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Abteilung Orientierte Forschung
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NCCR Proposal for Continuation

Phase	**Phase 3 (2009 – 2013)**
Title of the NCCR	**NCCR Climate** **Climate Variability, Predictability and Climate Risks**
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Signature of the NCCR Director

Place, date: Bern, 20 December 2008 Signature:

1. Executive summary

The past few years have seen a solid and continuous development of the NCCR Climate program with high-profile research, sustained capacity building and education, successful knowledge transfer and communication, and tangible institutional accomplishments. Based on the Pre-Proposal (submitted in December 2007), the written comments by the Review Panel (20 March 2008) and the 'Decision on Pre-proposal for phase 3' by the Research Council (25 August 2008) we submit the Full Proposal for the NCCR Climate Phase 3 (2009-2013) that builds on these achievements. The NCCR Climate has made significant contributions at the national and international (e.g., IPCC) levels to a topic that is undoubtedly of paramount relevance to society and arguably at the top of current public concerns.

The SNSF budget reduction by 50% for Phase 3 (compared with Phase 2; **total of 5 M CHF**) poses severe strategic limitations to the future of the NCCR Climate, the smallest among the 14 NCCRs of the first round. In consequence, and considering the rapidly increasing resources for climate research programs in European countries, the Board has set the priorities as follows: (i) to maintain a conceivable network of Swiss Climate Research, (ii) to discontinue 6 out of 18 current projects, and (iii) to focus the research on a few carefully selected emerging topics of utmost societal relevance. Maintaining the NCCR central services (EDU, KTT, Management Centre) is a comparatively large burden for the limited budget of a small program. Consequently, the full research activity of Phase 3 will span over 3 years only; the 4th year is used to phase out the programme. Phase 3 will see 12 projects from 8 Swiss research institutions collaborating with precisely defined interfaces in four truly interlinked Work Packages WPs ("Past Climate", "Future Climate", "Climate Impacts" and "Climate Risks for Society").

Research

Concerted research in the four WPs is designed to develop along three major pertinent cross-cutting thrusts:

a) The hydrological cycle: The dynamics, possible feedbacks and causes of short- to long-term variations of the water cycle from local to global levels is certainly of utmost relevance for ecosystems, provision of ecosystem services to society (water, food), climate risks assessment, and management options.
Specific challenges for the NCCR Climate Phase 3 are:
- to prepare high-quality spatially explicit multi-century long data sets for selected parameters (humidity, drought) for Europe;
- to prepare a set of global/regional scenarios using models and statistical tools;
- to study terrestrial ecosystem responses to variations in water availability and key-processes in the coupled land surface - climate system;

b) Extreme events, assessment of climate risks: The occurrence of extreme events, their dynamics and statistical representation is undoubtedly the most significant but scientifically the most challenging facet of climate change. Extreme events are the main drivers of system changes and sources of 'damage'. While 'temperature extremes' have been the focus of the NCCR up to now, the spotlight will shift to floods and droughts, which is scientifically much more difficult but more relevant.
Specific challenges for the NCCR Climate Phase 3 are:
- to assess the statistics of humidity-related extremes from the past to the future;
- to study the underlying processes and predictability;
- to assess risks for forests, crops and pastures, in particular in relation to heatwaves and drought;

c) Management of climate risks: Managing climate risks spans over very large spatial (local to global), temporal (daily to centennial) and organizational (individual to the UN) scales. Sound assessment of the different options at various hierarchical levels (adaptation and mitigation), assessment of the appropriate policy measures and their (economic) implications, and related transformation knowledge ("How to get there?") is elementary to strategic decision making and, ultimately to sustained development. *Specific challenges for the NCCR Climate Phase 3 are:*

- to asses risk management options for specific and selected user groups or agents at different organizational levels (farm level/agricultural production to national/international finance and insurance instruments);
- to assess options for domestic and international climate policy from an economic and technological point of view;
- to produce concrete results that allow advising of stakeholders and (inter)national policy makers.

According to the recommendations by the Review Panel (Report of 7th Site Visit) and in light of a **possible budget up-grade for Phase 3 (increase of 500 kCHF to a total target of 5.5 M CHF)** we have made the following major changes relative to the Pre-Proposal:

- Research on the Swiss Energy System (former P4.1) is no longer pursued and replaced by research on international regulations and trade (P4.1 CITEL, total budget 300 kCHF); thus a formal collaboration with NCCR Trade regulations is established;
- IP-Carbon is no longer pursued. As proposed by the Review Panel, the soil part will be pursued at a very small activity rate (150 kCHF; with additional matching funds from the Oeschger Centre).

Education

The yearly International Summer Schools and the Young Researchers Meetings will be pursued throughout Phase 3 (3 years for the budget 5 M CHF; 4 years for the budget 5.5. M CHF). The continuation of both high-profile series beyond NCCR is guaranteed through the NCCR Climate leading house (follow-up structures at U Bern and ETHZ: Oeschger Centre for Climate Change Research OCCR and Centre for Climate Systems Modeling C2SM).

KTT, communication

The NCCR will enhance its focus on operational tools and research designed to implementation (applied research) and to advise policy makers and stakeholders. A formal collaboration with the NCCR Trade regulations is established. In addition to the successful communications program, Phase 3 will see a series of high profile international conferences (build on NCCR Phase 1-3). Close collaboration with ProClim is natural and continues.

We have diversified the contacts and funding to industry and 3rd Parties. However, due to the short remaining life-time of the NCCR Climate this additional funding materializes in the new structures OCCR (U. Bern) and the C2SM (ETHZ), and not in the NCCR Climate.

Upon the recommendation by the Review Panel, we have evaluated the creation of a "Climate Service Centre" similar to Germany in 2007. However, the "Climate Service Centre" is part of the "Hightech Strategie für Klimaschutz", a new **German programme worth 255 million Euro** for research on Climate Change over the next three years (Bundesministerium für Bildung und Forschung Press Release 094/2007). For comparison, SNSF plans to invest 3.3 million Euro (5 M CHF) into the NCCR Climate for four years. We feel that such a Service Centre exceeds by far the capacity of the NCCR Climate. Therefore, this valuable and important suggestion by the Review Panel cannot be further developed and implemented at the anticipated, much reduced funding level.

Added value ("three unique selling opportunities")

(i) The NCCR Climate has a demonstrated record of successful performance (Phases 1-2), and a detailed description of future (Phase 3) concerted collaboration among projects and WPs across Swiss research institutions (joint publications, data exchange, shared lab facilities, expertise, joint education programs, etc.).

Undoubtedly it is the common framework of the national NCCR Climate program (oriented research) that builds the trustful umbrella across people and institutions, stimulates and enables collaboration to explore novel fields, and places the corner stones on the scientific roadmap that is specific to the Swiss expertise and infrastructure, and tailored to the national and international challenges. The complex nature of the issue under investigation (i.e. "Climate and Society") calls intrinsically for such an approach. Furthermore, the NCCR Climate has a demonstrated record of cost-effective division of labour and specialization across Swiss research and 3rd Party institutions. In fact, this is the 'unique selling opportunity' for the NCCR Climate and beyond: very productive high-profile research at economic costs (synergies used and coordinated) in novel fields of research that are top of societal concern;

(ii) The NCCR Climate puts a different complexion on the matter of Swiss Climate Research. Undoubtedly, the NCCR Climate has established itself and provides a very high international visibility (as a national research program) and fosters a clear national profile through concerted KTT and communication; The NCCR Climate is the carrier (ambassador) of a brand mark (Swiss Climate Research) within Switzerland and abroad.

(iii) The NCCR Climate educational program has established itself a firm position at the national and international levels. The NCCR Climate is attractive for young researchers worldwide.

Structural changes:

NCCRs were designed and implemented to initiate and pursue three long-term processes of strategic research policy: (i) to enhance the top-class profile of Swiss research in strategic areas, (ii) to build a network for cost-effective collaboration across institutions, and (iii) to consolidate the momentum created by the NCCR through adequate structural measures.

While the NCCR Climate Phase 2 was very successful in consolidating the momentum and network at the "domestic level" (Oeschger Centre OCCR at University of Bern; Centre for Climate Systems Modeling C2SM at ETHZ), the structural effort during the years 2009 – 2012 will target **the sustainability of research network structures at the national level ("Swiss Climate Research")**.

This national level is fundamental for three reasons: (i) because of the nature of the issue under investigation ('Climate Change and Society'); (ii) because 3rd Party stakeholders (e.g., Federal Administration, policy and decision makers, the private sector) benefit from a national network (NCCR Climate), and (iii) because a tangible and powerful cross-institutional research network is a precondition to enforce cross-institutional coordination and, ultimately cost-effectiveness through collaboration. Most European countries have become aware of this issue and have massively increased funding for multiple programs (oriented research) targeting climate and climate impact research (see 2.1. Portfolio analysis), while, at the same time Switzerland is significantly decreasing funding for the only and unique national research program, the NCCR Climate.

These genuine achievements stimulated by the NCCR Climate are at risk with the termination of NCCR Climate Phase 3 (2012-2013). In particular the reason (iii) "to enforce cross-institutional coordination" is an assignment that is beyond the possibilities and interests of an individual institution (e.g., Leading House of an NCCR) but instead an intrinsic task for the bodies responsible for sustainable research policy making at the Federal level (SER, SNSF and SUK). It is one of the goals of the leadership of NCCR Climate to start and facilitate the thinking and scoping process of cross-institutional Swiss Climate Research beyond 2013.

2. Research

2.1. Topics and key questions for Phase 3

2.1.1. Three major thrusts

Overall, research in NCCR Climate Phase 3 is designed to develop along three major thrusts:

The hydrological cycle (Thrust 1): The dynamics, possible feedbacks and causes of short- to long-term variations of the water cycle from local to global levels is certainly of utmost relevance for ecosystems, provision of ecosystem services to society (water, food), climate risks assessment and management options.

Specific challenges for the NCCR Climate Phase 3 are:
- to prepare high-quality, spatially explicit, long (multi-century scale) data sets for selected parameters (humidity, drought) for Europe;
- to prepare a set of global and regional scenarios using numerical models and statistical tools;
- to study terrestrial ecosystem responses to variations in water availability, and key-processes in the coupled land surface-climate system;

Extreme events, assessment of climate risks (Thrust 2): The occurrence of extreme events, their dynamics and statistical representation is undoubtedly the most significant but scientifically the most challenging facet of climate change. Extreme events are the main drivers of system changes and the main sources of 'damage'. While 'temperature extremes' have been the focus of the NCCR up to now, the spotlight will shift to floods and droughts (according to Thrust 1), which is scientifically much more difficult but much more relevant to society and economy, and ecosystems.

Specific challenges for the NCCR Climate Phase 3 are:
- to assess the statistics of humidity-related extremes from the past to the future;
- to study the underlying processes and predictability;
- to assess risks for forests, crops and pastures, in particular in relation to heatwaves and drought;

Management of climate risks (Thrust 3): Managing climate risks spans over very large spatial (local to global), temporal (daily to centennial) and organizational (individual to the United Nations) scales. Sound assessment of the different options at various hierarchical levels (adaptation and mitigation), assessment of the appropriate policy measures and their (economic) implications, and related transformation knowledge ("How to get there?") is elementary to strategic decision making and, ultimately to sustained development.

Specific challenges for the NCCR Climate Phase 3 are:
- to asses risk management options for specific and selected user groups or agents at different organizational levels (from agro-economic risks to national/international finance and insurance instruments);
- to assess options for domestic and international climate policy from an economic point of view and international regulations and legal perspective;
- to produce concrete results that allow advising of national and international policy makers and foster implementation. Several projects will directly contribute to recognized gaps in the Report "Klimaänderung und die Schweiz 2050" (OcCC 2007), or even aim at drafting treaties and legislative proposals (P4.1 CITEL).

These three fields of research will be addressed by 12 projects organized in the four Work Packages WPs “Past Climate” (WP1), “Present and Future Climate” (WP2), “Climate Impacts” (WP3), and “Climate Risks for Society” (WP4).

Please note:
The outline of the planned research (Thrusts 1-3, WP1-4) takes into consideration other research initiatives in Switzerland that are currently being started, under evaluation or submitted such as

- the **NFP 61 “Nachhaltige Wasserversorgung und –nutzung”** (Department of the Interior, State Secretary for Education and Research SER, 28 November 2007; the call is currently open),
- the **ETH Competence Centre Environment and Sustainability (CCES)** large collaborative projects (approved on 26 November 2007)
    - Climate policy design for enhanced technological innovation (CLIMPOL)
    - Impact of biomass burning aerosol on air quality and climate (IMBALANCE)
    - Modelling and experiments on land-surface interactions with atmospheric chemistry and climate (MAIOLICA)
    - Advanced process understanding and prediction of hydrological extremes and complex hazards (APUNCH)
    - The Swiss Experiment (SWISSEX, running).

  These collaborative projects are exclusively accessible for research groups of the ETH Domain and are not open for Universities or the NCCR Climate.

Also the idea for a ‘National Adaptation Plan’ NAP (similar to Finland and currently under consideration in France, UK and Norway) was no longer pursued because of limited funding and the strictly national and applied focus. The budget for Finland’s NAP was 8.0 M Euro.

2.1.2 The NCCR Climate in the international context

“The main goal of the currently 20 NCCRs is the promotion of scientific excellence in areas of major strategic importance for the future of Swiss research, economy and society” (SNSF Guide 2007 National Centres of Competence in Research, page 7).

Undoubtedly, climate change is of utmost relevance for the Swiss society and ranks constantly among the top priorities of public concern; climate change is of paramount relevance for the economy, welfare and security (Stern Review Report 2006, UN Security Council 2007, among others), and Swiss Climate Research (including the NCCR Climate) has made arguably substantial contributions in the past and continues to do so today.

The challenge of climate changes has clearly national, international and global dimensions and requires, in consequence, adequate research frameworks, organization and infrastructure at all levels. The NCCR Climate does not work in isolation but collaborates and/or stays in constant scientific competition with the neighbours. The NCCR Climate is proud to accept that challenge.

