29 May 2008) that aimed at assessing the current state of Global Change research in the region and at developing first ideas for a Carpathian Research Strategy, the S4C initiative became visible through various means. The S4C electronic Newsflash informing the 320 network members about current and future activities in the field of Carpathian research is complemented by a S4C website documenting its progress. Part of the progress is the growth of the "S4C List", a simple spreadsheet with names and expertise of the numerous network members that actually embody the initiative.

As a product from the Kraków workshop, a synthesis paper on "Global Change Research in the Carpathian Mountain Region" with 15 co-authors has been submitted for publication. The paper reviews the current status, identifies knowledge gaps and suggest avenues for future research. From the same occasion, a workshop report was compiled by the Institute of Geography and Spatial Management, Jagiellonian University, and published by the MRI Bern

Office. The workshop report comprises background information, abstracts from presentations and posters, and results from the thematic working groups. These products testify the interest, willingness and active support of the S4C community to give the Carpathian mountain research a new impetus and profile.

To sustain the S4C network on a long-term basis, the initiative needs to be formally established in the region. On the one hand, this requires financial contributions from the Carpathian countries to support, for instance, a part-time position of a regional S4C Program Manager. On the other hand, it needs the commitment of a critical mass of mountain researcher and their institutions in form of a S4C Steering Committee or Advisory Board. For this

purpose, i.e. to move the S4C network to the desired direction and to connect researchers from the Alps and the Carpathians, a 2nd S4C Meeting has been scheduled for 9-10 June 2009 at the Slovak Academy of Sciences in Bratislava.

The scientific part of the workshop (Day 1) will focus on "Securing the Sustainable Provision of Ecosystem Services" in two major mountain systems: the Alps and the Carpathians. The institutional and planning part of the workshop (Day 2) targets at

- (i) the formation of a S4C Steering Committee,
- (ii) the preparation of the first Forum Carpathicum scheduled for 15-17 September 2010 in Kraków, Poland, and
- (iii) the discussion between representatives of National Science Academies



Figure 1: Mt. Sivy vrch and Mt. Ostra in Western Tatra Mts. (N Slovakia) Author: Luboš (Lubos) Halada (photo by Lubos Halada)



and Carpathian scientists on the long-term establishment of S4C.

The collaborating partners are the Research Unit for Mountain Research (IGF, Innsbruck, Austria), the Institute of Landscape Ecology, Slovak Academy of Sciences (Bratislava, Slovakia), the Institute of Geography and Spatial Management, Jagiellonian University (Kraków, Poland), the International Scientific Committee on Research in the Alps (ISCAR, Bern, Switzerland), the Swiss Academy of Sciences (Scnat, Bern, Switzerland), the Austrian Academy of Sciences (ÖAW, Vienna, Austria), the Interim Secretariat of the Carpathian Convention (Vienna, Austria), EURAC (Bolzano, Italy), Joanneum Research (Graz, Austria), and the MRI Europe Program.

The Bratislava Meeting is a good example of the smooth and efficient collaboration between institutions and individuals of the MRI Europe network, which was facilitated mainly through personal contacts that prepared the necessary “fertile ground”.

## Science for Southeastern Europe

Scientists in Southeast Europe expressed interest in developing a science network for Global Change research in the mountains of Southeastern Europe, which are plentiful, spectacular and diverse! The evolution of the Carpathian science network is an encouraging example for other regions that have undergone strong political, historical and environmental changes during the last decades.

The international conference on “Identifying the research basis for sustainable development in the mountain regions of Southeastern Europe” in Borovets, Bulgaria (24-26 April 2009) will be crucial for the preparation of the “Balkan Convention” but similarly, lay the foundation for the establishment of a science network within the region. The MRI Europe Program will be supportive in facilitating this process. Similar to S4C, the long-term vision is a regional science network steered and controlled by scientists from Southeast Europe.

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## Weblinks

MRI Europe

<http://mri.scnatweb.ch/mri-europe>

MRI Carpathians

<http://mri.scnatweb.ch/networks/mri-carpathians/>

Bratislava meetings June 2009

<http://mri.scnatweb.ch/events/mri-events/>

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Photos banner p.39: Spiš castle and Spišské Podhradie, E Slovakia (by Tatiana Hrnčiarová); Erlenbach, Switzerland (MRI); Exkursion of the Forest Ecology Group, ETH Zürich, Switzerland (MRI); Chočské vrchy Mts. (N Slovakia) (by Ľuboš Halada).

Photos banner p.40: View from Wildstrubel, Switzerland (MRI); Mountain Forest above Walensee, Switzerland (MRI); Traditional land use in the Biosphere Reserve Eastern Carpathians, village Jalová, NE Slovakia (by Ľuboš Halada); Bratislava castle, Slovakia (by Tatiana Hrnčiarová).

# News from GCRN\_AM, the Global Change Research Network for African Mountains

As noted in the previous MRI News, a major task of the GCRN\_AM has been to develop in-depth profiles of current global change research at mountain sites in Africa to characterize what exists now and to discern gaps that should be filled if we are to achieve inter- and transdisciplinary research programs.

MRI has been reviewing information from researchers who participated in the Kampala workshop and soliciting information from other researchers. MRI is using the Global Land Project's (GLP) analytical structure (see Fig. 1 of the GLP portrait on page 46) from the GLP's Science Plan (GLP 2005) as a framework with which to understand the orientation of each project.

**The GLP science plan posits the overarching themes,** which are themselves linked together by the dynamics of the coupled human-earth system. The first theme Dynamics of Land Systems focuses on the causes of change in land systems, with some changes driven directly by the larger earth system, while others are anthropogenic. The second theme, Consequences of Land System Change follows the feedback mechanisms, whereby changes in the land system affect the larger earth system and human societies, which in turn create new pressures on land systems. Finally, the third theme; Integrating Analysis and Modeling for Land Sustainability focuses on the evolution of the land system itself, particularly, loss of options, vulnerability and governance. This scheme, while developed with all land systems in mind, is very useful for MRI, as it provides an overall framework within which to categorize the specific topics of the GLOCHAMORE strategy and those pursued by individual research projects.

Figures 2, 3 and 4 portray draft examples of how different research projects fit within the GLP scheme. Most projects gather data (shown as a call-out rectangle) and examine relationships (shown as a call-out oval). The work of Andreas and Claudia Hemp and their collaborators on Kilimanjaro (Fig. 2) show a great number of activities concentrated principally on the drivers of land systems and their internal functioning. In contrast, Figure 3 shows the work of the African Highlands Initiative at the Galessa site in the highlands of Ethiopia summarized by Admassu et al. (2008). The AHI did a considerable volume of work concentrated principally on what the GLP calls the social system: the cropping and livestock technologies available and the factors determining their use. Figure 4 portrays the work by Kiteme et al. (2008) on Mt. Kenya, oriented largely around the water resources of the mountain. While this group

may not have the detailed information that the previous two groups had on specific parts of the coupled human- earth system, it did however create a very coherent picture of the whole system.

Obviously this work remains incomplete, as for instance, we have yet to capture important other research on Kilimanjaro. But as this work proceeds, we hope to produce a detailed summary of the kinds of research that have occurred in different important African mountain regions. This summary could then serve as the basis for a discussion about a more comprehensive interdisciplinary research program that addresses similar concerns using comparable methods over multiple mountain sites in Africa, and, with this, for an understanding of the coupled human-earth system as sketched the GLP analytical structure.