The NCCR Climate is the only Swiss national collaborative research program dealing with research on climate, climate change and climate change impacts. This is different compared with other European countries and, therefore relevant to the portfolio analysis: **the NCCR Climate is obliged to maintain a highly visible, truly national network that involves the relevant institutions in the fields concerned.** This is in a straight line dictated by the need for cost-effective research trough collaboration and cross-institutional coordination.

Turning the spotlight to Europe reveals that many of the countries have substantially increased the volume of **program funding** for climate and climate impact research. These programs are the direct competitors of the NCCR Climate. Table 1 shows the major programs of European countries in comparison with the NCCR Climate Phase 2 (2005-2009). In addition to the central national funding schemes listed in Table 1, many national science agencies have increased their general research budgets in the climate area, and several new climate research centres have been established from other sources (such as the recently founded Grantham Institute for Climate Change of the Imperial College, London, UK). While Switzerland has played a pioneering role with the formation of its national climate research strategy (through SPP Umwelt and NCCR Climate), a mid-term strategy for the post-NCCR phase is currently not evident.

Country	**Name of Program**	**Focus**	**Focus**	**Focus**	**Focus**	**Duration**	**Funding [M €]**
		Climate	**Impacts**	**Adaptation**	**Other**		
Austria	ProVision*	x	x	x	x	2004-2006	7.0
Belgium	SSD*	x	x	x		2005-2010	65.4
Finland	Nat. Adapt. Plan*	x	x	x		2004-2006	8.0
France	GICC*	x	x	x		1999-2010	20.0 annually
Germany	Adapt/Mitigation*	x	x	x		2006-2009	30.0
	DEKLIM*	x	x			2001-2006	ca 39.0
	GLOWA*		x	x		2000-2009	ca 75.0
	CLISAP Hamburg (CoE)	x	x			5 years	32.6
	CLISAP Hamburg (computing facility exclusively for climate)	x	x			Investment	40.0
	The Future Oceans	x	x			2007-2011	39.0
	Hightech Strategie für Klimaschutz	x	x	x		2008-2011	255.0
Italy	SD and CC*	x	x			2006-2009	54.0
UK	QUEST	x	x	x		2003-2009	29.4
	APPRAISE (aerosols only)	x	x			5 years	5.6
	RAPID (rapid change)	x	x			2000-2008	33.6
NL	CCSP*	x	x	x		2004-2011	80.0
Norway	Bjerknes Centre	x	x	x		2008-2012	2.1 annually
Switzerland	**NCCR Climate - 2**	**x**	**x**	**x**		**2005-2009**	**6.6**
	NCCR Climate - 3 (50%)	**x**	**x**	**x**		**2009-2013**	**3.3**

*Table 1: An overview of the major European programs for climate and climate impact research in comparison with the Swiss national Program on Climate and Climate Impact Research (NCCR Climate). Source: * from CIRCLE ERA-Net http://www.circle-era.net/ (Report 2006), Program websites.*

Launching Germany's ‚**Hightech Strategy for Climate Protection**' the Bundesministerin für Bildung und Forschung Annette Schavan has stated: "*Das Bundesministerium stellt in den nächsten drei Jahren 255 Millionen Euro für Forschung zum Klimawandel zur Verfügung*" (Press release BMBF 094/2007).
This comparison leads to the second important implication of the portfolio analysis: Anticipated funding of a 50% budget (5 M CHF) is clearly sub-critical for a full 4 years period with a NCCR Climate network of the current size. This is compounded by the fact that the NCCR Climate is the smallest of the 14 NCCRs funded by SNF. At the funding level considered, it is not feasible to maintain the profile of the NCCR Climate at today's level, and this would likely negatively affect the international recognition of Swiss climate research. It

remains open whether or not Switzerland may maintain its presently leading role in the European context.

2.2. Structure of the NCCR

The organizational structure of the NCCR Climate program has been very successful and is also regarded as most suitable for Phase 3. The four Work Packages WPs remain, while the number of projects will be reduced to a maximum of three per WP.
The University of Bern remains the Leading House. Its 'Oeschger Centre for Climate Change Research' will provide a significantly enhanced institutional background for the NCCR Climate Management Centre. The 12 projects are hosted at the **University of Bern, ETH Zürich, EPF Lausanne, WSL Birmensdorf, ART Reckenholz and MeteoSwiss.** The Universities of Basel and Geneva and the PSI lose their role as hosts of projects. The researchers remain, however in the NCCR network.
Prof. T. Stocker remains the NCCR Climate Director for Phase 3. The Bodies (Core Group, Board of PI) as well as the Management Centre and the Executive Director remain unchanged.

More specifically, the NCCR Climate Phase 3 will be organized as follows (Fig. 1a):

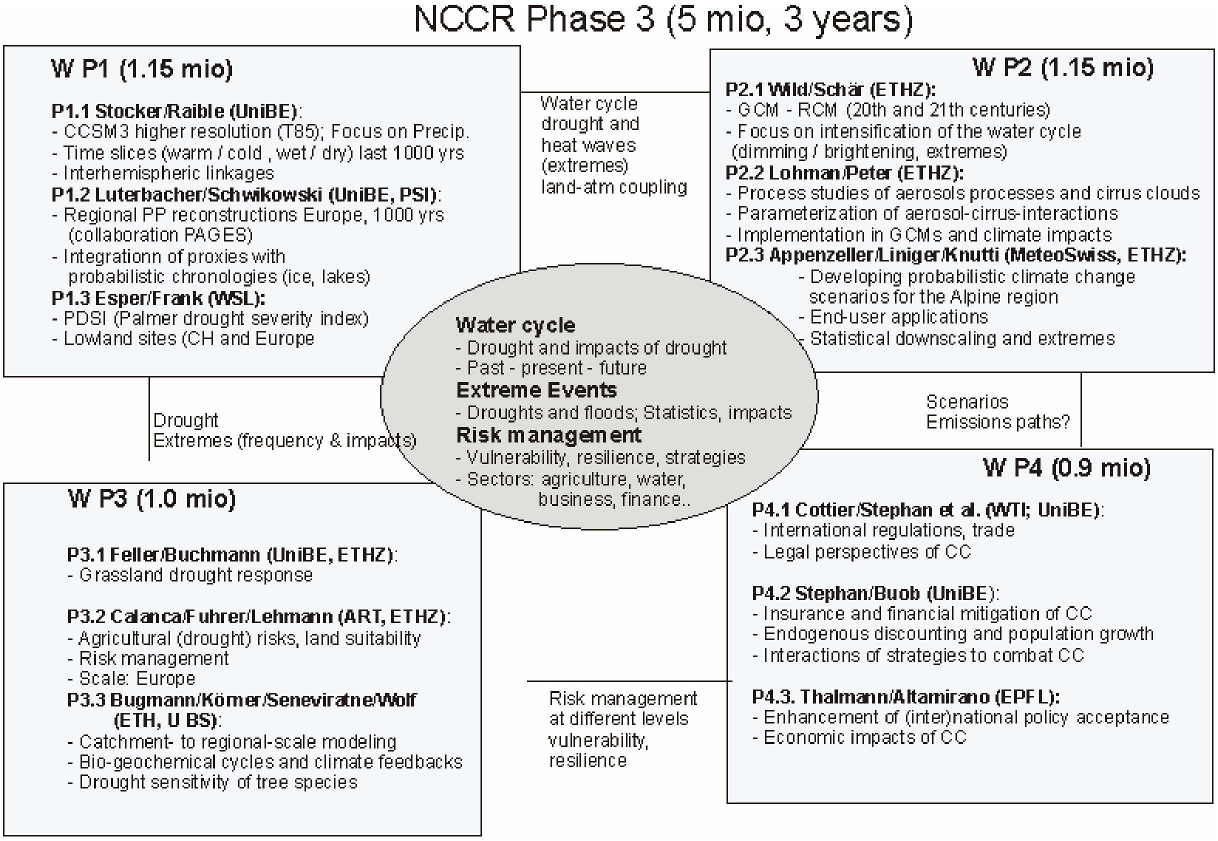

Fig. 1: Schematic view of the structure of the 5 M CHF program with the four WPs (budget allocation in brackets, in M CHF) with the projects (bold: leaders and institutions) and keywords with the overall NCCR Climate themes (dark shaded) and the interfaces.

The four WPs and the 12 Projects with the Principal Investigators (PI), Deputy PIs, Co-PIs and affiliations are:

WP1 Reconstructing and modelling past drought variability

P1.1 Modelling and Reconstruction of North Atlantic Climate System Variability (MONALISA III)
T.F. Stocker (PI KUP Uni Bern), C.C. Raible (Deputy PI, KUP Uni Bern)
P1.2 PALeoclimate VARiability and EXtreme Events (PALVAREX III)
J. Luterbacher (PI, GIUB, Uni Bern); M. Schwikowski (Deputy PI, PSI Villigen)
P1.3 Drought effects and PDSI reconstruction from Southern and Central European trees (DE-TREE)
J. Esper (PI, WSL, Birmensdorf), D.C. Frank (Deputy PI, WSL, Birmensdorf)

WP2 Future Climate

P2.1 Intensification of the water cycle: Scenarios, processes and extremes (HYCLIM).
M. Wild (PI, IAC ETH Zurich) and C. Schär (Deputy PI, IAC ETH Zurich)
P2.2 Global climate processes: role of cirrus clouds for present and future climate (CCC).
U. Lohmann (PI, IAC ETH Zurich), T. Peter (Deputy PI, IAC ETH Zurich)
P2.3 Probabilistic climate change scenarios for mean and extremes in the Alpine region (PRECLIM)
C. Appenzeller (PI, MeteoSwiss), M. Liniger (Deputy, MeteoSwiss), R. Knutti (Co-PI, ETH)

WP3 Ecosystem Impacts and Adaptation

P3.1 Drought effects on Swiss grasslands and adapted plant mixtures as management options under changing climate conditions (PLANT/SOIL)
U. Feller (PI, University of Bern), N. Buchmann (Deputy PI, ETH Zürich)
P3.2 Climate change and agricultural production risks – AGRISK
P.-L. Calanca (PI, ART), J. Fuhrer (Deputy PI, ART), B. Lehmann (Co-PI, ETH Zurich)
P3.3 Impacts of changing drought conditions on catchment ecology and water cycle (ECOWAT)
H. Bugmann (PI, ETH), C. Körner, (Deputy PI, U Basel), S.I. Seneviratne (Co-PI, ETH), A. Wolf (Co-PI, ETH)

WP4:Integrated assessment analysis of global climate change, economy and society

P4.1 Climate change and international trade from an economic and legal perspective (CITEL)
T. Cottier (PI, WTI), G. Stephan (Deputy PI, Uni BE), K. Holzer (Co-PI, WTI) and O. Schenker (UniBE); (with the **5.5 M CHF budget**)
P4.2 Climate vulnerability, risk assessment and management in a Post-Kyoto World (CVR)
G. Stephan (PI, Department of Economics, U Bern) and S. Buob (Deputy-PI, Department of Economics, U Bern)
P4.3 Modelling Climate Change Policies: Mitigation, Adaptation, and Acceptance (MIADAC)
Ph. Thalmann (PI), J.-C. Altamirano-Cabrera (Co-PI), EPFL Research group on the economics and management of the environment (REME)

Depending on the final budget of the NCCR Climate and the amount of the NCCR Reserve available we have planned, besides of CITEL in the first priority, for **two small modular additions** (each of which with a budget for one PhD student):

R1 Climate Lessons from radiocarbon data (CLER)

PI: F. Joos (Uni BE); this PhD project follows the suggestion of the Review Panel to pursue the soil part of the IP CARBON (see Pre-Proposal). If funded, this PhD project will be integrated in WP1 and WP3.

R2 Solar Forcing and Climate Change of the last 1000 years (SOLAR)

PI: J. Beer EAWAG; this PhD project is the completion of work that has started in NCCR Climate Phase 2; it was also originally a part of IP CARBON and is essential for WP1. If funded, the PhD project will be integrated in WP1

The connection and collaboration between the different projects is demonstrated in Fig. 2.

	P11	P12	P13	P21	P22	P23	P31	P32	P33	P41	P42	P43	R1	R2
P11	■	▨	▨	▨		▨								▨
P12	▨	■	▨	▨		▨								
P13	▨	▨	■			▨ x			▨					
P21	▨	▨		■	▨	▨		▨ x	▨ x		▨ x			
P22				▨	■	▨			▨					
P23	▨	▨		▨	▨	■	x	x	x		▨ x			
P31						▨ x	■	▨	▨					
P32				▨ x		▨ x	▨	■	▨	▨	▨			
P33			▨	▨		▨	▨	▨	■					
P41				▨ x		▨ x		▨		■	▨ x	▨ x		
P42				▨ x		▨ x		▨		▨	■	▨		
P43				▨ x		▨ x				▨	▨	■		
R1	▨	▨					▨	▨	▨				■	▨
R2	▨	▨											▨	■

Fig. 2: Relational matrix showing the 12 projects and 2 Reserve Projects R1 and R2 with their collaboration (shaded fields) as specified in section 2.4.); x marks all the projects that are involved in climate scenarios either as climate scenario providers (P2.1 numerical downscaling; P2.3 statistical downscaling, operational tools and data sets) or as climate scenario users (all the other projects).

In summary: The NCCR Climate Phase 3 is a truly cross-institutional network with a balanced representation of the major Swiss institutions working in climate and climate impact research (topics according to the scientific profile of NCCR Phase 3).

2.3. Research plans

The following section specifies (i) the objectives of the 4 WPs and the 12 project, (ii) the milestone '36 Months' (achievements after 3 years), and (iii) the collaboration with the projects within or across the Work Packages.

WP1 Reconstructing and modelling past drought variability

WP Leader: J. Luterbacher, University of Bern

1. Three Key Questions

- What is the response of the hydrological cycle to changes in external forcing functions in the North Atlantic during key periods of the past 1000 years and which feedback mechanisms between atmosphere and ocean operating?
- What are the timing, spatial characteristics, and underlying dynamics of the purported anomalous drought/wet precipitation regimes during the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA) relative to the 20th century conditions for the North Atlantic and European area?
- What are the effects of water availability on long-term tree growth and how can we optimally utilize ring width and isotopic data to reconstruct changes in the water cycle from widespread (non-boundary/treeline) forests in southern and central Europe?

2. Contribution to the NCCR Climate

For the 3rd phase of NCCR Climate, the aims of WP1 are designed to build upon the findings during the previous two phases, and to exploit and strengthen the collaboration and synergies within the Work Package and the other components of NCCR Climate. WP1 comprises three projects that aim at a better quantification of the long-term changes in the hydrological cycle. In line with the overall NCCR Climate research goals for Phase 3, the proposed research has three main foci: (i) to identify the dominant processes in the coupled system, which led to past changes in the hydrological cycle; (ii) to reconstruct spatial European-scale precipitation/drought patterns with special emphasis on extremely dry and wet periods back to the MCA, and (iii) to reconstruct drought variability and impacts from widespread European tree species, and compare empirically based estimates with long-term climate model simulations and intra-seasonal growth data. The specific aims of the three projects are:
P1.1 will develop model simulations to help identify the dominant processes of low-frequency, large-scale variability due to internal atmosphere-ocean processes and external forcing. This will improve our understanding of the mechanisms that led to severe changes in the hydrological cycle during the past. As the ocean plays a major role in driving and modulating the hydrological cycle, identifying processes which work on the low-frequency time scales, offers the potential to increase predictability of the hydrological cycle. In this respect, teleconnections are a central theme and will be assessed utilizing model simulations, proxy data and reconstructions (from P1.2 and P1.3 among others).

P1.2 aims at reconstructing anomalous drought/wet precipitation patterns over Europe back to the MCA using sophisticated statistical methods that can optimally combine terrestrial, marine, and documentary data of widely differing temporal resolutions. The main underlying dynamics will be addressed, and connections to the large scale circulation regimes (NAO/AMO and ENSO/PDO, teleconnections) as recorded by different proxies and ocean conditions, will be evaluated.

P1.3. will focus on the long-term assessment of hydroclimatic impacts on aboveground woody biomass, and initial evaluations of vegetative feedbacks on the European climate. Compilations of existing drought-sensitive ring width data of widespread European tree species will be complemented by new long-term isotopic and ring-width measurements from key areas to reconstruct changes in the hydrological cycle. Regional drought reconstructions from southern and central Europe, accompanied by well-constrained reconstruction error estimations, will be produced.

3. Integration and Cohesion within the WP

The mechanisms of internal atmosphere-ocean variability of, and external forcing imprints upon the hydrological cycle will help in the interpretation of the reconstructions at different spatio-temporal scales (P1.2 and P1.3). The model simulations of P1.1 will provide a test-bed for reconstruction methods to refine reconstructions of the large-scale atmospheric circulation patterns (P1.2). Using results from P1.1 and downscaling methods from P2.3 we attempt to estimate local impacts and compare them with information available from the proxy data (P1.2). P1.2 and P1.3 will conduct joint analyses of quantile regression methodology and contribute to long-term drought records to spatially explicit precipitation reconstruction, and compare reconstructed decadal-scale changes in the regional hydrological cycle with CCSM3 time-slice experiments and 500-year simulations from P1.1. P1.2 will also contribute to WP1 with paleoclimate reconstructions, such as circulation indices from ice cores, which complement tree ring based reconstructions (P1.3).

4. Interfaces with other WPs

There is a close connection between WP1 and WP2 as both will address suitable statistical techniques to identify changes in the past and future hydrological cycle. Extreme value statistics used in P1.1, P1.2 and P2.3 will form a common language to interpret the non-gaussian characteristics of the hydrological cycle. The hydrological characteristics of the anthropogenic era investigated by WP2 will form a continuum with the millennial-length reconstructions of natural variability developed in WP1. As P2.1 uses a different climate model, we will inter-compare our model simulations in overlapping periods. The reconstructed hydrological extremes provided by WP1 will provide a historical test-bed for the assessment of statistical downscaling methods and multi-model approach (P2.3). Association of the inter-annual drought reconstructions (P1.2./P1.3) with the intra-annual monitoring of forest growth from the Swiss Canopy Crane and helicopter-based forest sites (P3.3) will also be performed.

5. Expected Impact of the WP

International Level:

The model simulations will help identify the dominant processes of low-frequency variability of the hydrological cycle due to internal atmosphere-ocean variability and external forcing. This will help in understanding the variability of sparsely distributed proxy data. New tree-ring based reconstructions will be of importance to assess the transition from naturally to anthropogenically forced climate at the regional to global levels. Advances in understanding the impacts of climate change on forest productivity are expected.
Results will be of relevance to authorities and regional organizations as well as to scientific programs and databases dealing with climate change issues and climate impacts. Examples include: (i) Past Global Changes Program (PAGES) of the International Geosphere-Biosphere Program (IGBP); (ii) MedClivar; (iii) National Geophysical Data Center (NOAA) and (iv) The Intergovernmental Panel on Climate Change (IPCC).

National level:

Assessment of the impacts of drought variability on tree-growth and carbon sequestration which is relevant to the forestry industry, landscape preservation, and the national carbon balance objectives. The increased understanding of the unforced variation of the hydrological-cycle in the past, including seasonal shifts in precipitation and occurrences of extremes will be necessary information to put projected changes in a longer-term perspective. In addition, the pre-anthropogenic to current perspective on climate change provided by the time-series developed and analyzed in WP1 are fully in line with the Swiss Parliamentary (Bundesrat) decision of June 6, 2008 to increase support (e.g., 77% financial increase between 2010 and 2011) for Swiss program of Global Climate Observing System which currently manages indicators of climate change during the anthropogenic period. Reconstructions and scientific to societal conclusions and implications will be disseminated to policy makers as part of the NCCR framework.

P 1.1

Modelling and Reconstruction of the North Atlantic Climate System Variability (MONALISA III)

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1. Three research questions of the project

- What is the response of the hydrological cycle to changes in external forcing functions in the North Atlantic during key periods of the past 1000 years and which feedback mechanisms are operating between the atmosphere and the ocean?
- How do long-distance to inter-hemispheric climate teleconnections and decadal to multi-decadal modes interact with the hydrological cycle?
- How do synoptic-scale atmospheric variability and large-scale low-frequency atmosphere-ocean modes affect extremes in the hydrological cycle?

2. Research Summary

The IPCC 4th Assessment Report (2007) showed that the large-scale meridional transport of moisture becomes stronger due to enhanced evaporation in the subtropics and increased precipitation in the mid to high latitudes. This may increase the risk of desertification in some regions which would have a strong impact on society (e.g., migration) and economy. In the past there are also indications that the climate system was characterized by dramatic changes of the hydrological cycle. Bradley et al (2003) suggested that the so-called Medieval Climate Anomaly (MCA) was a period with rather strong and prolonged hydrological anomalies, with droughts and wet spells in the US, the Mediterranean and possibly Europe. There is evidence from tree ring records that Morocco was substantially dryer during the MCA than today (Esper et al., 2007). However, it is still not clear whether or not these changes of the hydrological cycle are a response to external forcing. Another important contribution to these changes could be generated by internal atmosphere - ocean feedback mechanisms. The ocean circulation interacts with the hydrological cycle, in particular in deep water formation regions in the North Atlantic (Wu et al., 2005; Stocker and Raible, 2006). The coupled atmosphere-ocean system shows low-frequency regime behavior (e.g., the Atlantic Multidecadal Oscillation; AMO; Dijkstra et al. 2006), which has also an effect on precipitation (Raible et al. 2004). The response of the hydrological cycle to these long-distance to inter-hemispheric climate teleconnections is not well understood. Moreover, such modes influence extremes of synoptic-scale features like deep cyclones or prolonged blocking situations and therefore precipitation (Raible et al. 2007). It is thus necessary to deepen our understanding on the connection between atmospheric high-frequency and atmosphere-ocean low-frequency variability and the response behavior of the hydrological cycle, in particular extremes, like droughts or heavy precipitation events. For instance, serial clustering of synoptic features (Mailier et al. 2006) could also help explaining extremes in precipitation. Thus, the overall aim is to identify the dominant processes which led to past changes in the hydrological cycle, i.e., long-term droughts and prolonged wet periods.

3. Data and methods

As in the previous two phases of NCCR Climate our major research tool is the Community Climate System Model (CCSM3, Collins et al., 2006), provided by the National Center for Atmospheric Research (NCAR, Boulder, USA). We will first investigate the ensemble and sensitivity simulations available from NCCR Climate Phase 2, which were performed with the coarse resolution version of the Community Climate System Model (CCSM3). This will help us develop suitable analysis tools for the hydrological cycle.

However, important aspects of the hydrological cycle may be heavily affected by the coarse resolution of this model. Therefore, we will use a version of the Community Climate System Model CCSM3 model with a higher resolution (version of T42, T85 or if available at the new finite-volume resolution of 2.1°×1.9°, which will be the next IPCC version CCSM4) in the atmosphere and on average 1°×1° in the ocean component. To start the simulations NCAR will provide initial conditions for pre-industrial (1870 AD) and 1990 AD conditions.

As in NCCR Climate phases 1 and 2 we aim at generating ensemble simulations for periods during the last 1000 years of particular interest, e.g., the MCA, the Maunder Minimum (1645-1715), and the transition period into the Dalton Minimum. The ensemble approach for the transient simulations is used to isolate and extract the externally-forced signal from internally generated noise. The final decision on the resolution will also depend on the available computation time and portability of the model to the platforms offered at CSCS. To investigate the simulations we will employ a large variety of analysis tools including classical time series analysis methods (spectral methods, e.g., wavelet analysis), extreme value statistics to spatio-temporal analysis tools such as EOF-, composite-, and correlation analysis, as well as regime definitions (Raible et al., 2006, Casty et al., 2005, 2007). The synoptic scale variability will be investigated using Lagrangian cyclone tracking schemes (Raible et al., 2008) and blockings (Schwierz et al., 2004, Scherrer et al., 2006, Buehler et al., 2008) and will be compared with results of WP2 (from the second phase of NCCR Climate).

4. Milestones and deliverables

After 18 months:

- To develop suitable analysis tools for the hydrological cycle, using the existing simulations with the coarse resolution version of CCSM3;
- To investigate the impact of the Atlantic meridional overturning circulation (MOC) shutdown on the hydrological cycle in the coarse resolution version based on existing simulations (inter-hemispheric connection);
- Characterization of atmosphere-ocean feedback mechanisms and their effects on the hydrological cycle mainly based on existing long-term simulations (1000-1350 and 1500 -2100) from NCCR Climate phase 2;
- Quantification of changes in the hydrological cycle in response to natural forcing based on the simulations of NCCR phase 2;
- Start of time-slice experiments of 100 years duration with the higher resolution CCSM3 (ocean 1°×1°).

After 36 months:

- To analyse the sequence of teleconnection patterns (including inter-hemispheric connections) to the hydrological cycle and its extremes as simulated by CCSM3;
- Investigation of the influence of low-frequency atmospheric-ocean modes on the statistics of synoptic-scale extremes and their serial clustering;
- To apply the methods on the high resolution version and compare the results obtained with the low-resolution version;
- Investigation of the higher resolved time-slice experiments with respect to the atmospheric-ocean coupling and the hydrological cycle;
- To deliver a test-bed for climate reconstruction methods for the hydrological cycle developed for all WP1 projects.

5. Contribution to the WP1 and collaboration with other NCCR projects and 3rd parties

Within WP1 we first will select key periods within the past 1000 years with respect to the hydrological cycle in order to compare model simulations and climate reconstructions. Model simulations are used to identify the dominant processes of low-frequency variability, the forcing impacts on the hydrological cycle, and possible connections to the ocean circulation which will help in the interpretation of the reconstructions (P1.2). We will also use climate field reconstructions (from P1.2) to evaluate the model results, which will lead to a gain in confidence in the model's ability of projecting future climate scenarios. The model simulations of P1.1 will also provide a test-bed for reconstruction methods (P1.2), in order to assess uncertainties and refine reconstructions of the large-scale atmospheric circulation patterns and teleconnections, which could explain past changes and extremes in the hydrological cycle in Europe (provided by P1.3). P.1.1 will provide model data to P1.3 in order to combine proxy-based reconstructions and the model data using proxy-surrogate-techniques. The collaboration on method development and data supply with the two SwissRe projects (related to MONALISA) will be continued.

Moreover, we will extend our fruitful and successful collaboration with WP2. P.1.1 will collaborate on statistical techniques (from WP2) using past modeled (from P1.1) and reconstructed data (from P1.2). Another link is extreme value statistics, used in both, the WP1 and P2.3. Using similar methods but different time windows, the future changes in extremes in the hydrological cycle (P2.3) will be placed in a longer perspective by comparing these with results of P1.1. As P2.1 uses a different climate model we will inter-compare our model results using available control and possibly past or future simulations.
The collaboration with the project SOLAR (PI J. Beer; pending on funding resources from the NCCR Climate reserve) concerns a technical aspect. This project will generate new estimates of the solar irradiance, which will be prescribed in the new simulations with the higher resolved version of CCSM3 (P1.1). On the other hand P1.1 will provide forcing fields of surface temperature and precipitation.
The collaboration with 3rd parties includes the existing connections to MedCLIVAR (including contributions from WP1.2 and WP2). Moreover, the collaboration with the Swiss National Supercomputing Centre (CSCS) will be continued in order to be able to complete the ensemble simulations. Note that the supercomputing power of CSCS is essential for this project.

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P 1.2

Paleoclimate Variability and Extreme Events (PALVAREX-3)

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1. Three research questions of the project

1. What is the timing of the suggested anomalous drought/wet precipitation patterns, their geographical extent, and their magnitude during the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA) relative to the 20th century conditions for the North Atlantic/European area?
2. What are the underlying dynamics of extended dry and wet periods in Europe and how are they related to large scale atmosphere and ocean conditions and remote (NAO/AMO and ENSO/PDO, teleconnections) forcing?
3. Is it possible to relate past wet and dry periods in Europe to variations in circulation regimes as recorded by different proxies?