Figure 1: View on Lake Batoda (4017 m asl) in the Batoda Valley. Tree groundsel forest covers most of the slopes, and Carex tussocks most of the bog surface (photo Hilde Eggermont)



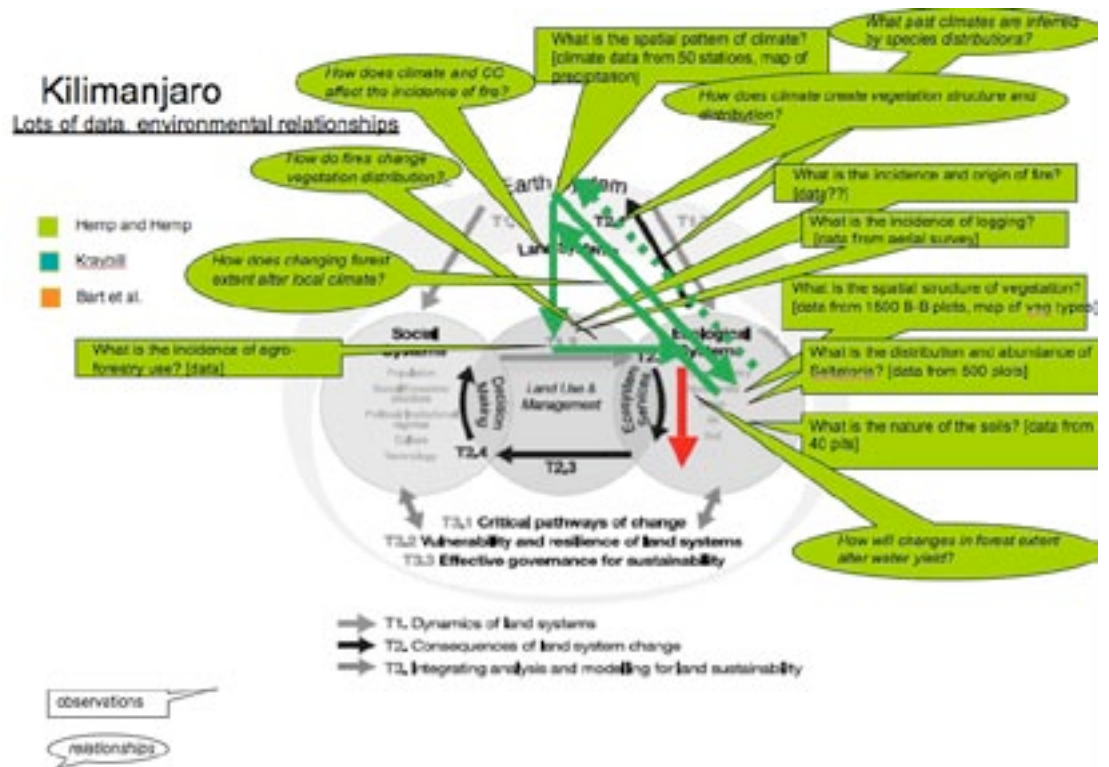


Figure 2. Research of Andreas and Claudia Hemp on Kilimanjaro (Hemp, pers. comm.) Note that the research of Bart et al. and D. Kraybill has not yet been placed with the framework.

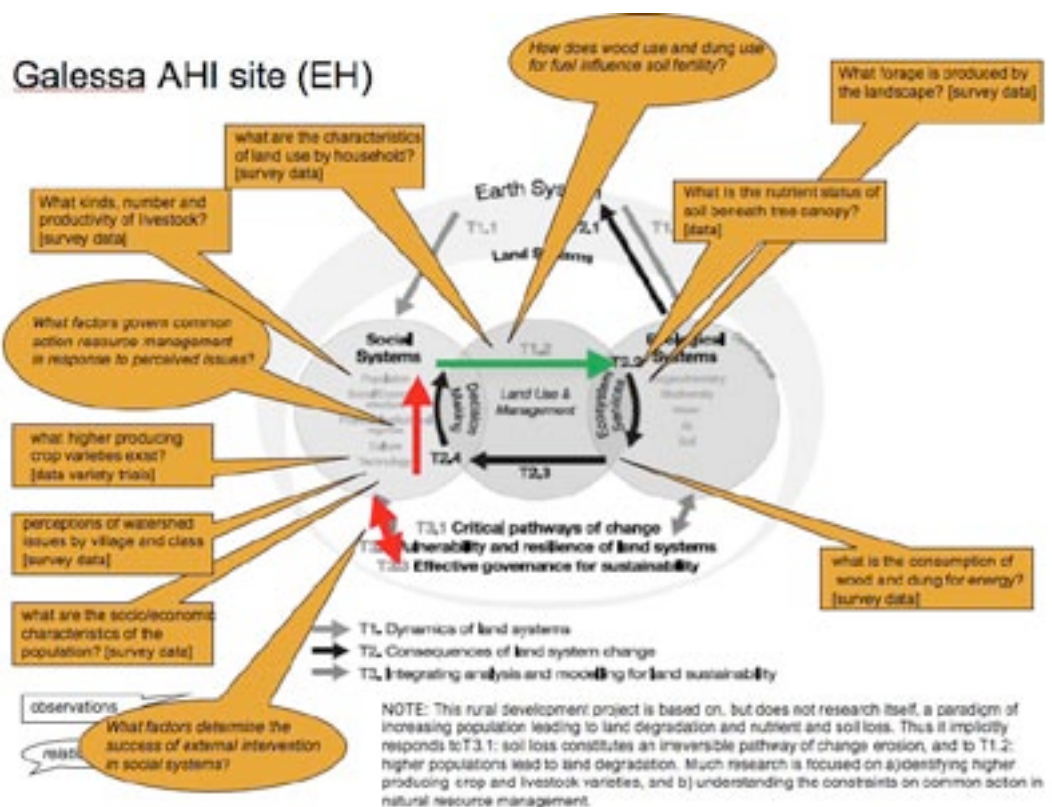


Figure 3. Research by AHI at the Galessa site in the Ethiopian Highlands ( Admassu et al. 2008)

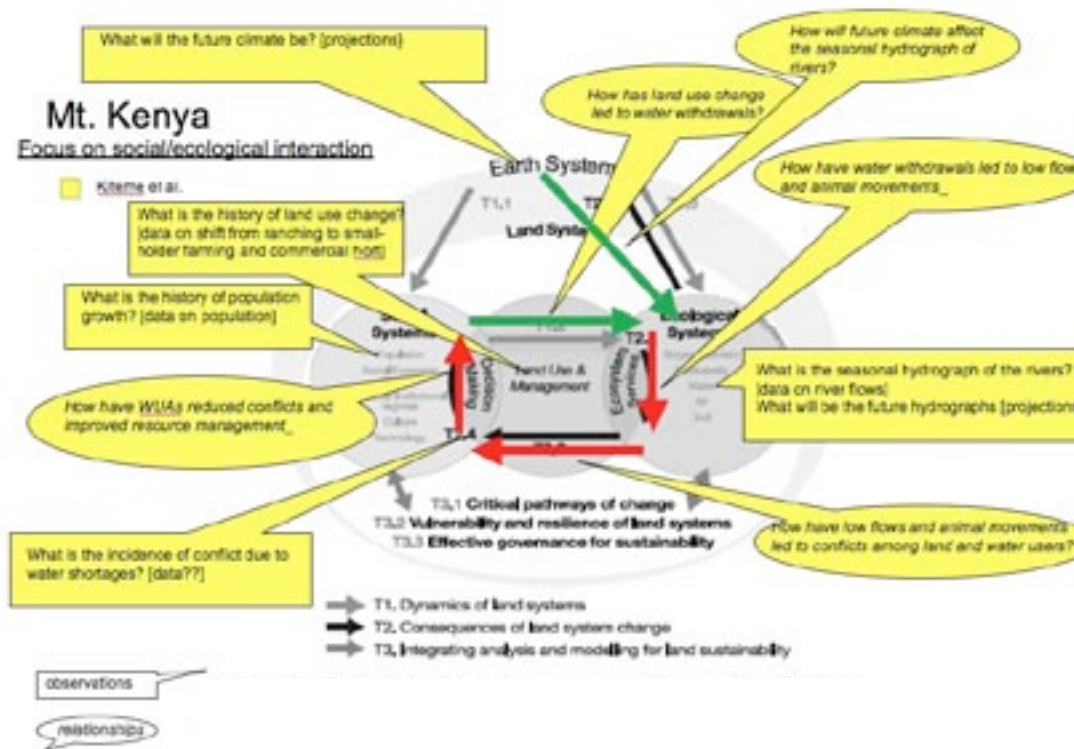


Figure 4. Research by Kiteime et al. (2008) on Mt. Kenya

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## Weblinks

GCRN\_AM: <http://mri.scnatweb.ch/networks/mri-africa/>

Launching Workshop, Kampala, Uganda, 23-25 July 2007:

[http://mri.scnatweb.ch/events/mri-events/gcrn\\_am-kampala-workshop-july-2007.html](http://mri.scnatweb.ch/events/mri-events/gcrn_am-kampala-workshop-july-2007.html)

African Network for Earth System Science (AfricanNESS): Eric O. Odada, University of Nairobi, Kenya, eodada@uonbi.ac.ke

Consultative Group on International Agricultural Research (CGIAR)/African Highlands Initiative (AHI):

<http://www.africanhighlands.org/>

Global Mountain Biodiversity Assessment: <http://gmba.unibas.ch>

Global Land Project (GLP): <http://www.globallandproject.org/>

International Council for Science (ICSU)/Regional Office for Africa (ROA): <http://www.icsu-africa.org/>

Iphakade Conference: <http://www.humboldt5.uct.ac.za/>

Diversitas Open Science Conference 2009: <http://www.diversitas-osc.org/>

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Admassu, Z., Mekonnen, K. and Gojjam, Y., eds.. 2008. Working with Communities on Integrated Natural Resource Management. Ethiopian Institute of Agricultural Research, Addis Ababa. 137 pp.

Kiteime, B.,P., Liniger, H.P., Notter, B., Weismann, U. and Kohler, T. 2008. Dimensions of Global Change in African Mountains: the Example of Mount Kenya. (IHDP Update October 2008, issue 2 "Mountainous Regions: Laboratories for Adaptation", pp 18-22).





# The Americas Cordillera Transect for Global Change Research

## History and objectives of the network

The goal of the Americas Cordillera Transect (ACT) is to enhance research on global change drivers, impacts, and adaptation along the American Cordillera. It does so by invigorating mountain studies implementing the GLOCHAMORE Research Strategy, and by stimulating multidisciplinary approaches and inter-American exchange and coordination.

ACT started as an output of the 2006 CONCORD meeting organized in Mendoza, Argentina, by a consortium of South- and North-American partners that included MRI. This meeting was the first inter-American conference on global change research along the American Cordillera and brought together key scientists working on global change in the Cordillera of North and South America. Presentations over three days yielded insights into topics, methods and findings of current global change research along the American Cordillera. The participants defined the urgent topics with respect to earth system functions and to impacts on people and resources. The conference also aimed at putting disparate efforts into a replicable and reliable methodological framework.

Immediately following the CONCORD conference, MRI and UNESCO MAB chaired a workshop on the creation of an American Cordillera Transect (ACT). This workshop offered the opportunity to sign up for concrete collaboration on specific research themes in sites along the American Cordillera, addressing the issues raised during CONCORD. Experienced mountain scholars and an enthusiastic cadre of young researchers interested in the study of climate change in the mountains of the Americas defined three main goals for ACT:

1. To improve networking by expediting the exchange of information on proposals, projects, and results in the region.
2. To lobby in favor of mountain research within the context of national research programs and the Inter-American Institute for Global Change.
3. To influence research funding by access funding sources and research brokers who could support young researchers with unconventional, critical questions, particularly related to the role of the human dimension of climate change in the Andes.

MRI developed an ACT logo, a website, and a Newsflash, produced and distributed every second month.

In 2007 MRI organized an ad hoc Steering Committee, composed of Miguel Saravia (CONDESAN, Peru) Ricardo Villalba (IANIGLA, Argentina), and Fausto Sarmiento (UGA, USA) to advise

on further directions. MRI provided leadership and facilitated email discussions and tele-conferences of the Steering Committee with senior scientists (Raymond Bradley, Henry Diaz, Stephen Bender, Ricardo Villalba) and key players, including the Mountain Institute (Jorge Recharte) and the Mountain Forum-InfoAndina/CONDESAN (Miguel Saravia).

The SC concluded that the goals could only be achieved with a coordinator who would

- establish the networking via a regular Newsflash,
- develop scenarios of collaborations with IAI and,
- initiate interdisciplinary proposals and help them to find funding.

MRI convened an agreement with Fausto Sarmiento whereby he would act as coordinator of ACT.

At the same time MRI worked with Alvaro Duque (Universidad Nacional de Colombia), and Nate Stephenson



Figure 1: Students collecting box samples for our project on the paleoenvironmental reconstruction of the Cauca Lake in the northern Andes of Colombia (photo by José Ignacio Martínez, Universidad EAFIT, CO)



(USGS) to promote CORFOR, the Cordillera Forest Dynamics Network, as part of the larger ACT. CORFOR is a collaborative, open, network of scientists and institutions, focused on understanding forest responses to global changes in mountainous ecosystems along the American Cordillera. CORFOR held its first workshop as part of the MTNCLIM meeting in Silverton, Colorado, USA, in June 2008 (see weblinks).

## Progress Report 2008

### The ACT Newsflash:

- March 2008: Call to 1'500 scientists in South- and North-America to alert them of the existence of ACT, and to invite them to become ACT members. InfoAndina and other information nodes circulated the invitation to their mailings lists.
- April 2008 call for contributions to the new bilingual ACT Newsflash.
- Bimonthly ACT newsflash starting in April 2008 have been compiled by Fausto Sarmiento, and sent out by MRI. In June, August, October, November and January 2009.

This opportunity for information exchange that has proven fruitful for colleagues inquiring about contacts, searching information for specialized equipment, in need of dissemination of their localized research efforts, or even for the distribution of open research positions in the Americas. The bilingual NewsFlash (Spanish-English) is facilitated by Claudia Drexler and Fausto Sarmiento and receives a regular influx of updates. MRI sends it out bimonthly or monthly, as needs require.

### Publication:

Fausto Sarmiento guest edited a special issue on landscape transformation to be published in PIRINEOS 163, the Journal of Mountain Ecology based on presentations from the session on Farmscape Transformation and Climate Change in the Andes organized by Fausto Sarmiento as part of CONCORD.

### CORAG:

Fausto Sarmiento is currently develo-

ping a second working group, CORAG, the Cordillera Agricultural Dynamics Network, focused on natural resource use amidst changing landscapes in the Americas within the new area of emphasis of the US-National Science Foundation on Environment, Society and Economics (ESE). Researchers who agreed with the effort include Gerardo Bocco (Mexico); Ricardo Russo and Jeffrey Jones (Costa Rica); Luis Ortega and Lylieth Varela (Colombia), Juan Hidalgo and Ana Luz Borrero (Ecuador); Karina Yager (Bolivia), Alejandro Leon and Stephen Halloy (Chile); and Juan Gonzalez (Argentina). Other prospective members include Gerardo Gudyas (Uruguay), Francisco Roca (Peru), Guillermo Rodriguez (Colombia), and Oswaldo Baez (Ecuador).

A proposal by Fausto to the National Science Foundation requesting funding for the establishment of the Network with a regional state of the knowledge workshop and a publication of research was presented but denied funding this cycle. A new, revised proposal will incorporate mayor players in the study of farmscape transformation, such as Carol Harden and Alvaro Ugalde, along with individual research efforts in the study of how shift of agricultural commodities, including staple crops such as banana, key export production such as tequila, flowers, and charcoal, or strategic resources such as water in agricultural development of semidesert mountains, or ethnobotanical knowledge of traditional communities could exacerbate climate change related consequences to rural economies in several countries.

## Network Coordinator

**Fausto Sarmiento**, Associate Professor of Mountain Science, Department of Geography, The University of Georgia  
fsarmien@uga.edu

## Weblink

<http://mri.scnatweb.ch/networks/mri-americian-cordillera/>



## The Global Land Project



### Introduction

The Global Land Project (GLP) is a joint core project of the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP). GLP builds on the legacy of two former programs: Global Change and Terrestrial Ecosystems (GCTE) and Land Use/Cover Change (LUCC). The GLP Science Plan is the core of the program and provides a research framework for land systems for the coming decade. The science plan is the outcome of numerous meetings, beginning with an initial scoping meeting in 2001. Scientists from core projects associated with both programs provided further input to the development of the GLP Science Plan at a joint IHDP and IGBP-sponsored meeting in Bilthoven, The Netherlands, in 2002. Finally IGBP and IHDP appointed a GLP Advisory Team in 2004 to improve the focus and balance of the document.