2. Research Summary

Bradley et al. (2003) point to the fact that the MCA could be more a period with widespread hydrological anomalies from 900 to 1300 AD. Prolonged droughts/wetness affected many parts of the western United States (in particular eastern California and the western Great Basin) and other parts of the world (e.g Mediterranean, Morocco and possibly other parts of Europe), with impacts on society, 'economy' and nature. Prolonged droughts in some areas and exceptional rain events in others suggest that changes in the frequency or persistence of circulation modes (such as ENSO) may account for the climate in some areas. However, the causes of such persistent anomalies remain unknown and need to be investigated. Wet and dry periods in the past centuries suggest that internal variability and external forcings were important to explain observed climate variability over the North Atlantic/European area (e.g. Esper et al. 2007). European precipitation reconstructions back to 1500 were performed recently. Pauling et al. (2006) mainly used land based proxies that are unequally distributed in time and space. Principal component/multiple regression was applied that tended to fit towards mean conditions that did not allow statistical analysis on anomalous dry or wet periods prior to the early 18th century. One major aim is to reconstruct past precipitation combining different high and low resolution climate proxies from land and ocean covering the areas of the North Atlantic and European area by applying RegEM and quantil regression methods.

A new challenge in paleoclimatology is to interpret stable isotope ratio time series from hydro-climatic archives in areas with varying contributions of different moisture sources. For the period 1995-2002, trajectory analysis revealed the following humidity source contributions for Alpine precipitation: Atlantic (50%), the Mediterranean (23%), and European land evaporation (21%) (Sodemann, 2007). Variations in circulation patterns during the MCA and LIA may affect these source contributions as indicated by temporal variations of various ice core parameters (stable isotope ratios, deuterium-excess, sea salt and mineral dust concentration) over the last millennium. The potential of these ice core – derived parameters to capture changes in atmospheric circulation and humidity sources will be investigated. The underlying hypothesis is that the deuterium-excess is sensitive to varying contributions of different moisture sources (Atlantic, Mediterranean, land evaporation), whereas the sea salt concentration is related to the strength of the westerlies. Main mineral dust events on the other hand are of Saharan/Sahelian origin and the transport is influenced by the NAO.

3. Data and methods

New temporally highly resolved proxies from terrestrial and marine archives will become available within the next 2 years from international projects or personal contacts. For instance, highly resolved speleothems from Turkey, the Middle East and from the central Mediterranean area provide information on the past hydrological cycle (Fleitmann, Bar-Matthews, Silenzi, Montagna, pers. com.). Further, new tree-ring isotopic data (Masson-Delmotte et al. 2005; Treydte et al., 2007) from central Europe and parts of the Mediterranean will be derived by DeTree (P1.3). Existing Fe-exe-flux data at low resolution from the French Massif Central is interpreted as a proxy for rainfall during the growing season (Schettler et al. 2007) will be used as well. New high-resolution information from the same proxies will become available from Ireland (Schettler, pers com). Documentary based information from the Iberian Peninsula resolve anomalous dry and wet periods and floods for more than half a millennium (e.g. Benito et al. 2003). Important precipitation-related information from northwestern and central Europe might be available from EuroClimhist (www.euroclimhist.com; Pfister, pers com). During the two NCCR Climate phases the major focus of the ice core research was obtaining suitable cores, analyzing various parameters (Jenk et al. 2007a), dating (Schwerzmann et al., 2006; Jenk et al. 2007b), and interpretation with respect to temperature variations and air pollution (Schwikowski, 2006; Reithmeier et al., 2006). Within Phase 3 we will build on existing ice core data, but investigate new parameters, which have only recently become available such as deuterium-excess. In order to assess the potential of the new parameters a variety of tools will be applied (spectral methods, e.g., wavelet analysis, PCA and correlation analysis). We will also perform back trajectories analysis over a longer time period using NCEP/Reanalysis and ERA-40 data. The RegEM method was successfully used in the NCCR phase 2 to reconstruct large scale climate fields. We will apply RegEM also within the NCCR Phase 3. Quantil regression, a new method not yet introduced in paleoclimatology will also be tested for multiproxy drought/wetness reconstruction covering the last millennium. The advantage of quantile regression is that it does not fit to the mean values as linear regression based methods, but estimates and conducts inferences, so-called conditional quantile functions. Therefore, a better representation for anomalous dry and wet periods can be expected.

4. Milestones and deliverables

After 18 months:

- To perform trajectory analysis to investigate potential proxies of atmospheric circulation (deuterium-excess, sea salt and mineral dust concentration) covering the last approximately 60 years
- To select periods of interest concerning the hydrological cycle and test RegEM and quantil regression with data covering the last 500 years.

After 36 months:

- To assess the potential of different proxies to capture changes of past circulation and humidity sources;
- To develop indices for past circulation changes;
- To reconstruct spatial patterns of single and extended dry and wet extremes for the last millennium combining climate information from sea and land;
- To better understand the physical processes and large-scale circulation for past changes and anomalous hydrological events;
- To characterize the forcing impact on the past precipitation variability;
- To compare and combine reconstruction and model results;
- To use model output from P1.1 as test-bed for developing reconstruction methods like quantil regression.

5. Contribution to the WP1 and collaboration with other NCCR projects and 3rd parties

(i) Coordination within WP1 regarding key periods for model-reconstruction comparison. P1.1 provides a test-bed for reconstruction methods (P1.2) and processes, large-scale circulation patterns and teleconnections, explaining past changes and long-term droughts and prolonged wet periods in the hydrological cycle in Europe (P1.3); (ii) Contribute to WP1 with paleoclimate reconstructions from ice cores, including circulation indices which complement tree ring-based reconstructions (P1.3). (iii) Contribute long-term drought records and interaction/comparison with reconstructions at local to regional scale (P1.3); (iv) Collaboration on statistical downscaling (from P2.3) using past modelled (from P1.1) and reconstructed data (from P1.2); (v) Joint research with P2.1 on model comparison using control and possibly past or future simulations with both model systems; (vi) using similar methods but different time windows, the future changes in extremes in the hydrological cycle (P2.3) will be placed in a longer perspective by comparing these with results of P1.2 and P1.1. Another link relates to extreme value statistics that is used both in WP1 and P2.3. Results will be of relevance to authorities and regional organizations as well as to scientific programs and databases dealing with climate change issues and impacts. Examples include: (i) Past Global Changes Program (PAGES), Bern, Switzerland; (ii) MedClivar; (iii) National Geophysical Data Center (NOAA) and (iv) the Intergovernmental Panel on Climate Change (IPCC).

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P 1.3

Drought effects and PDSI reconstruction from Southern and Central European trees (DE-TREE)

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1. Three research questions of the project

- What are the effects of water availability on tree growth and how can we optimally utilize ring width and isotopic data to reconstruct changes in the water cycle from widespread (non-boundary/treeline) forests in southern and central Europe?
- What long-term changes in drought and pluvial episodes (e.g., via the Palmer Drought Severity Index, PDSI) occurred in Europe, and how do PDSI and precipitation variance spectra appear over multi-centennial timescales?
- Can regionally explicit moisture-regime changes be reconstructed in Europe, and can these variations be related with long-term climate model output?

2. Research Summary

Most efforts to reconstruct regional to large-scale climate variability have focused on temperature. This tendency, driven to quantify natural and anthropogenic radiative forcing changes, neglects the arguably much greater importance of water availability, and its short to long-term variations, to society and ecosystem functioning. We thus seek to reconstruct drought variability and impacts from widespread European tree species, and compare empirically based estimates with long-term climate model simulations and intra-seasonal growth data.

Within De-Tree analyses of tree-ring width and stable isotope data from widespread forests in southern and central Europe and subsequent calibration of these proxy data against gridded and long-term instrumental station records are scheduled. We will assess age-related biases in tree-ring isotopes (Treydte et al., 2006), explore possible changes in transpiration related to the ~35% increase in atmospheric CO_2 over the past 150 years, and combine stable isotope with traditional tree-ring width data (Treydte et al., 2007) to develop multi-parameter supported climate reconstructions.

De-Tree includes an analysis of drought fingerprints in existing and newly developed data, and estimation of PDSI signals both in extremes and for multi-decadal to centennial scale variations (Cook et al., 2004). Particularly sensitive sites and species will be combined with low elevation archaeological/relict data to reconstruct PDSI over the past millennium (Esper et al., 2007) and to associate these histories with climate models using time-slice experiments (Trouet et al., 2008). Changes in boundary conditions and possible shifts in source water will be explored by analyses of isotopic signatures in existing tree-ring and precipitation data, and changes in water use efficiency assessed via annual timeseries of carbon isotope discrimination from broadly distributed locations throughout Europe (Treydte et al., 2007). Expected output includes a better quantification of the long-term changes in the hydrological cycle, a long-term assessment of hydroclimatic impacts on aboveground woody biomass, and initial evaluations of vegetative feedbacks on the European climate.

3. Data and methods

To answer the above research questions, we will shift foci and methods from those developed and successfully implemented during the previous two phases of NCCR-Climate. Rather than targeting extreme treeline locations, compilations of existing and development of new data will target forested areas representative for the European continent. This will allow changes in continental-scale productivity and related water use to be assessed. For one selected location in central Europe (e.g., Germany or Switzerland) we will develop an annually resolved isotope-based timeseries and for another location in the Mediterranean (e.g., Spain or Italy) we will develop a long-term tree-ring width series. The species and the exact sites will be selected based upon pre-investigations to maximize chronology length and sensitivity to changes in the hydrological cycle. *Pinus spp* in the Mediterranean and both hardwood (*Quercus spp.* or *Fagus sylvatica.*) and conifers for central Europe are under primary consideration. The newly developed records will be compared and combined with existing tree-ring timeseries that contain some precipitation signal. As particularly the ring width data from central Europe often contain weaker climatic signals (Friedrichs et al., 2008), we seek to integrate larger multi-species datasets from both living stands and historic material to cope with this shortcoming, and develop longer-term records indicative of changes in the hydrological cycle on timescales from years to centuries.

Novel methods of tree-ring detrending – including basal area increments – carbon data correction, reconstruction error estimation, and empirical data versus model comparison will be explored. Also new to De-tree will be the possibility to link, for the first time, intra-annual responses of trees to climate (e.g., growing season length, periods of cellular activity, wood anatomical features) with signals in long-term proxy based reconstructions. We will develop and improve upon various methodological aspects of palaeoclimatic reconstruction, better quantify possible age-related trends (Esper et al., 2008) in isotope data, and hence test their suitability for unobstructed reconstruction of low-frequency climatic variations. Pre-investigations have shown that the drought indices such as the PDSI (van der Schrier et al., 2006) may capture a significant amount of the year-to-year variability in broadly distributed tree species, and may thus offer the possibility to develop regional (Esper et al., 2007) and gridded PDSI reconstructions (Cook et al., 2004) that do not require stationary assumptions of climatic teleconnections defined during the calibration period.

Particular attention will be paid to relationships inferred and calibrated during the instrumental period to (i) assess possible inconsistencies and biases in early instrumental station data that are relevant to test the temporal stability of transferred reconstructions (Frank et al., 2007a; Böhm et al., 2008), (ii) define the amplitude of reconstructed variations (Esper et al., 2005), and (iii) determine possible instabilities or long-term changes in the sensitivity of biological systems to climatic change and extremes (Rutishauser et al., 2008; Büntgen et al., 2008). The spectral properties of proxy and instrumental dataset will be considered (Osborn and Briffa, 2004) to determine the most suitable reconstruction targets and techniques (Frank et al. 2007b; Esper and Frank, 2008).

These and methodological uncertainties will be considered to set more realistic and properly defined error estimates (Esper et al., 2007) that will allow De-Tree to contribute well-verified regional reconstructions of longer-term drought variability, and will aid in the multi-proxy compilations and the overall objectives scheduled for the third NCCR Climate phase. Proxy-based reconstructions will be associated with regional output derived from global climate models using proxy-surrogate-techniques (Graham et al., 2007) to assess the spatial coherence of reconstructed drought patterns and further knowledge of the association of atmospheric high- and low-frequency climate modes (Raible 2007).

4. Milestones and deliverables

After 18 months:

- Composition of existing drought-sensitive ring width data of widespread European tree species;
- Documentation of local and regional precipitation and drought reconstructions including assessments of variance changes and spectra;

After 36 months:

- Development of one long-term, PDSI sensitive ring width datasets from the Mediterranean, and one long-term, PDSI or relative humidity sensitive stable isotope dataset from Central Europe;
- Regional drought reconstructions from southern and central Europe integrating existing and newly developed data, accompanied by well-constrained reconstruction error estimations.

5. Contribution to the WP1 and collaboration with other NCCR projects and 3rd parties

The expertise developed by De-Tree members in reconstructing past climate variability will form a critical part in linking changes in the past with those observed by modern instrumental networks and projected via simulations, within the NCCR-framework. Collaborative efforts include: (i) Joint analyses of quantile regression methodology (P1.2); (ii) Contribute long-term drought records to spatially explicit precipitation reconstruction (P1.2); (iii) Comparison of reconstructed decadal scale changes in the regional hydrological cycle with CCSM3 time-slice experiments and 500-year simulations (P1.1); (iv) Associate proxy-based reconstructions with CCSM3 output using proxy-surrogate-techniques (P1.1); (v) Association of the inter-annual drought reconstructions with the intra-annual monitoring of forest growth from the Swiss Canopy Crane and helicopter-based forest sites (P3.3). De-Tree is well placed to contribute to the European Community projects “Millennium” and “CARBO-extremes”, representing larger coalitions of the 6th and 7th framework programmes, respectively. Results will be relevant to local and regional organizations and authorities, and to scientific programs and databases dealing with climate variability, impacts, and global change issues. Examples include: (i) Past Global Changes Program (PAGES), Bern, Switzerland; (ii) National Geophysical Data Center (NOAA) and the International Tree-ring Databank (ITRDB), Boulder, Colorado; and (iii) The Intergovernmental Panel on Climate Change (IPCC), WMO and UNEP, Geneva, Switzerland. Long-term reconstructions will be of importance to large-scale proxy data compilation, the assessment of inter-regional drought variations, and likely for attribution studies.

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WP2 Future Climate

WP Leader: C. Schär, ETH Zurich

1. Three Key Questions

- What are the main mechanisms that govern trends and variations of the hydrological cycle from the recent past into the future (1850-2100), and how well are these reproduced in a comprehensive global/regional climate modelling system?

- How will aerosol-induced perturbations of cirrus and mixed-phase clouds affect the surface energy budget and the hydrological cycle, and how can the underlying microphysical and aerosol processes be represented and simulated?

- How can end-users make optimal use of the full multi-model climate information, and how can statistical downscaling help them to obtain information at high temporal and spatial resolution?

2. Contribution to the NCCR Climate

In the transition from the 2nd to the 3rd phase, the structure of WP2 undergoes considerable changes. Yet the thrust of the WP remains directed towards modeling and understanding climate variations and trends from the presence into the future, with a particular emphasis on the hydrological cycle and extreme events. The main tools of WP2 are:

- Global climate model: the ECHAM5-HAM model that includes a sophisticated aerosol module and detailed cloud-microphysical processes.
- Regional climate model: the CLM/COSMO model which has been introduced during the last phase of NCCR Climate.
- Statistical downscaling: several statistical and probabilistic approaches will be used to bridge the gap between raw model output and end-user needs.

WP2 comprises three projects, which are linked to the three questions listed above:

P2.1 (Wild/Schär) will use global and regional atmospheric models at resolutions of up to 25 km. Simulations will be conducted for the period 1850-2100. Beyond the generation of climate change scenarios, the long duration of the simulations is attractive as covering a wide range of climatic conditions. The research will address the role played by changes in surface radiation (i.e. global dimming and brightening), and assess how well past variations of this type can be reproduced. We will also study the linkage to the intensification of the hydrological cycle and how changes in the hydrological cycle might affect the frequency and distributions of hydrological extremes.

P2.2 (Lohmann/Peter) will investigate the role of cirrus and mixed-phase clouds in our climate system. While past work has been directed towards aerosol effects on liquid water clouds, aerosol effects on cirrus and mixed-phase clouds should receive more attention. The role of the underlying microphysical processes on regional and global cirrus properties and on the radiation balance will be explored. The research will develop a heterogeneous ice nucleation parameterization based on trajectory-box model, and employ model simulations with an extended version of the ECHAM5-HAM model.

P2.3 (Appenzeller/Liniger/Knutti) will develop and employ statistical and probabilistic methods to optimally exploit the information contained in multi-model ensembles. The project will develop new methodologies for the generation of end-user products and thereby contribute to the generation of climate change scenarios. P2.3 will use the relevant simulations available simulations from the international community (e.g. from ENSEMBLES), among those conducted by P2.1. The project will give consideration to seasonal means as well as extreme weather events.

Together WP2 provides a wide-ranging scenario capability, bridging from global to regional to local scales. During the second phase of NCCR, WP2 has built expertise regarding climate change scenarios and the generation of user-specific products for climate assessment purposes. This work will be continued and strengthened during the last NCCR Climate project phase.

3. Integration and Cohesion within the WP

The integrating aspect of WP2 is the joint focus on current/future climate, as well as the shared interest in the hydrological cycle. All WP2 projects deal in some way with these challenges. Within the work package we will closely collaborate on modelling issues (in particular regarding the ECHAM5 shared by P2.1 and P2.2, but also between MeteoSwiss and P2.1 regarding the use of CLM/COSMO), and exchange a wide range of data (e.g. between P2.1 and P2.3).

4. Interfaces with other WPs

There are close connections between WP1 and WP2 (together they cover past, current and future climates), and there are also important ties between WP2 and WP3/4 (in particular regarding climate change scenario data for impact studies). The temporal overlap of GCM simulations between P1.1 (1000-2000) and P2.1 (1850-2100) will allow detailed model intercomparison. Reconstructions from P1.1-3 will provide the observational context, which is of particular interest given that we will simulate the period 1850-1950 with a high-resolution GCM/RCM modelling system, whose application is normally restricted to more recent and future periods. Several projects from WP3 and WP4 will use scenario information from WP2, either using direct model output (P2.1) or statistically downscaled and probabilistic scenarios (P2.3), In addition, there are links to P3.3 regarding the use of the CLM model.

5. Expected Impact of the WP

International Level:

The work of WP2 will help to better understand important processes related to climate change. This concerns in particular the role of (i) global dimming and brightening, (ii) cirrus clouds, (iii) intensification of the hydrological cycle, and (iv) processes behind changes in extreme precipitation events. In addition, our work will contribute towards broadening the availability of climate simulations and contribute to the development of statistical and probabilistic downscaling methodologies. The results will be relevant to future assessment reports of the IPCC as well as several international projects (e.g. WCRP, SPARC).

National level:

Scenarios for the Alpine and European region are of prime interest to impact studies conducted within and outside the NCCR Climate, to governmental bodies (e.g. BAFU, OcCC) and to the economic sector (e.g. construction, traffic, energy). Indeed, climate change adaptation is closely tied to the availability of credible climate projections. WP2 will provide the backbone of this work within Switzerland. Although increasingly climate change scenarios become available internationally, it is important that Switzerland maintains its established expertise and competence in this area. The research conducted will also be linked with the newly established Center for Climate Systems Modelling (C2SM, see www.c2sm.ethz.ch and section 4.1.2 of this proposal), which will also provide a home for the newly developed scenario results beyond the lifetime of NCCR Climate.

P 2.1

Intensification of the water cycle: Scenarios, processes and extremes (HyClim)

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1. Three research questions of the project

- What are the main mechanisms that govern changes and variations of the water cycle from about 1850 to the end of the 21th century, and how are they reproduced in a comprehensive global/regional climate modelling system?
- How do the substantial decadal variations in the surface radiation balance (global dimming/brightening) affect the global energy and water cycles?
- How does the anticipated intensification of the water cycle affect the occurrence of extreme events?

2. Research Summary

There is increasing evidence from theory, observations and climate models that climate change will lead to an intensification of the hydrological cycle. On the regional scale, the magnitude of the changes in precipitation and evapotranspiration will strongly depend upon the season and affect the characteristics and frequency of extremes (heavy precipitation events, floods, droughts, and heatwaves). The main goals of the proposed project are:

(1) *Global and regional climate change scenarios:* New extended integrations using global (ECHAM5-HAM) and regional climate models (CLM/COSMO) will be conducted. They will cover the time period 1850-2100. In comparison with previous simulations (e.g. Schär et al. 2004, Bättig et al. 2006), the new integrations will make use of updated GCM and RCM model versions, will adopt improved histories of greenhouse gas and aerosol emissions, will include improved representations of aerosol effects, and will employ higher computational resolution (GCM: T106, RCM: 25 km). In addition, the simulations will be extended further back in time, considering also the climate evolution in the 19th century. These extended simulations allow addressing a number of open issues associated with hydrological features at the end of the little ice age. For example, the summers in Central Europe in this period frequently experienced extraordinary amounts of precipitation, leading to devastating flooding in various instances. These aspects of will be addressed in a PhD project based on the abovementioned global and regional climate simulations.

(2) *Anthropogenic and natural radiative forcings and their impacts on water and energy cycles:* The primary anthropogenic forcing upon our climate occurs through a perturbation of the Earth radiation balance (“radiative forcing“) in response to anthropogenic changes in atmospheric greenhouse gas and aerosol concentrations. Recent evidence suggests that significant decadal variations occur not only in the thermal (greenhouse) radiation but also in the amount of solar radiation reaching the Earth’s surface (Wild et al. 2005). A substantial reduction of surface solar radiation was observed between the 1950s and 1980s (“global dimming”), with a more recent partial recovery (“brightening”). Recent studies suggest that global dimming and brightening has a major impact on various elements of the climate systems, not only on global warming, glacier and snow cover retreat (Wild, 2007, Wild et al. 2007), but particularly also on the strength of the water cycle (Wild et al. 2008). We intend to investigate the link between these anthropogenic and natural perturbations of the radiation balance and the intensity of the hydrological cycle using the global and regional climate models and comprehensive observational databases.

(3) *Impacts of intensified water cycle upon extremes:* The main thrust of the work funded by the current proposal will be related to the analysis of our own regional climate simulations in comparison with simulations conducted within the EU-project ENSEMBLES (Hewitt and Griggs 2004). In methodological terms, the work will extend on recent investigations conducted in relation to heat waves (Schär et al. 2004, Vidale et al. 2007, Fischer et al. 2007, Fischer and Schär 2008) and heavy precipitation events (Frei et al. 2006, Fowler et al. 2007). Simulations will be analysed for changes in characteristics (e.g. frequency, intensity) of the hydrological extremes with a focus on the European to Alpine region. The principal tool used will be statistical extreme value theory, applied to indices representing key aspects

of climatic extremes on both seasonal and annual timescales (e.g. multi-day maxima; upper quantile values; return periods), and this builds upon recent such studies (e.g. Frei et al 2006; Fowler et al 2007). The physical nature of extreme events will also be examined in the context of known inter-model deficiencies, such as dry biases in southern European summer (e.g. Giorgi 2006) and the sensitivity of simulations with respect to convection parameterization (e.g. Brockhaus et al. 2008). Simulations will be validated against the latest high-resolution observational datasets (e.g. Haylock et al 2008).

The research on extremes will also be linked to work on cloud-resolving climate simulations (Hohenegger et al. 2008), which will be funded from other sources. Recent studies using this approach show that the representation of moist convection is a key uncertainty and can decisively influence climate-relevant feedback processes such as the soil-moisture precipitation feedback (Hohenegger et al. 2009). This approach is currently still too expensive for climate scenario simulations, but will become feasible within a few years.

3. Data and methods

To address the abovementioned scientific goals, we intend to perform extended simulations with the global climate model ECHAM5-HAM and the regional model CLM/COSMO. ECHAM5 HAM is a special version of the global climate model ECHAM developed at the Max Planck Institute for Meteorology, Hamburg, which includes in addition a sophisticated aerosol module (Hamburg Aerosol Model - HAM, Stier et al. 2005) and detailed cloud microphysics processes (Lohmann et al. 2007, Lohmann 2008). This allows an improved representation of aerosol direct and indirect radiative effects. Since these effects are considered as major contributors to the observed decadal trends of dimming and brightening (Wild et al., 2005, Norris and Wild, 2007), this model version is particularly well suited to address the abovementioned research questions. The cloud microphysics scheme will undergo continuous development in project P2.2 during Phase 3, and we will employ the latest version provided by this project for the proposed simulations. The close interaction with project 2.2 will ensure the access to cutting edge modelling tools in our project. Decadal variations in surface radiative forcings and associated impacts on the climate system are currently unsatisfactory simulated in most climate models as e.g. used in the 4th IPCC assessment report (Wild 2008). We will thoroughly test the impact of the newly developed model physics on the model's ability to reproduce the observed changes in the radiative forcing and related impacts, and provide feedback to the ongoing model development process in project P2.2. The comprehensive in-house observational radiation datasets, updated to near present during Phase 2, will be used for this testing purpose.
The regional climate model experiments will be carried out using the CCLM numerical model (see http://clm.gkss.de/, formerly referred to as COSMO or CLM or LM). Within NCCR phase II, we have switched to this model and developed both conventional (Δx=25 km) and cloud-resolving resolution (Δx=2 km) modeling systems. Since the beginning of our work with the CLM model in 2005, considerable experience has been established (cf. Brockhaus et al. 2008, Hohenegger and Schär 2007, Hohenegger et al. 2008, 2009, Jaeger et al. 2008).

4. Milestones and deliverables

After 18 months:

- thorough evaluation of latest ECHAAM-HAM model version provided by Project 2.2;
- completion of GCM integrations1850-2100;

After 36 months:

- completion of RCM scenario integrations;
- physical understanding of variability / trends of precipitation and extremes;
- publications.

5. Contribution to the WP1 and collaboration with other NCCR projects and 3rd parties

The results of the model integrations will be made available to P2.3 and P4.2 that rely on global and/or regional climate change scenarios. We rely on P2.2 regarding expertise in cloud and aerosol microphysics and provide feedbacks to P2.2 on the performance of the new scheme in extended simulations. We will further interact with P3.3 regarding land-surface parameterizations. Aerosol information obtained from ice core analyses in P1.2 (and related EU-FP6 IP 'Millennium') will be used in the interpretation of detected variations in surface radiation. Model intercomparison will be conducted with P1.1 using either a control period or a past period. The project will also be linked to the newly founded Center for Climate Systems Modeling (C2SM, see http://www.c2sm.ethz.ch)

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P 2.2 CCC
Global climate processes: Role of cirrus clouds for present and future climate

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1. Three research questions of the project

- How do number densities and composition of natural and anthropogenic ice nuclei affect cirrus clouds in the present and future climate?
- Does mineral dust lead to cirrus clouds with fewer and larger or more and smaller ice crystals? Does that depend on their chemical aging and active sites?
- How will aerosol-induced perturbations of cirrus clouds affect the surface energy budget and the hydrological cycle?

2. Research Summary

Aerosol-cloud interactions constitute one of the biggest uncertainties in climate prediction. Cloud feedbacks have been confirmed as a primary source of differences between climate model estimates of the equilibrium climate sensitivity, i.e. the global mean surface temperature increase, for a doubling of carbon dioxide (Solomon et al., 2007). While much work has been directed towards aerosol effects on liquid water clouds, aerosol effects on cirrus and mixed-phase clouds should receive more attention. These effects may change in uncertain ways when homogeneous freezing in sulphate-containing aerosols will compete with natural ice nuclei, such as mineral dust particles. While higher aerosol number densities normally lead to more cloud droplets, the situation in cirrus clouds is more complex, as the competition between homogeneous and heterogeneous freezing can lead to cirrus clouds with more or less ice crystals whereby fewer ice crystals are more likely (e.g. Kärcher et al., 2006). Clouds containing fewer particles have a smaller cross-sectional area for the same water content and thus reflect less solar radiation back to space. For cirrus clouds a decrease in crystal concentration would also impact the longwave radiation and could lead to a net cooling. Thus, it is important to better understand the role of ice nuclei for cirrus clouds in order to estimate the response of cirrus clouds to increasing levels of anthropogenic aerosols.