GLP related research aims to improve the understanding of land system dynamics in the context of Earth System function by measuring, modeling and understanding the coupled human-environmental system. GLP studies the human transformation of ecosystems and

landscapes, and the important feedbacks between ecosystems, social systems and the large earth system at local, regional, and global scales (see Fig.1 for the GLP analytical structure).

The day-to-day coordination is carried out by an Executive- and an Administrative Officer at the International Project Office (IPO) in Copenhagen, Denmark, which is funded by University of Copenhagen. The Scientific Steering Committee (SSC) consisting of 16 scientists from different disciplines and regions provides overall guidance.

### Implementation

Practical implementation is challenging, as the GLP Science Plan is broad and inclusive. GLP is not equipped to carry out research in the above mentioned themes, but is a coordination platform. Hence, despite the name GLP is a research programme rather than an actual research project.

The endorsement of ongoing or planned activities is another important means to implement the strategy. GLP invites research projects, individuals (PhD projects) and events such as meetings/

conferences or educational activities (e.g. PhD courses), worldwide to join the GLP community and to submit an endorsement application. Each endorsement application is carefully reviewed by three SSC members of GLP. The overarching criteria for endorsement are scientific excellence, and contributions to the goals of the GLP Science Plan. Since August 2006, when the IPO of GLP became operational, GLP has endorsed 57 research projects, PhD projects, networks, and events. These projects cover many different disciplines, geographical areas, approaches, and research themes, which reflect the holistic research approach of the GLP science plan.

In the section below we present three of the GLP endorsed projects with a mountain focus.

### Range Enclosure on the Tibetan Plateau of China: Impacts on Pastoral Livelihoods, Marketing, Livestock Productivity and Rangeland Biodiversity (RETPEC)

Grant Davidson, Macaulay Institute, Aberdeen, UK, g.davidson@macaulay.ac.uk

RETPEC, a 3-year research project, will investigate the biophysical and socio-economic impacts of policy-driven changes that are transforming China's rangelands in response to a perceived threat of environmental degradation. Specifically, this research will investigate the biophysical and socio-economic effects of fenced versus open range grazing management across several major ecological zones in the Tibetan Plateau. The project's leaders selected field sites to represent the five main environmental conditions that characterize the Plateau as a whole. Each of the sites contains both enclosed and open range grazing management systems, or hybrid systems that combine elements of enclosure and open access. A hierarchical research design begins with analysis of national policies, their application at local administrative levels, field site investigations of biological parameters at community level and, finally, detailed surveys of in-

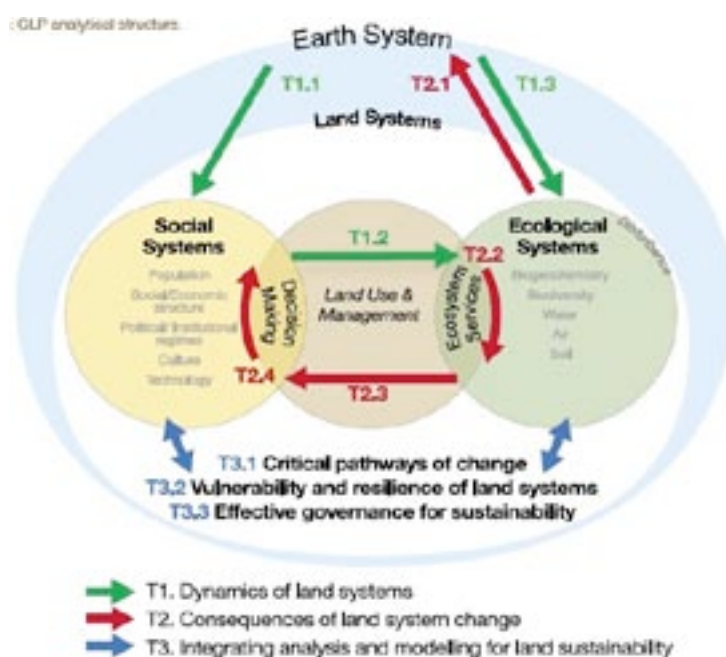


Figure 1. GLP analytical structure. T.x.y refers to the sub-themes which make up the GLP science plan

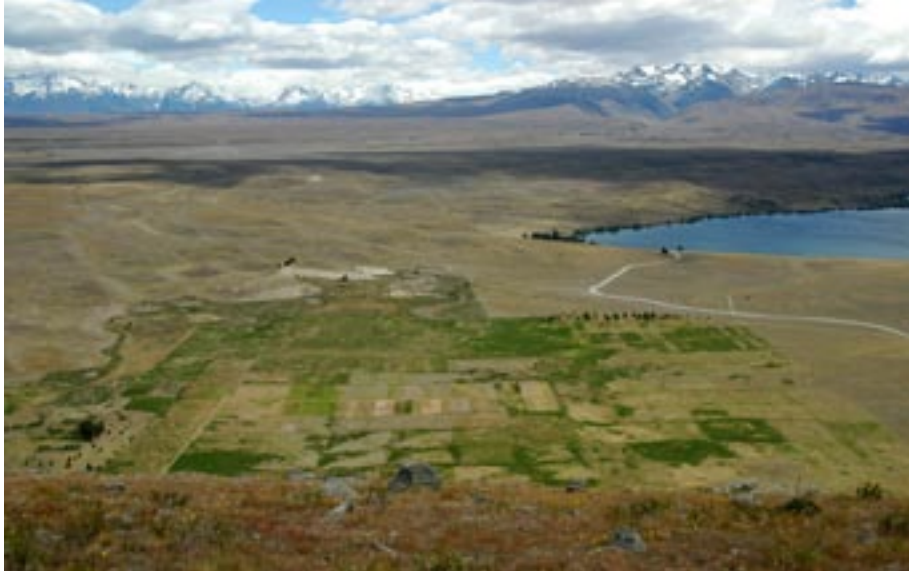


Figure 2: Aerial view of the study area in New Zealand. The picture was taken from the summit of Mount John and shows the Mount John trial site in the foreground, with Lake Alexandrina and the Southern Alps in the background. (Photo by Etienne Laliberté).

dividual households and flocks.

The RETPEC project will inform public policy by assessing whether the new land tenure and grazing regimes ameliorate land degradation. It will also measure the consequences of sedentarisation - when pastoralists are forced to settle in rural areas or are obliged to leave the rangelands altogether to seek alternative livelihoods in towns - on pastoralists' social and economic welfare.

#### **York Institute for Tropical Ecosystem Dynamics (KITE)**

Rob Marchant, Environment Department, University of York, UK, [rm524@york.ac.uk](mailto:rm524@york.ac.uk)

The KITE research cluster is combining new environmental data sets on past ecosystem change, present-day species ranges, and genetic analysis of populations with modeling initiatives to explore past, present and future ecosystem dynamics along the Eastern Arc Mountains of Kenya and Tanzania, one of the world's hotspots of plant biodiversity. At the heart of KITE is the linkage of paleoecology, biogeography, genetics, and bioclimatic modeling initiatives with research on past human impacts to gain a holistic understanding of ecosystem dynamics. KITE is combining expertise from a number of disciplines to understand how ecosystems respond to climate change and societal impacts, and determine why the Eastern Arc Mountains are so biodiverse. KITE is developing a common set of regional GIS layers for environmental, ecosystem and social drivers of ecosystem change for Eastern Africa that will form the backbone for the development of models and scenarios. The research

will also improve forecasting of climate variability impacts on ecosystem functioning, and will lead to an increased understanding with which to develop ecosystem conservation under a changing climate.