Besides nucleation effects, ice growth impedances were recently found to lead potentially to high supersaturations within cirrus clouds (e.g. Peter et al., 2006). The role of physico-chemical processes affecting the deposition of water vapour on ice and of water vapour on aerosols is presently unclear. These effects could be related to unknown intrinsic properties of the ice substance at the lowest temperatures of cirrus clouds close to the tropopause, or due to natural or anthropogenic species on the ice surface.

The effects of these nucleation and growth effects on regional and global cirrus properties and on the radiation balance will be investigated by means of process-based or parameterization-based trajectory models in task 1 and in the global climate model (GCM) ECHAM5 in task 2.

3. Data and methods

The following work is planned:

Task 1: Develop a heterogeneous ice nucleation parameterization based on trajectory-box model runs for competing homogeneous and dust-induced heterogeneous ice nucleation and impeded ice particle growth.

The trajectory model will be a generalization of the model used by Hoyle et al. (2005) for purely homogeneous nucleation studies. This will enable us to study the nucleation of ice crystals using realistic mesoscale temperature fields. This is an important ingredient of nucleation modelling, as higher instantaneous cooling rates lead to favouring homogeneous over heterogeneous nucleation and results in higher ice number densities. While Hoyle et al. (2005) used exclusively the mesoscale temperature fields obtained from the SUCCESS field campaign, we will here acquire an overview over published temperature fluctuation measurements (e.g. Gary, 2006) in an attempt to obtain climatologically realistic fields for various altitude levels.

Mineral dust aerosols will be investigated as the arguably most important category of heterogeneous ice nuclei (IN). We will focus on the issue how natural mineral dust particles are processed physically (e.g. in deep convection) and chemically (e.g., by HNO_3), and develop refined parameterizations. For the heterogeneous freezing mechanism we will start with the efficiency of immersion mode ice nucleation on surrogates of mineral dust, which we derived recently from our laboratory measurements (Marcolli et al., 2007). A model for the freezing has been developed, which describes the ice nucleation on active sites and which currently comprises the most advanced treatment of the freezing process. From this a parameterization for dust induced ice nucleation to be applied in Task 2 will be developed.

While this parameterization will first be constrained to the freezing process of mineral dust immersed in pure water, in a second step this will be generalized to various kinds of solutions (ammoniated sulphate solutions, organics-containing solutions). Measurements for this are currently on the way in our laboratory. From the literature we will collect data on the deactivation of sites due to chemical aging, e.g. by HNO_3.

Task 2: Analyse the role of cirrus clouds formed by heterogeneous vs. homogeneous freezing for current and future climate with implications for the surface energy budget.

Contrails have been shown to reduce the diurnal temperature range in the United States (Travis et al., 2002). On the contrary a shift from cirrus clouds formed by homogeneous freezing of solution droplets to cirrus clouds formed by a combination of homogeneous and heterogeneous freezing would lead to cirrus clouds with a reduced optical depth. These clouds would allow more solar radiation to reach the Earth surface with implications for the surface energy budget and the hydrological cycle. Previous climate model simulations did not investigate this issue because these simulations were conducted with climatological sea surface temperature (Lohmann et al., 2004). In these simulations only the land surface temperature could react to changes in cirrus cloud properties. In order to analyze effects of cirrus on the surface energy budget, it is appropriate to couple a GCM to a mixed-layer ocean model (MLO) (e.g., Feichter et al., 2004). Thus we suggest studying the effect of cirrus on the surface energy budget in coupled GCM-MLO studies. This also allows us to study the importance of cirrus clouds on climate sensitivity.

Moreover, previous cirrus studies were conducted with the ECHAM4 GCM that only predicted the mass mixing ratios of the major aerosol compounds (sulphate, organic and black carbon, dust and sea salt). In the meantime, the newest version of the ECHAM GCM, the ECHAM5 is coupled to the two-moment aerosol scheme ECHAM5-HAM that predicts the aerosol mixing state in addition to the aerosol mass and number concentrations (Stier et al. 2005). The size distribution is represented by a superposition of log-normal modes including the same major aerosol compounds. Also the two-moment cloud microphysical scheme has been improved in terms of the ice crystal fall velocity and ice crystal shape and a simple treatment that allows both homogeneous freezing and heterogeneous freezing by immersed dust aerosols in cirrus clouds has been developed (Lohmann et al., 2008).

However, chemical aging of dust aerosols, the role of the water uptake and active sites have not been considered so far. Task 2 will focus on adapting and applying the parameterization that considers these effects and was developed in task 1 in coupled GCM-MLO simulations with ECHAM5-HAM. It will then investigate the importance of homogeneous and heterogeneous freezing on cirrus clouds with implications for future global and regional scenarios, the surface energy budget and for the hydrological cycle.

4. Milestones and deliverables

After 18 months:

- Cirrus box model runs for close intercomparison with aircraft and balloon-based observations, yielding basic information for parameterization development.
- A parameterization considering active sites of mineral dust aerosols for use in large-scale models.

- Analysis of the importance of cirrus clouds formed by heterogeneous vs. homogeneous freezing in the present and future climate with the present cirrus scheme.

After 36 months:

- Generalization of the active-site/nucleation parameterization for a wide range of solutions including chemical aging during aerosol transport.
- Implementation of the heterogeneous freezing parameterization developed in task 1 in ECHAM5-HAM; comparisons with observations and implications for future climate.
- Make the new cirrus module available for P2.1, in particular, for high-resolution GCM scenarios in collaboration with M. Wild and Ch. Schär.

5. Contribution to the WP1 and collaboration with other NCCR projects and 3rd parties

The improved parameterization will be used to assess the impact of mineral dust versus sulphate aerosols on cirrus clouds, with implications for future global and regional scenarios (P2.1 HyClim Wild/Schär) and for the hydrological cycle (P2.3 PreClim Appenzeller/Liniger/Knutti and P3.3 ECOWAT Bugmann/Seneviratne).

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P 2.3 PRECLIM
Probabilistic climate change scenarios for mean and extremes in the Alpine region

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1. Three research questions of the project

- How can the uncertainty of expected seasonal temperature and precipitation changes in Switzerland be quantified using a multi-model ensemble approach?
- How can end-users make optimal use of the full multi-model information and how can statistical downscaling help them to obtain information in a high temporal and spatial resolution?
- How will extreme weather events change in Switzerland and Europe? Can we use the multi-model approach to reliably quantify expected changes and uncertainty in extremes? How can the characteristics of changes in extremes be preserved in downscaling? To what degree can patterns be scaled to other scenarios?

2. Research Summary

Climate change is projected to have major impacts on various aspects of our society. In order to plan the future effectively, reliable information on the expected changes are needed that can be communicated and applied in end-user models. Such models typically require information on very local spatial and temporal scales. Several national climate change assessments (e.g. CH, NL, UK) made first attempts to make available such information by providing expected changes in mean quantities mainly derived from time slice experiments. Although today's climate models (as e.g., developed in P2.1 Schär/Wild) do have comparably high resolution, there is still a substantial gap to the end-user needs. E.g. the current climate change scenarios for Switzerland (OcCC 2007, Frei 2004) only consider seasonal averages for Northern and Southern Switzerland, thus limiting their applicability from a user perspective. This gap is even wider if climate extremes are considered, which are more difficult to predict because the relevant processes are often not adequately incorporated in today's climate models, and because the events are poorly sampled. Yet it is precisely those events that are probably most important to society.

P2.3 aims to fill this gap. P2.3 develops and applies statistical techniques to generate climate change scenarios with high temporal and spatial resolution while at the same time quantifying the underlying uncertainties. This involves the construction of calibrated multi-models from transient scenarios (e.g. Scherrer et al., 2005, Tebaldi and Knutti, 2007, Weigel et al., 2008, 2009) as well as the development and application of statistical downscaling methods to station level (e.g. Schmidli et al. 2007, Kilsby et al. 2007). Thereby, not only climate mean variables are considered, but also changes in climate extremes.

3.Data and methods

The recent OcCC (2007) climate change scenarios for Switzerland are based on model runs from the international PRUDENCE project which do not represent the state-of-the-art any more. The new scenarios to be developed in P2.3, on the other hand, will be based on the output of a new generation of Global Climate Models (GCMs) and Regional Climate Models (RCMs) as provided by P2.1 and particularly by the EU FP6 ENSEMBLES project. The ENSEMBLES model runs (Jacob et al. 2008) consist of 22 GCM-driven transient RCM simulations (1950-2050; A1B scenario), which will be available by the beginning of the 3rd phase of the NCCR Climate. They are based on various combinations of 6 GCMs and 14 RCMs, thus allowing for a probabilistic multi-model approach and a quantification of model uncertainties.

A methodological key question with respect to the construction of multi-model scenarios is whether or not all participating single models shall be considered, and whether or not weights shall be assigned to them (e.g. by applying the method of Buser et al. 2008). This requires an assessment of model performance with observational data, considering appropriate skill metrics (Weigel et al. 2007), such as model bias and the reproduction of observed climate characteristics (e.g. Liniger et al. 2007, Scherrer et al. 2006, 2008). For this task, the ENSEMBLES gridded high-resolution observational datasets of daily temperature and precipitation (Haylock et al. 2008) can be used, as well as homogenized observational data of MeteoSwiss. These data will also be the basis for the development and assessment of an appropriate statistical downscaling method.

The downscaled probabilistic multi-model scenarios will not only quantify changes in climate mean but will also estimate changes in extremes over Switzerland and Europe. In this context, more fundamental questions regarding the characteristics of extreme events in climate models will be additionally considered. For example, while changes in many variables can often be assumed to scale linearly with temperature, this may not be true for extreme events. Tebaldi et al 2006 have shown that even the globally averaged changes in dry days (defined as the annual maximum number of consecutive dry days) aggregated over several models show some change-points where the trends change or reverse abruptly, for example in the A2 scenario. Moreover, the B1 scenario indicates no significant trends despite substantial warming. Global models available from the CMIP3 multi-model archive will be used to test how spatial patterns of changes in extremes vary over time and across scenarios.

4. Milestones and deliverables

After 18 months:

- Scenarios for seasonal mean temperature and precipitation in regional resolution for Switzerland and (if possible) the Alps, based on multi-model transient climate scenarios (A1B scenario, time range until 2050);
- A set of statistical methods to robustly extract extreme statistics from climate model simulations.

After 36 months:

- A method to combine a statistical downscaling technique with a probabilistic multi-model approach to generate highly localized time series of temperature and precipitation on seasonal to daily time scales for Switzerland (A1B scenario, time range until 2050);
- An assessment of projected changes in extreme events in central Europe, with a focus on robustness, methods on how to combine models, the validity of pattern scaling and the consistency of the downscaled results.

5. Contribution to the WP2 and collaboration with other NCCR projects and 3rd parties

P2.3 will be strongly interlinked within WP2, as well as with WP1 and WP3. The dynamical global and regional climate model runs from P2.1 and P2.2 (as soon as available) together with model runs from international projects (PRUDENCE, ENSEMBLES) are the basis for our multi-model calibration effort. Historical model simulations and reconstructions from P1.1 MONALISA-3, P1.2 PALVAREX-3 and P1.3. DETREE will provide the historical context. Transient scenarios for end-user modellers (WP3, P4.2) are provided after 18 months (regional seasonal mean temperature and precipitation) and after 3 years (downscaled to daily time scales). Swiss scenarios are of prime interest to many other governmental bodies (e.g. BAFU, OcCC) and economic sectors (e.g. infrastructure as SIA, energy).

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WP3 Ecosystem Impacts and Adaptation

WP Leader: J. Fuhrer, FAL Reckenholz

1. Three Key Questions Addressed by WP 3

1. What is the sensitivity of common species or functional types in forests and grasslands, and of soil physical and chemical properties to drought?
2. What are the short- and long-term impacts of changes in drought occurrence for Swiss forests and grasslands, and on larger scales for the biosphere-atmosphere coupling?
3. How will drought-related production risks in agriculture change, and how can they be managed effectively?

2. Contribution to the NCCR Climate

WP3 continues to address potential impacts of changing climatic conditions on agricultural crops and grasslands as well as forest ecosystems, and examine options for suitable adaptations in ecosystem and risk management at the regional scale. In line with the overall research goals of the NCCR Climate in Phase 3, the focus of WP3 is on water and carbon cycles, and on risks from extreme climatic conditions such as precipitation shortage and episodes of drought. These are particularly important events as they are projected to become more frequent and more persistent during the growing season in the coming decades. Droughts can act as drivers for ecosystem development, and they can impact upon the provision of ecosystem goods and services, with economic implications for the sectors concerned (i.e., agriculture, forestry), unless suitable measures are taken to minimize risks. They can also change land surface characteristics, which in turn affect the energy and radiation balances at the surface, and thus the coupling of the land surface to the atmosphere.

Based on a combination of manipulative experiments and modelling during both Phases 1 and 2, WP3 has provided information on a variety of processes taking place in agricultural and forest ecosystems in relation to different climate change scenarios and elevated CO_2. These included changes in soil carbon stocks, productivity, water relations and biodiversity in forests and grasslands at different scales ranging from individual plots to catchments. Moreover, it has provided first assessments of possible adaptations - mainly in crop production - to minimize the risk of yield and economic losses in agriculture.

In Phase 3, this line of work will be continued. The focus remains on extreme climate events, in particular drought. The plan is to build largely on previous work and structures established in Phase 2, with some new elements included and others discontinued. The aim is to promote established synergies within WP3, to more tightly link experiments with modelling, and to benefit from associated activities such as the Swiss Fluxnet, a network of trace gas flux measuring sites (collaborative effort by ART and ETH Zurich), ongoing EU projects (e.g. ACQWA, Carbo-Extreme) and projects funded by NSF or other agencies, and finally from those projects carried out by associated members.

The overarching aims in Phase 3 will be to produce a broader and more general view of ecological and economic risks resulting in forestry and agriculture from climate change for the periods 2030, 2050, and 2100, to develop short-term and long-term risk management strategies, and to evaluate in more detail implications of changes in the surface boundary conditions for the regional climate.

In detail, WP3 aims are:

(i) to advance the understanding of climate change impacts on forests (P3.3) and grasslands (P3.1) at the process-level, with an emphasis on changing occurrence of hot/dry periods, and to improve process-based modelling capacities to extrapolate experimental results in time and in space (P3.2, P. 3.3);

(ii) to improve the understanding of the feedback of altered surface properties to the regional climate (P3.3), and to assess agricultural production risks resulting from effects of climate extremes on soils, water availability and land suitability (P3.2);

(iii) to obtain a regional and national perspective of efficient adaptation measures in the agricultural sector by taking into account the development of agro-climatic conditions across the agricultural land on the one hand, and in international trade, world market prices, and developments in the insurance industries on the other hand (P3.2).

3. Integration and Cohesion within the WP

During Phase 2, WP3 has made an effort to integrate results from individual projects in order to develop coherent answers to the key WP questions. This involved integration of experimental with modeling results, as well as integration of results from different experiments with grassland systems. In Phase 3, several of the research lines started in Phase 2 will be continued: (i) drought risks for grasslands observed in manipulative experiments, with an emphasis on above-and belowground processes and on soil chemical and physical properties; (ii) Long-term implications of individual tree species' sensitivity to drought for carbon and water cycles in forest ecosystems; (iii) Assessments of production risks in agriculture and evaluation of efficient management options. Along theses lines, individual projects will collaborate by using the same climate scenarios, sharing data, comparing experimental with modeling data and, for agriculture, by preparing common recommendations for adaptive strategies. Integration of work with grasslands and forests will also benefit from joint participation of ETH Zurich (Bugmann, Wolff) and ART (Calanca, Fuhrer) in the EU project ACQWA as well as participation in the EU project Carbo-Extreme (Buchmann, Seneviratne).

4. Interfaces with other WPs

WP3 will interact with WP2 as a user of regional and downscaled, high resolution climate scenarios to simulate longer-term changes in forest and grassland ecosystems, and to assess climate-related risks in agricultural production. WP3 will interact with WP4: results for market and price developments will be used and information will be shared regarding adaptation and technological change, and regarding (financial) risk management.

5. Expected Impact of the WP

International Level:
Through these efforts, WP3 will provide (i) information related to eco-hydrological implications of climate variability and change in pre-alpine and alpine ecosystems and catchments, which is relevant for larger areas of Europe, (ii) an appraisal of drought effects on soil properties, which is of general interest and a high-priority research topic internationally, and (iii) a better understanding of the biosphere-atmosphere coupling, which is relevant for the modelling of the regional climate, an issue of particular importance in larger parts of Europe.

National level:

WP3 will deliver (i) information on the sensitivity to drought of common tree species, which will be relevant for management decision in forestry, and (ii) a framework for discussions of adaptive strategies to support stakeholder decisions in the agricultural sector. In both cases, links to external groups (forestry, agriculture) are established and will be used.

Drought effects on plant water uptake and water use as well as soil carbon dynamics in Swiss grassland systems under changing climate

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1. Three research questions of the project

- Do re-occurring water shortages over mid- to long-term influence the susceptibility of grasslands to drought?
- Do plants in grassland systems shift to different water sources and use water more efficiently under prolonged drought conditions?
- How does drought affect soil CO_2 losses, organic matter decomposition as well as soil organic matter formation?

2. Research Summary

During phase 2, PLANT/SOIL provided first information how extreme drought periods, by prohibiting natural rainfall for 10 to 12 weeks in spring/early summer with rainout shelters and thus strongly reducing soil moisture during these weeks, affected community composition and competition, net primary above- and below-ground productivity, gas exchange as well as soil CO_2 losses after doubling litter inputs. However, it remained unclear if grassland systems also show time-lagged responses to drought periods over the short-term (within a season) as well as over mid- (3 yrs) and long-term (6 yrs). Such time-lags or memory effects might increase the susceptibility of grasslands to drought in the future (IPCC 2007). Therefore, we plan to built on our 3 yrs experiment and extend the drought treatment into the long-term (6 yrs) (Task 1). This will allow us to assess potential time-lagged responses and increased susceptibility to drought at various time scales and provide important long-term input data of three Swiss grasslands along an elevational gradient for the models used in project WP3.2.

Furthermore, plant resource use, in particular water use, will become more relevant when grasslands are to provide forage productivity of high quality despite varying climate (e.g., Nippert and Knapp 2007). If and which grassland plants shift water sources under drought stress is not known. To better understand grassland vulnerability, plant traits related to water use, plant water dynamics as well as water sourcing, water uptake and water use will be studied and most sensitive plants identified (Hector and Bagchi 2007; Suttle et al. 2007) (Task 2). Such process-based information will help to better understand system-scale responses and sensitivity to extreme events.

Soil carbon dynamics under drought conditions are often modelled driving relationships from ambient climate conditions to their very extreme. However, if these relationships really hold true under such extreme conditions is hardly known (e.g., Davidson and Janssens 2006, de Boeck et al. 2007). If soil carbon dynamics are slowed down by low soil moisture, thus increasing soil carbon sequestration, or if lower biomass production will decrease soil carbon sequestration, is not clear yet. We will thus investigate the impacts of drought on soil CO_2 losses, soil organic matter (SOM) decomposition as well as SOM formation under the typical management regimes of three grasslands (Task 3). This information will help us (and WP3.2) to better understand and model soil carbon sequestration potentials in grasslands under drought conditions.

3. Data and methods

The three tasks proposed will be investigated at the three grassland sites Chamau (intensively managed grassland at 400 m), Früebüel (medium-intensively managed grassland at 1000 m) and Alp Weissenstein (expensively managed grassland at about 2000 m) already used during phase 2, thus creating a unique, long-term dataset from a traditional three-stage grassland farming system. Two of these three sites (Chamau and Früebüel) are also part of the EU project Carbo-Extreme. This EU project will provide detailed information about community CO_2 exchange and high-temporal resolution data on carbon isotope fluxes and the fate of recently fixed photosynthates after a ^{13}C-tracing experiment. Here, we will focus on long-term, potentially time-lagged responses to drought (task 1), on water dynamics at the plant species scale (task 2), and on drought impacts on soil carbon dynamics (task 3). Two Ph.D. students will carry out the proposed work, supervised jointly by the PIs.

1. To assess potential time-lagged responses of grasslands to drought and memory effects after the drought period at various time scales. Phase 2 results indicated time-lags of plant responses and longer-lasting memory effects (over winter) after summer droughts. Thus, key parameters representative for various time scales (seasonal, annual, mid-term, long-term) will be measured to assess if re-occurring droughts also increase the susceptibility to drought. Therefore also the recovery phase after an extended drought period will be considered as equally important as the drought period itself for the overall performance of grasslands. The competition among plant species and as a consequence species composition and total biomass production are relevant already in the short- to mid-term, while effects on soil properties will become more important in the long-term after several extended drought periods.

Leaf water potential, stomatal conductance and photosynthetic capacity decline during the day and partially recover during the night throughout the drought period (results from phase 2). Diurnal courses must be analyzed to properly compare the performance of species during the drought period as well as during the subsequent recovery phase. Leaf water potential and gas exchange analyses in abundant species are suitable to detect vegetation acclimation and serve as a basis for model validation. The intrinsic water use efficiency is a key aspect in this context. Reduced transpiration as a consequence of reduced stomatal opening affects cooling in illuminated leaves and higher leaf temperatures may negatively influence CO_2 assimilation. Besides these physiological parameters, the species composition as well as the above- and belowground biomass production are parameters to be addressed. These results together with measured soil characteristics (volumetric soil water content, soil water potential) will provide short- and long-term data for community responses of typical Swiss grasslands and will allow addressing the susceptibility question.

2. To investigate plant traits related to water use, plant water dynamics as well as plant water sourcing and to identify most sensitive plants to drought. Plant traits are known to be good indicators of plant functioning (Diaz and Cabido 2001, Cornelissen et al. 2003) although traits related to water use, such as leaf water content, specific leaf area and specific leaf weight, but also the temporal course of leaf senescence, have not been fully explored yet in concert with physiological responses to pronounced drought. Measurements of leaf water potentials, net CO_2 assimilation rate, transpiration and leaf conductance will be carried out as core parameters at all sites over three years at selected times (before, during, after drought manipulations), but also at higher temporal resolution (diurnals as well as during the transition times before and after drought manipulations; see task 1) at one site per year. This will provide detailed information about competition among plants as well as on sensitivity of plants to drought. Analyses of stable isotopic signatures (carbon, nitrogen) will provide further information about underlying mechanisms such as changed resource use.

In addition, a strong focus will be on plant water sourcing, uptake and use. The origin of plant water uptake and potential shifts during the drought manipulations will be assessed using oxygen and hydrogen isotope ratios in xylem water of dominant plant species (collected according to Barnard et al. 2006). Potential water sources will be collected either event-driven (i.e., precipitation) or on a regular basis (i.e., soil water from different depths, groundwater). In phase 2, some preliminary data have already been collected (e.g., local meteoric water lines), testing the method by Barnard et al. (2006) successfully under field conditions (Gilgen 2009). In combination with root biomass and productivity (see task 1) as well as leaf water potentials and transpiration rates (see above), we will be able to address competition for water among species in the grasslands independently and be able to identify shifts in water sources as a consequence of drought.

3. To quantify the impacts of drought on soil CO_2 losses, SOM decomposition as well as SOM formation in Swiss grasslands. Soil CO_2 fluxes, SOM decomposition and formation *in situ* are important processes driving carbon sequestration potentials in grasslands. Although soil respiration after doubling litter input has been already measured in phase 2, no information is available about soil CO_2 fluxes under ambient litter regime or about their response to drought.

We will measure soil respiration (on a regular basis for one site per year) and soil climate (as in phase 2) to determine its dependency on soil temperature and soil moisture, the two most important drivers (Davidson and Janssens 2006). To assess the long-term carbon turnover, we will use C4 soil cores (originating from a 17-yr-old *Miscanthus* field). Four cores (5 cm in diameter) will be buried per plot: two cores (in 2 mm mesh bags) will allow root growth, soil fauna exchange and thus SOM formation as well as decomposition, two cores (in 1 μm mesh bags, with some drainage holes) will be used only to assess microbial SOM decomposition. One of each type will be harvested after one year (mid of year 2) and after two years (mid of year 3). Based on carbon isotope analysis and root input, SOM turnover rates can be calculated since the C3 roots have very different isotopic signatures than the C4 soil. Although the C4-soil is not the native soil from the individual sites, such a controlled approach will still provide valuable insights into the impacts of drought on soil carbon dynamics.

4. Milestones and deliverables

After 18 months:

- analyses of species competition, aboveground and belowground productivity, root traits and soil properties at Chamau, Früebüel and Alp Weissenstein,
- short-term in-depth physiological responses of grassland plants to drought (one field season at each site), identification of plant water sourcing, uptake depths and water use
- assessment of soil carbon dynamics at short- and mid-term time scales

After 36 months:

- long-term datasets on grassland vegetation (species composition, plant physiology, functional traits, water uptake/use) and soil responses to drought for Swiss grasslands,
- identification of delayed vegetation and soil carbon responses to drought (i.e. recovery, memory effects) and potential of increased susceptibility,
- quantification of soil carbon dynamics at mid- to long-term time scales

5. Contribution to the WP3 and collaboration with other NCCR projects and 3rd parties

Artificial drought periods will be based on climate scenarios of P2.3 PreClim. Model validation and improvement with P3.2 AGRISK (PaSim) will be possible based on 6 yrs of data on responses to drought of typical Swiss grassland types. Soil responses to drought will be carried out jointly with P3.2, task 1. Data will be shared with Swiss Fluxnet and Swiss-wide project Maiolica (PI Buchmann) leading to a comprehensive analysis. Basic infrastructure will be used for this project as well as for the EU project Carbo-Extreme (Co-PI Buchmann). The collaboration of the Institute of Plant Physiology with the Bulgarian Academy of Sciences (project referring to drought responses of Bulgarian wheat varieties) is focused on physiological responses of whole plants to an extended drought period and the subsequent recovery phase. More recently, the response of red and white clover (important grassland species) to soil water status became a crucial issue for the Bulgarian colleagues allowing an even more intense collaboration.

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P3.2. Climate change and agricultural production risks

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1. Three research questions of the project

- Will changes in drought occurrence (frequency/persistence) increase crop production risks by affecting physical and chemical properties of agricultural soils? (Task 1)
- How will changes in climate, water availability and associated production risks alter the spatial distribution of land suitability for agricultural production? (Task 2)
- What are the possibilities offered by either financial market or agronomic instruments to manage relevant climate-change induced production risks in Swiss agriculture? (Task 3)

2. Research Summary

More frequent and persistent periods of agricultural droughts (insufficient soil moisture supply) during the cropping season present a difficult challenge to European farmers. In Phase 2, the project GRASS provided a quantification of drought risks in Swiss agricultural regions (Calanca, 2007) and an evaluation of consequences for crop production at the field scale (e.g. Torriani et al. 2007). In Phase 3, we will further examine implications of increasing drought risks for agricultural production resulting from effects either on soils and water availability, or on farm profitability, and evaluate in more detail options for risk management.