#### **Long-term impacts of agricultural intensification on plant functional diversity, ecosystem functioning, ecosystem services, and resilience of New Zealand rangelands**

Etienne Laliberté (PhD candidate), School of Forestry, University of Canterbury, New Zealand, [etiennelaliberte@gmail.com](mailto:etiennelaliberte@gmail.com)

Pastures and rangelands are the most extensive land uses on earth. They are expected to undergo rapid intensification to meet the forecasted doubling in global food demand by 2050. This research project explores the long-term impacts of agricultural intensification on plant functional diversity, ecosystem functioning, ecosystem services, and resilience in New Zealand high country rangelands. The study uses 32 8x50m grassland plots from a rangeland improvement trial – the Mount John trial site, west of Lake Tekapo in the Mackenzie Basin of New Zealand's South Island. Since 1982 this trial been over-sown with a mixture of 25 exotic pasture species and then experimentally subjected to different levels of fertilizer, irrigation, and sheep grazing intensity. Moreover, two ungrazed and undeveloped control plots located directly adjacent to the experimental site are part of the study (see picture above).

## **What is the added value for the endorsed project?**

### **Networking and communication:**

GLP endorsement provides an opportunity for participation in the development, planning and implementation of a collaborative international research program. Endorsed projects gains access to the GLP network (including various international and regional workshops) and associated opportunities for publications and rapid communication.

**Funding:** GLP influences international and national research funding activities. However it is essential that the endorsed projects help GLP in capturing the full range of research achievements underway and to map out essential research topics that require major investments.

**Synthesis:** GLP plans to undertake major synthesis activities summarizing the state-of-the-art science for major global change and sustainability themes in coupled human-environment systems.

**Capacity building:** GLP builds capacity by sponsoring fora for sharing knowledge, methodology, and analytical tools for inter-disciplinary studies of the coupled human-environment system through specialized institutes and workshops.

**Extended research context:** GLP endorsement adds to the scientific value of planned work by providing complementary information; for example, by widening the range of studies and thereby extending their spatial and temporal coverage.

### **GLP**

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# The Water Towers of the World at the 5th World Water Forum Istanbul 2009

### **Mountains of the World: Water Towers for the 21st Century?**

was a special Side-Event, organized by FAO (initiated by Dr. Thomas Hofer), ICIMOD (International Centre for Integrated Mountain Development, Kathmandu), NWCF (Nepal Water Conservation Development Foundation) and GIUB (Institute of Geography, University of Berne).

The objective was to send a clear message to the water community that mountain water resources are under increasing pressure, and that innovative management approaches and forward looking political decisions are required in order to face the future challenges.

The assessment of mountain water resources has changed significantly since the Rio conference 1992. At that time, the mountain chapter of Agenda 21 stated that mountains are an important source of water, energy and biological diversity. In 2007, the UN-General Assembly Resolution recognized the global importance of mountains as the source of most of the Earth's fresh water. This shift shows very clearly the fundamental change in our perception about the rapidly increasing significance of mountain water resources, not only for agriculture and food security, but also for industrialization and urbanization, especially in connection with the growing population in the developing world in these 15 years from 1992 to 2007.

The central text "mountains as the source of most of the Earth's fresh water" guided the presentations and discussions and led to the following questions addressed to the political leaders of the 5th World Water Forum:

- Is this statement from the UN-General Assembly Resolution 2007 understood by all the governmental and non governmental organizations present at the Forum?
- Are the mountain people compensated for their ecosystem services?
- Are we all aware that mountains represent in a vertical order very different climatic zones and that they are therefore most sensitive indica-

tors of climate, environmental and hydrological change?

- Have we understood that an open and transparent exchange of data and information is fundamental for upstream-downstream transboundary cooperation between nations sharing river basins for managing extreme events and for energy and food production?

### **Some general remarks to the 5th World Water Forum Istanbul**

It was said that over 20.000 participants were present. It was not only an impressive water oriented market place of UN-institutions, governmental and non-governmental organizations, national exhibitions, etc., but also a meeting point of science and policy with all its discrepancies and problems. The expression "upstream-downstream" was used in several sessions without realizing or discussing the hydrological significance of mountains. The scientific communities must understand that they have the responsibility to better inform the media and the policy makers - from the national to the global level - about mountain water resources in a time of global change in general and about transboundary processes and conflicts in particular.

### **Author**

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### **Reference and Contacts**

The World Water Report for the Istanbul Forum was again produced by UNESCO: Water in a Changing World: The United Nations World Water Development Report 3, UNESCO/WWAP, Paris 2009.

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**Daniel Viviroli**

[viviroli@giub.unibe.ch](mailto:viviroli@giub.unibe.ch)

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**Mats Eriksson**

[meriksson@icimod.org](mailto:meriksson@icimod.org)

5<sup>th</sup> WORLD WATER FORUM  
ISTANBUL 2009



## Mountain Hydrology under Increasing Climate Variability and Anthropogenic Pressure

**Special session on Water in Mountains, organized by the Mountain Institute, University of Savoy, France  
1 September 2008,  
in the frame of the 13th IWRA (International Water Resources Association)  
World Water Congress in Montpellier**

**Carmen de Jong**, Scientific Director of the Mountain Institute, University of Savoy, Chambéry, France  
Expertise: mountain hydrology, micro-meteorology, fluvial geomorphology, integrated water resources management, tourism  
<http://www.institut-montagne.org/Carmen/carmen-de-jong.htm>

Prof. Carmen de Jong chaired the session on Water in Mountains with invited speakers from Canada, Austria, France, Switzerland, Spain and Israel, who presented water management issues both in semi-arid and humid mountain regions. Carmen de Jong introduced the session by underlining the importance of comparing hydrology and water management issues across different mountain regions in the world (de Jong et al 2009). She also described the new Interreg project „Alp-Water-Scarce“ on Water Management Strategies against Water Scarcity in the Alps lead by the Mountain Institute with 17 partners in five countries. De Jong stressed the importance of a stakeholder interaction forum within the project, bridging the gaps between scientists, government bodies and stakeholders in dealing with current water problems induced by climate and anthropogenic change in the Alps (de Jong et al 2005).

**Hans Schreier**, Professor Emeritus of the Institute of Resources, Environment and Sustainability of the University of British Columbia, Vancouver, Canada  
Expertise: geomorphology, watershed analysis, GIS, land-water interactions, water soil quality and pollutants  
<http://research.ires.ubc.ca/schreier/>

Hans Schreier focused on the need for green water management (water that leaves the ground and vegetation into the atmosphere in the form of vapor, interception, transpiration or evaporation) and the necessity of adapting to increased climate variability in mountain communities starting with an assessment of the water footprint (Schreier et al 2006).

He described the case studies of Kimberly and Elkford in the Columbia river basin in the Rockies, strongly supported by the local mountain communities. The aim of this project is to support the communities in developing a strategy for climate change adaptation. Hans Schreier showed that there is no consensus yet on the future projections of precipi-

tation in mountains. It is clear however, that the springtime temperatures have increased considerably in the higher altitudes over the last 50 years (Redmond and Abatzoglou 2007) (Fig. 1) and that there are large increases in discharge particularly in the month of June over this period. Snowmelt and glacier melt discharge generally peaks higher and earlier in the season and therefore leads to prolonged drier summer flow. In response to these changes Hans Schreier demonstrated concrete methods to lessen a community's water footprint by stricter regulation of existing and new housing developments. The approach used to reduce surface runoff is threefold: firstly, initiate Basin Management Plans (BMP) at individual property scale, secondly in neighborhoods and thirdly, at the watershed scale. For example, by decreasing impermeable surfaces and augmenting surfaces with high infiltration capacities, such as lawns and driveways, by applying rules to replenish organic topsoil around new houses, and by collecting rainwater on roofs, the communities are aiming to decrease surface flow to 0% (see Schreier 2009 and website).

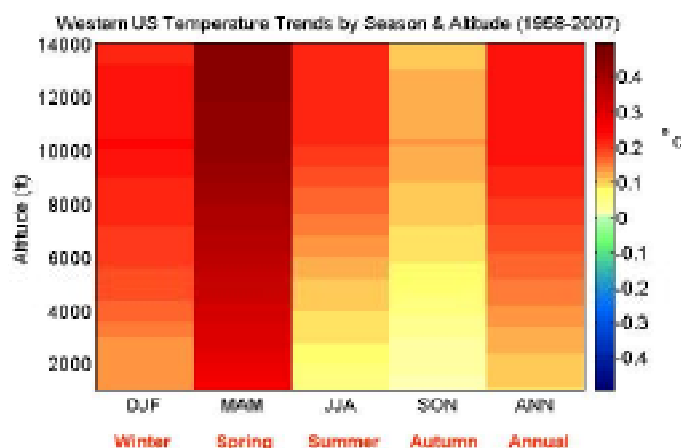


Figure1: Increase in temperatures over the last 50 years in the western US Mountains. Notice the strong increase in spring time. (Redmond and Abatzoglou 2007).

**Hans-Peter Nachtnebel**, Director of the Institute of Water Management, Hydrology and Hydraulic Engineering of BOKU, Vienna, AT  
Expertise: eco-hydrological modeling, stochastic hydrology, particle transport, sustainable water management, impact of climate change, conflict analysis, GIS  
[https://forschung.boku.ac.at/fis/suchen.person\\_uebersicht?sprache\\_in=en&menue\\_id\\_in=101&id\\_in=185](https://forschung.boku.ac.at/fis/suchen.person_uebersicht?sprache_in=en&menue_id_in=101&id_in=185)

Hans-Peter Nachtnebel led a discussion on mountain hydrology under changing environmental conditions, in particular on the modifications of the water balance due to human influences. He emphasized that natural retention capacities in river basins have substantially decreased in the Austrian Alps. He showed how hydro-electric dams, water ponds for artificial snow-making, river corrections and land use changes have changed the hydrological behavior of streams. In river basins with river training works the peak discharge of the 100 year flood can increase by several percent (See Fig. 2). He demonstrated that the monthly discharge has increased by up to 30% in winter and decreased by between 10-15% in summer due to the impacts of hydropower dams in the Inn valley. Since dams are filled during snowmelt, downstream discharge decreases below dams in spring and summer but in winter, with increased energy requirements, the emptying of dam reservoirs results in more downstream discharge. He emphasized that the combination of decreased snow depth in

winter, warmer global temperatures and rain replacing snow increases winter discharge, however the lack in snow resources and decreased summer precipitation decreases summer discharge (Kling and Nachtnebel 2009).

**Jean-Paul Bravard**, Professor of Geography at Lyon 2 University, France  
Expertise: environment and hydrology, river dynamics, interdisciplinarity  
[http://ghhat.univ-lyon2.fr/article.php3?id\\_article=388](http://ghhat.univ-lyon2.fr/article.php3?id_article=388)

Jean Paul Bravard presented the alpine lakes of Geneva, Bourget and Annecy and the dynamics of man-induced and natural lake levels. He showed that the increase in evaporation due to global warming and the increased control of discharge at the exit of lakes - in order to maintain ideal lake levels and buffer their increasing variability - can cause problems for the lake- and downstream stream ecology. In Lake Annecy, climate change is increasing the tendency for high lake levels in winter and low levels in spring and summer. Tourism has had significant influence on lake levels since levels that are too low are not attractive. In the past, lake levels fluctuated by up to 4 m naturally whereas nowadays these fluctuations are controlled and limited to hardly more than 30 cm. In the past, the largest fluctuations were recorded in Lake Bourget and Annecy. Today, the level of Lake Annecy has been artificially increased by 30 cm. With this increase there is less potential to store and

buffer flood waters entering the lakes. Present trends are an increase in winter precipitation and a decrease in spring precipitation, as well as an increase in summer evaporation. At the same time, important amounts of discharge are used in summer for the production of hydro-electricity. The exit of Lake Annecy is opened in winter and closed in summer, but there are more and more problems of maintaining high enough lake levels for the beaches to remain attractive for swimming or boating. At times, the gorges of the Fier below Lake Annecy dry up during the summer when large amounts of water have to be stored in the lake. This has major consequences for the survival of flora and fauna and the associated aquatic biodiversity (Bravard, 2008).

**Bettina Schaeffli**, Assistant Professor at the Water Resources Section of the Technical University of Delft, the Netherlands  
Expertise: hydrological modeling and rainfall runoff modeling  
<http://www.citg.tudelft.nl/live/pagina.jsp?id=33226e9c-7f7f-46d3-8710->

Bettina Schaeffli spoke about climate change impacts on glacier-fed hydropower production in Switzerland. She described the case study of the Mauvoisin hydro-power plant. Until present, its management was based on extremely stable hydrological regimes. With the increase in snowline altitude and the rapid melt of glaciers (30% of the surface area melted in only one year - 2003), there will be a decrease in total water availability. By 2050, there will be 7% less water available annually in the reservoirs.

With an earlier snowmelt and warmer winters, winter discharge is prone to increase. Water managers need to be aware of this and also face more variable regimes and higher discharges in autumn due to an increase in rainfall events relative to snowfall events. The discharge entering the reservoirs will be less reliable, in particular where rainfall events are becoming more dominant. Since rainfall is more erratic and more

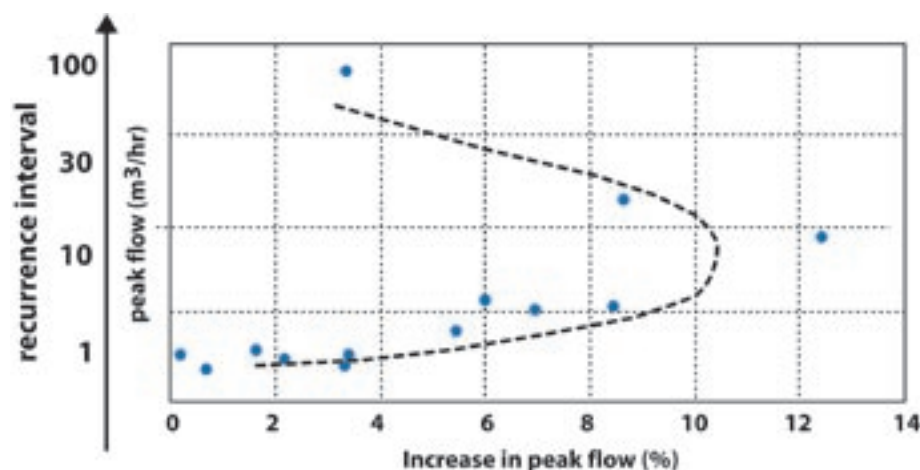


Figure 2 : Influence of river training works on peak flow in the Traisen catchment (Debene 2004). Notice the 10% increase in peak flow for events with 10 year recurrence interval.



short-lived and has little storage capacity compared to snowfall it is also less predictable.

The switchover to a decrease in the water availability will be reached by the year 2050 but may already happen in 30 years from now. This is an important fact that has to be considered for future investments and developments in hydropower. Schaeffli estimates that the capacity of hydropower production will decrease by about 4% by 2050 for Mauvoisin and other climatologically The switchover to a decrease in the water availability will be reached by the year 2050 but may already happen in 30 years from now. This is an important fact that has to be considered for future investments and developments in hydropower. Schaeffli (?) estimates that the capacity of hydropower production will decrease by about 4% by 2050 for Mauvoisin and other climatologically and geographically comparable sites in the Alps.

**Ignacio López-Moreno**, Postdoc at the Dept. of Geoenvironmental Processes and Global Change at the Institute of Pyrenean Ecology, Saragossa, Spain  
Expertise: geography and environmental sciences, mountain hydrology, climate change, watershed management and evolution of Pyrenean glaciers.  
[http://www.ipe.csic.es/erosion\\_hidrologia/pgspers/nlm.htm](http://www.ipe.csic.es/erosion_hidrologia/pgspers/nlm.htm)

Ignacio López-Moreno discussed climate change impacts on snowpack, river discharge, and the filling of reservoirs. In the Ebro valley, water management and dam reservoirs face serious problems. Snowmelt discharge is very important and contributes between 30 and 40% of the total discharge. Therefore, snowmelt controls river discharge and the infill of dam reservoirs. Since the 1950s, there has been a significant statistical decrease in discharge of March and April. Since 1979, discharge has decreased especially between April and July when most strongly influenced by snowmelt (López-Moreno 2008). The general tendency is for snowmelt to be stronger and set on earlier in the

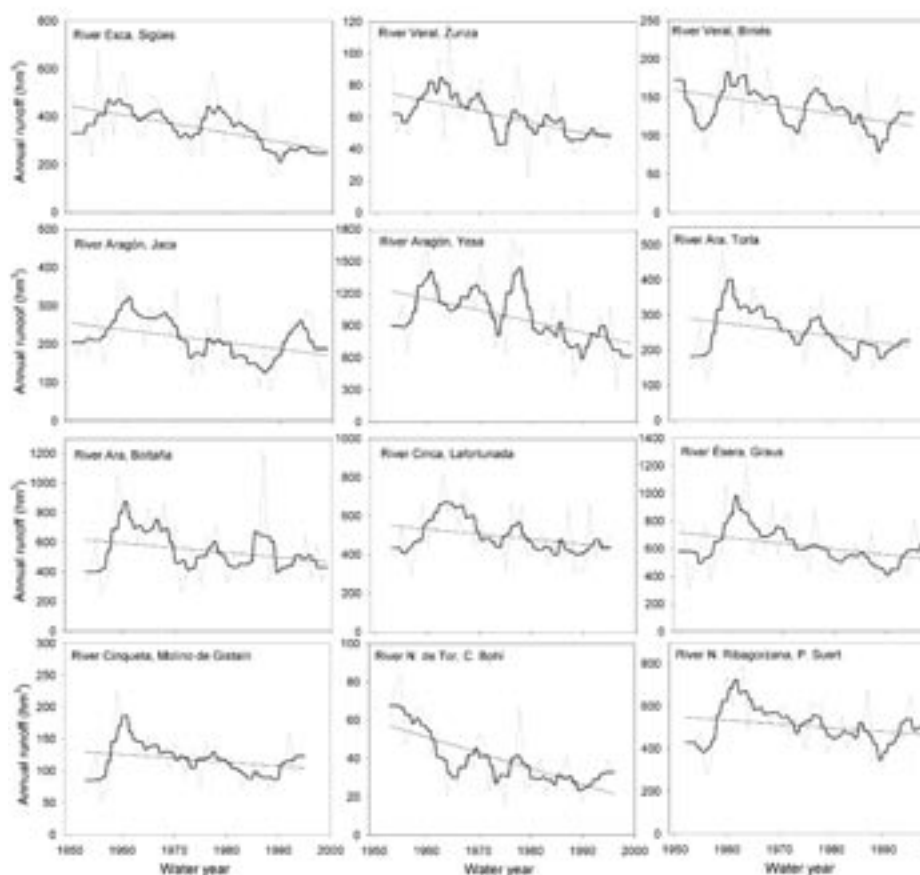


Figure 3: Trends in annual runoff recorded at selected Pyrenean gauging stations. Grey lines represent annual trends; black lines are 5-year moving averages. (López-Moreno, J.I., Beniston, M. and García-Ruiz, J.M. 2008).

season but discharge to be weaker over the late spring and early summer. . This enhances the extremes between floods in early spring and drought in summers. There have also been changes in the maximum discharge. Water managers face the problem of having to reduce the amounts of water exiting the reservoirs in order to maintain reservoir levels, which causes major problems for downstream irrigation. Because of the difficulties in reaching storage levels, a higher percentage of winter and even spring flows have to be stored. An increase in temperature in the order of 1.3-3.1 °C is projected for 2070-2100 based on comparisons of the 1960-1990 period, with stronger precipitation on the French side of the Pyrenees and weaker precipitation on the Spanish side. Snow pack has decreased in the order of 44% in the period between 1950-2000 in the Pyrenees (Fig. 3). On the whole, there will be less and less water available during the year since annual discharge has decreased by about 30-35% in the period from 1950-2000 (López-Moreno et

al 2008).

**Alon Rimmer**, Lake Kinneret Research Centre, Israel.  
Expertise: physical limnology, groundwater hydrology, surface water hydrology, river basin models for contaminants transport. [http://www.ocean.org.il/Eng/Researchers/page\\_alon.asp](http://www.ocean.org.il/Eng/Researchers/page_alon.asp)

Alon Rimmer spoke on the subject of hydrological modeling in the karstic region of Mount Hermon, Israel, a water tower for several countries, namely Syria, Lebanon and Israel. 30% of the water in the basin of the Upper Jordan is consumed by Israel and Palestine. Surface water is entirely consumed. This deprives the groundwater reservoirs from being sufficiently recharged to act as long-term storage buffers. Since the perimeters of the groundwater reservoirs are independent to those of the river basins hydrological modeling is difficult in this region. This is mainly due to the difficulties of linking surface

water routing to groundwater routing within the same sub-basin and to model the erratic nature of flow in a karstic basin. High evaporation rates aggravate the situation of water loss from the basin and the limited availability of water for groundwater discharge. All in all this increases water stress in the region (Rimmer and Salingar 2006).

## Summary

Of all the mountain chains discussed it seems that the Pyrenees are most directly affected by climate change already, with up to 30% loss in discharge over the last 50 years and enormous consequences in the reliability and filling of dam reservoirs. The changing seasonality of discharge, caused by changes in snowline altitude and timing of snowmelt was at the heart of the debate. Spring and summer discharge have changed most, with spring melt starting up to one month earlier. The discussions showed that it will be important in future to change modes of water management in mountains based on seasonal predictions that are adapted to discharge data reflecting the present trends of climate change. Predictions for the summer should be made at least one month earlier in the year than up to now. Also, it is important to become more flexible in the management of extreme events and irregular flow. Human modifications of the water cycle are impressive, and some, such as artificial snow production in the Alps or the Rockies, locally represent a loss in water by evaporation in the order of 30%. Other water intensive uses include irrigation of mountain golf courses for summer tourism. Rapid development of housing and infrastructure around tourist resorts in the Alps and Rockies will also have impacts on the water cycle.

A loss in hydropower in the European Alps in the order of 5% is expected from 2050 onwards, maybe even a decade earlier. The drying up of rivers downstream of dams and the loss of nutrients will have to be compensated for by hydropower companies in the future. This is already the case in the Colombia river basin, where nutrients are injected below the dam as compensation.

A Special Publication on Water Management Strategies in Mountain regions is planned for "Water International" as a result of this session.

The television chain France 3 did a direct television interview of Carmen de Jong, Jean Paul Bravard and Hans Schreier on the topic of climate change and water in mountains (<http://sud.france3.fr/info/45928171-fr.php>).

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## Weblinks

Session Water in Mountains:

<http://wwc2008.msem.univ-montp2.fr/index.php?page=proceedings&itemid=187>

Alpine Space Interreg Programme: <http://www.alpinespace.org>

Alp-Water-Scarce: <http://www.alpwaterscarce.eu>

ClimAlpTour (Climate Change impacts on Tourism in the Alpine Space):  
<http://www.climalptour.eu>

IWRA (International Water Resources Association) <http://196.36.166.88/iwra/>

The Mountain Institute: <http://www.institut-montagne.org>

Kimberley and Elkford from the Columbia river basin Strategy for Climate Change Adaptation:

<http://www.cbt.org/newsroom?view&vars=1&content=Spotlight%20Gallery&WebDynID=902>  
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<http://www.cbt.org/uploads/pdf/CBT-ClimateChangeHS.pdf>

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# Introducing a New High Elevation Research Facility in the Southern Appalachian Mountains at Appalachian State University, Boone, NC USA



Figure 1: 30 m sampling tower installed in 2008.

AppalAIR (**A**ppalachian **A**tmospheric **I**nterdisciplinary **R**esearch) is an interdepartmental program at Appalachian State University in Boone, North Carolina, comprising faculty from the departments of Biology, Chemistry, Geography & Planning, Geology, and Physics & Astronomy.

The faculty members involved in AppalAIR are taking a synergistic approach to understanding atmospheric properties and processes and the associated impacts on terrestrial ecosystems and climate in and around the Southern Appalachian Mountain region in the eastern United States. Brett Taubman (Chemistry) is investigating transport and trends of air pollutants as well as chemical and optical properties of aerosols and their influences on the regional climate using surface based in-situ and remote sensing instruments. Physiological effects of air pollution on native plant species are being examined by Howie Neufeld (Biology) in Great Smoky Mountains National Park and on campus using exposure chambers and a research garden. Ryan Emanuel (Geology) is using the AppalAIR 30 m flux tower located on campus to quantify carbon and water vapor fluxes and to determine environmental responses to a changing climate, including elevated ozone. Jim Sherman (Physics & Astronomy) uses remote sensing techniques to measure water vapor and atmospheric aerosols which are key components for understanding environmental responses to climate change, and Baker Perry (Geography and Planning) uses surface based and balloon borne meteorological measurements to study synoptic climatology and orographically driven precipitation, with a particular emphasis on snowfall.

AppalAIR is located at the highest point on campus and the facility includes a climate controlled building for housing the research instrumentation, a 30 m flux tower, a research garden, and a staging area for balloon launches.

Appalachian State University is located in the Blue Ridge Mountains of western North

Carolina and is the highest elevation university east of the Mississippi River at 1075m above sea level. Several of the highest mountain peaks in eastern North America are within a few hours' drive, offering many opportunities for studying these unique mountain environments. AppalAIR was recently invited to become a collaborating member of the NOAA (U.S. National Oceanic and Atmospheric Administration) global network of aerosol monitoring stations, operating out of their Earth System Research Laboratory (ESRL) and in conjunction with the WMO Global Atmospheric Watch (GAW) network. AppalAIR has also been added to the NASA AERosol ROBOTic NETwork of globally-spaced solar-tracking radiometers. The radiometers are used together to form a ground-based 'satellite' to continuously measure aerosol properties relevant to climate change and also form one of the main tools to validate satellite aerosol measurements. We would welcome additional collaborative efforts from researchers interested in atmospheric processes in mountainous areas, both locally and abroad.

For more information, please contact either Dr. Brett Taubman (taubmanbf@appstate.edu) or Jim Sherman (shermanjp@appstate.edu).



Founding members of AppalAIR: Drs. Howard Neufeld, Baker Perry, Jim Sherman, Ryan Emmanuel and Brett Taubman.



# From Bergler“ to Greenkeeper. Structural Changes in Andermatt, Switzerland

**Valeria Kunz, a sociologist from the University of Bern, researched the decision making process used by mountain farmers in Andermatt when confronted with the planning process of a large scale tourism project in their village. In 2008 the University of Bern published her diploma project “Vom Bergler<sup>1</sup> zum Greenkeeper” which tells of an aspect of global change in mountains often neglected.**

### **The Urseren Valley as top-destination of the 21 century?**

The Urseren valley in the Canton of Uri has always depended economically on a larger European market: the Gotthard road and railway axis, and the military base in Andermatt have given shape to this valley with a population of only 1'630 in 2005. At the same time mountain agriculture in the Urserental has been more profitable than in other regions of Uri, mainly thanks to its wide valley floor.

In the last 5 years prospect of wrenching economic change has again reached this remote Swiss valley. The Egyptian billionaire and investor Samih Sawiris is planning a luxury holiday resort in Andermatt, which he maintains will bring long sought development to the economically weak village, which cannot afford to upgrade its outdated tourist infrastructure. The project in this village of 1'340 inhabitants foresees 5 hotels (4 to 7 stars), 600 holiday apartments, 100 holiday villas, wellness and shopping centers, as well as a golf course. In 2003 the whole Canton of Uri had only 3'340 guest beds while the Sawiris projects would build 3000 in Andermatt alone (p. 55) !

### **New divisions within the village**

In 2005 the cantonal building depart-

ment and the investor informed people in the valley about the project. A year later the authorities realized that the golf-course needed much more land than the decommissioned military base provided, as national law demanded both a buffer area and a zone of extensive cultivation. This revelation took local stakeholders by surprise, particularly when a coalition of the investors, the canton Uri, and the communal authorities suggested to 18 families that they sell large parts of their land, the very basis of their existence as farmers. According to the Swiss Farmers Association, after such sales the farmers would not possess viable farms. Pressure on individual families was enormous as they were cast as the only remaining impediment to the project. They found themselves confronted with the decision to either sell their most fertile land on the valley floor for the building of a golf-course, and to permit the launch of the enterprise, or to retain their land as the basis of their rural existence, and to risk being accused of preventing the community's development. This dilem-

ma created new divisions within the village, and people who dared to utter criticism were threatened verbally and with anonymous letters.

### **The research**

This choice was existential for the farming families, and the process by which they made their decisions was the starting point of Valeria Kunz's research. Her research was based on the assumption that there was more at stake for the mountain farmers from Urseren Valley than just the fate of the land. Their very existence as mountain farmers in a globalized world was at stake. The decisions taken by the families provided the researcher insights into their specific concepts of identity and cultural patterns of interpretation. How do mountain farmers justify their own role and identity in the face of structural changes that take economic profitability as the top priority?

Kunz used in-depth interviews (con-



The Urseren Valley with Andermatt to the right (photo by Valeria Kunz).

ducted in 2006 and 2007) with six families to understand the underlying frame of reference of the farmers' individual and social lives, and to understand why the farmers took the decisions that they did. For her book Valeria Kunz analyzed two interviews with the objective hermeneutic method and compared their opposing arguments.

The outcome is an exciting combination of historical and sociological accounts of the Urserental, and an analysis of how people take their decisions in the face of global change.

### To emigrate or to stay

The Bieri family moved to Andermatt 25 years ago. When confronted with Sawiris plans they decided to sacrifice their land and farm in the hope of a better future for the valley. They sold their land (which was outside the golf course's boundaries but would be used to compensate other farmers) in order to enable the "real" indigenous people an existence as farmers. The future situation of their farm was another reason for them to sell: in the investor's plans the Bieri's farm would have been a small island in the golf-course! The Bieri's were not prepared to let their dream of being mountain farmers turn into a life in an open-air museum, but have since been tormented by fears of the "sale of their homeland". They moved to a different part of Switzerland and have continued farming but "neither the family nor the cattle are adapting well to the new home" (Goldstein, 2009). Kunz concludes that people's self-perceptions and concepts of identity are changing at a slower pace than the operations of a globalized market.

The Renners, on the other hand, were convinced by Sawiris' vision of a shining future, and have tried with all their means to be part of the expected success, to live the life style of the "winners" in the future. They argue that alpine agriculture is already highly dependant on external market and political forces anyway, and that this development is just the next phase in the village evolution. Opting for this large

scale tourism project for them is a rational step. Income from tourism has been an important additional income for a long time, so this is nothing new. The Renners agree to their re-definition as landscape gardeners rather than production farmers. But even for them at the end of 2008 the project's success is no longer obvious (Goldstein, 2009). The future will tell if the promises of the resort are true.

### Conclusions

The global economy is a driving force of change in the mountains of the world that needs to be understood by policy makers. Research institutes and funding organizations should pay more attention to this aspect of global change, whereas today they focus on the changes of the physical environment.

Valeria Kunz's work further shows that time and money invested in research to this end, i.e. on the stakeholders of any change, is as important as research on the drivers of that change. Development can only be sustainable if it is based on the knowledge of stakeholder realities and identities. Sociological studies have an important role to play in the investigation of global change impacts, and in the definition of mitigation and adaptation strategies.

Book review by Claudia Drexler, MRI

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1 A „Bergler“ is a mountain farmer. This Swiss term implies that the Bergler loves his mountain environment more than anything else, and that he lives in close proximity to nature and cattle.

#### Valeria Kunz

Vom Bergler zum Greenkeeper?  
Strukturelle Umbrueche in Andermatt  
ISBN: 978-3-9523100-9-0/ Fr.25.-  
(plus mailing costs)  
To order the book please contact  
mahboob.hasan@soz.unibe.ch

#### Reference:

Goldstein, D. 2009. Wenn die Weide zum Golfplatz wird. Der Bund, 13 January 2009, p 28.

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