Task 1. *To investigate long-term changes in soil properties.* More frequent and persistent periods of hot and dry weather (droughts) could threaten soil fertility and the potential for soils to act as a carbon (C) sink. If the rate of organic matter (SOM) decomposition exceeds the rate of input and stabilization of C from plant residues, soils may turn from a C sink to a source of atmospheric CO_2. SOM stabilization depends on residue input quality, physicochemical properties and soil biological activity, all of which may be affected directly by more frequent and persistent dry spells and high temperatures, and indirectly through shifts in vegetation towards more xeric, drought-tolerant plant species. Modelling these changes at decadal to centennial time-scales remains a challenge due to limitations in current SOM models, but new experimental information could help improving the models. We currently investigate SOM amounts, SOM fractions and turnover rates along altitudinal gradients to infer the effect of temperature (e.g., Leifeld et al., 2008). In AGRISK, we will examine the hypothesis that frequent/persistent droughts will cause measurable changes in soil properties that affect SOM stabilization and turnover. Special attention will be given to the role of root dynamics, soil respiration, and C partitioning. Improved models will be used to test the long-term sensitivity to regional climate scenarios of SOM and C stocks in representative soil types.

Subtask 1.1: Characterizing changes in physical and chemical characteristics of soils either exposed to experimental soil water manipulation or from natural soil moisture gradients. We will build on work carried out in Phase 2 and complement investigation of plant-related changes by other groups (UNI Be, ETHZ).

Subtask 1.2: Improving the formulation of SOM turnover in mechanistic models such as PROGRASS (developed in Phase 2) and RothC based on results from Subtask 1.1

Subtask 1.3: Modelling direct and indirect effects of changes in temperature and soil moisture on soil C stocks at the decadal to centennial scale, with an emphasis on grassland soils in Switzerland.

Task 2. *To develop and apply a general methodology for the assessment of land suitability for agricultural production (cropland, grassland).* Shifts in the suitability of land available for agriculture are expected as a result of changes in temperature and water availability. Warming will favour regions where currently temperature is a major constraint (higher altitudes), but more frequent and persistent dry spells will increase the area at risk from limited soil water availability and therefore negatively affect the possibilities for rain-fed production.

Subtask 2.1: Development of a methodology for the assessment of climate suitability which explicitly takes into account risks from climatic extremes, in particular droughts. The development will be guided by existing approaches to agro-ecological zonation (e.g. Sivakumar and Valentin, 1997; http://www.fao.org/ag/agl/agll/aez.stm) but will more

systematically quantify the role of climate variability. Moreover, it will take advantage of advances in modelling landscape configuration based on optimization.
Subtask 2.2: Development of future scenarios of land suitability as constrained by projections for climate and water availability and under assumed levels of nutrients inputs and management.
Subtask 2.3: Application of the methodology developed in Subtasks 2.1 and 2.2 to create distribution maps of land suitability for Switzerland and selected areas in Europe.

Task 3. *To evaluate options for farm risk management:* Changing frequencies of extreme climate events, in particular drought, heat waves or heavy precipitation, in association with changes in mean temperature are becoming a specific concern for farm operations. Thus, improved risk management strategies will be necessary to cope with increasing agro-climatic risks. The aim of Task 3 will be to investigate the prospective role of climate-related risk management in Swiss agriculture, thus expanding the work of Torriani et al. (2008) and Finger et al. (2008) in Phase 2. In order to find efficient options for future risk management, potential measures will be identified, evaluated and compared from an economic and sustainability perspective. The considered time horizons for this analysis are the years 2030 and 2050. Different adaptive strategies ranging from agronomic measures such as irrigation to financial instruments (e.g. insurances, weather derivatives) will be considered. Taking into account trends and developments on national and international insurance markets, future demand for climate-related risk management will be analyzed.
Subtask 3.1: Identifying adaptation instruments that are potentially applicable and useful for agricultural production in Switzerland, taking into account short- and long-term needs for adaptation.
Subtask 3.2: Evaluation of financial market instruments to manage future climate-related risks in Swiss agriculture.
Subtask 3.3: Comparison of different adaptation measures to manage future climate-related risks, with an emphasis on risks associated with extreme events.

3. Data and methods

All Tasks: The same climate scenarios from PRUDENCE, ENSEMBLES and, depending on availability, from P2.1 and P2.3 will be used.

Task 1. *Climate change and soil properties*: **Data**: Experimental results from the PLANT/SOIL project obtained during Phase 2 and 3, and from other ongoing ART projects (SNF, COST, EU) (e.g., SOM amounts, SOM fractions, SOM turnover along gradients). **Methods**: Soil samples obtained from control and drought-treated plots at the two remaining sites in the PLANT/SOIL experiment will be analyzed. Samples taken at the start of the experiment are also available but have not been investigated so far. Retrieval of additional soil samples from other experiments such as the long-term experiment in the Southern Swiss Alps (A. Stampfli, UNI Be) will be considered, together with samples collected and analyzed from soils along natural soil moisture gradients. Established methods for SOM fractionation (Zimmermann et al. 2007a) and analyses of soil physical properties (e.g. wettability, hydrophobicity) will be used. **Models**: PROGRASS (Lazzarotto et al., 2008) and RothC (Zimmermann et al., 2007b).

Task 2: **Data:** Spatially explicit data for climate, soil and terrain, and for land use. Several GIS layers will be available from an ongoing country-wide project on crop water requirement. Crop-specific data for water requirements will be collected from ART experts. ***Methods:*** Combination of GIS and statistical and/or dynamic models. In particular, we envisage using an approach known as Bayesian Belief Network in which variables are linked together according to their dependencies, and which allows considering uncertainties in model results (Holzkämper et al., 2008).

Task 3: *Risk management:* **Data:** Farm-level data (management, yield, performance), weather data from different meteorological stations, survey data, crop simulation model output. **Methods:** Literature review, empirical field research methods (interviews), statistical models (using, e.g., extreme value analysis, bootstrap, multivariate statistics), economic modelling (e.g. linear and non-linear programming). For the latter, functional yield relationships for major crops will be inferred from crop simulation model outputs.

4. Milestones and deliverables

After 18 months:

- Sources of samples identified, soil analytical methods and sampling design established, explorative analysis of test samples completed (Task 1);
- Concept and modelling framework established, and model evaluation for land suitability mapping tested; data sources identified (Task 2);
- Climate-related risk and most promising risk management strategies are identified; effectiveness of different financial market instruments is analyzed and compared (Task 3).

After 36 months:

- Soil samples from experimental plots taken and analyzed, data evaluated and compared with simulation model results; long-term model simulations completed (Task 1);
- Maps of land suitability for different time slices, with uncertainties, available (Task 2);
- Optimal design of future insurance products developed, optimal strategies to cope with climate-related risks (agronomic and financial market) determined (Task 3).

5. Contribution to the WP3 and collaboration with other NCCR projects and 3rd parties

Field data will be used from P3.1, the Swiss Fluxnet, associated ART-projects and the project of A. Stampfli (UNI Be). Climate scenarios will be used - when available - from P2.1 for Europe and P2.3 for Switzerland. Simulation results will be provided to P3.3. Results for market and price developments will be used from P4.2 and information will be shared with P4.1 and P4.2 regarding (financial) risk management and international regulations. Collaboration with SwissRe and Swiss Hail-Insurance regarding index-based insurance will be continued. Further external collaboration will exist with partners in EU FP7 (ACQWA), the Federal Office of Agriculture, the Swiss Agency for Development and Cooperation (Project PACC) and with partners in associated NSF and COST projects.

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P 3.3 ECOWAT

Impacts of changing drought conditions on catchment ecology and water cycle

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1. Three research questions of the project

- What impact do drought waves have on the carbon and water relations of common tree species in Switzerland?
- What are the implications of this drought sensitivity for the response of forest ecosystems under the changing environmental conditions of the 21st century?
- What consequences do drought waves have for large-scale biosphere-atmosphere coupling and particularly for the feedback to the regional climate?

2. Research Summary

We will provide (1) observational information on the impacts of drought on carbon and water relations of common tree species, (2) a model-based up-scaling of these impacts to the catchment level, and (3) an investigation of land-climate feedbacks with a coupled regional climate-vegetation model. The outputs of this project are relevant for forest management (e.g., tree species selection; C sequestration under the Kyoto protocol) as well as for the climate modeling community.

At the local scale, as a follow-up of the CANOPY project (NCCR Climate Phase 2), we will verify, over a large area, the species-specific drought sensitivity of trees found at the Swiss Canopy Crane site (elaboration of a drought sensitivity index for Central Europe). We will employ helicopter-based infrared thermography to scan forests across a wide spectrum of Swiss habitats, ground-based moisture sensors and local microcore measurements of the growth response over ten years. Canopy temperature will serve as a proxy for transpiration under known atmospheric evaporative demand. Existing dendrometer data will be used to distil seasonal influences of drought on radial growth, including the 2003 drought episode (link with dendrochronology-based drought investigations by P1.3 DE-TREE).

At the catchment scale, data from the above campaign will be used to parameterize the specific drought response of trees in the LPJG-TM model (EcoHydro project of Phase II); we will continue (in collaboration with P3.1 and P3.2) to parameterize non-woody Plant Functional Types. Using empirical data from Switzerland, Poland and the US on the growth-mortality relationship, we will focus on the modelling of drought effects on tree mortality and associated C-cycle changes. Simulation results based on climate scenarios from P2.2 will be aggregated to the grid-cell scale of the CLM^2 outputs for consistency checks and in light of the higher process resolution regarding plant demography in LPJG-TM.

At the continental scale, the model CLM^2 will be used. It is currently developed at ETH Zurich, coupling the COSMO/Climate-Local Model (cf. P2.1) with NCAR's Community Land Model. Simulations will be performed (1) with the standard CLM^2; (2) including carbon-water relationships based on CANOPY data and related findings in Europe; (3) including land cover specifications based on results from LPJG-TM. We will investigate the role of subgrid-scale heterogeneity of vegetation dynamics for continental-scale climate (comparison with LPJG-TM), and assess the role of biosphere-climate feedbacks for future climate (comparison with P2.1, P2.2). In addition, the impact of the changing magnitude and frequency of droughts on these relationships will be investigated with/without soil moisture feedbacks.

3. Data and methods

Local-scale investigations on drought sensitivity

We will obtain remote sensing and ground data for a diverse set of abundant deciduous tree taxa (Quercus petraea, Fagus sylvatica, Carpinus betulus, Tilia platyphyllos, Prunus avium) during two summers, based on our experience at the Swiss Canopy Crane site during the summer 2003 drought (Leuzinger and Körner 2007). A transect will be established across a diverse landscape, including river flats and Jura foothills. Along this transect we will collect soil moisture, tree ring and species-specific canopy data to establish a species-specific drought sensitivity ranking. A comparison between humid and dry periods will yield baseline as well as stress-related data.

The central instrumentation will be a high profile thermal imager, operating at a 50k pixel resolution, 50 Hz and 0.2 K precision (see Leuzinger and Körner 2007). We will use an automatic dendro-bench to analyse radial tree growth during recent years, including the year 2003. We expect this year to illuminate the spatial variability of drought impact post hoc. For the soil moisture monitoring, a combination of mobile TRIME TDR probes and Dynamax Echo-probes with mini-data-loggers will be used. The Swiss canopy crane research site will remain the base node (reference site) for this landscape-wide screening. Canopy access will permit us to refine readings of our IR tool during critical periods. The helicopter flights will be timed to capture prolonged rainless periods during the forthcoming summers.

In addition to feeding the data into the LPJG-TM model (see below), we have established links to members of the WSL forest research community (A. Rigling, N. Kräuchi) as well as the BAFU (R. Volz) to ensure that forest planners and official environment authorities will obtain first hand information.

Upscaling and catchment-scale vegetation dynamics

In spite of the importance of mortality processes for ecosystem functioning, little empirical information has been used to date for modelling mortality in ecosystem models (cf. Wramneby et al. 2008). We will implement in the model LPJG-TM empirically-based growth-mortality models that have been parameterized for a dozen tree species in two PhD theses conducted in the Forest Ecology group at ETH (e.g., Wunder et al. 2008) to replace the current, theoretical approaches for modeling mortality in LPJG-TM. While these formulations were calibrated to fit observed ecosystem carbon storage and species composition, the independently derived, new formulations will provide a critical test of model robustness that is novel in the realm of Dynamic Global Vegetation Models. Model tests will use data from Switzerland and Poland (Wunder et al. 2008) and the US (Bigler et al. 2007).

Several important drought effects are currently not represented well in dynamic vegetation models. We will analyze the model-predicted growth reduction during drought periods and heat waves of varying severity and length against measurements of radial growth at the Hofstetten site (cooperation in this project, see above) and tree-ring data (with P1.3; Bigler et al. 2006). We will also investigate model sensitivity to an increased drought-related mortality risk of slow-growing trees using the approach by Bigler et al. (2007).

To further improve the model's applicability at the landscape scale, we will include a harvesting routine for grasslands (i.e. cutting and re-growth) into the ecosystem model. The calibration of grasslands in LPJG-TM (Phase II) showed satisfactory carbon budget estimates when compared to P3.2's PROGRASS model on an annual time scale (Wolf *in prep.*), but it did not allow for an evaluation of short-term responses e.g. during drought waves. Lastly, to enable predictions in the more productive regions of Switzerland, we will extend the model to represent a small variety of crop types (Bondeau et al. 2007). We will compare the simulated aboveground productivity and C pools as well as belowground carbon storage against the results of the site-specific model employed in P3.2.

LPJG-TM will be driven by climate scenarios (from P2.1) and land use suitability (from P3.2) to assess future carbon storage and the carbon sink/source relationships at the catchment scale. We will elucidate the key driving forces for the expected changes, and will assess the influence of management on the hydrological feedback of vegetation to the atmosphere, especially the dynamics of soil moisture content during drought periods.

Continental-scale regional climate simulations

We will use the CLM^2 regional climate model for the investigation of large-scale and continental-scale drought wave impacts on biosphere functioning and climate. CLM^2 is currently developed at ETH Zurich as part of the CCES MAIOLICA project (see http://www.cces.ethz.ch/projects/clench/maiolica). It is a new version of the COSMO/ Climate-Local Model (cf. Jaeger et al. 2008; see also P2.1), coupled to NCAR's Community Land Model (http://www.cgd.ucar.edu/tss/clm/). It will allow for a detailed representation of vegetation-climate interactions at the regional scale (20 km – 50 km resolution), as it includes the explicit representation of plant photosynthesis (i.e., carbon-water relationships). Modules for soil nitrogen cycling and dynamic vegetation processes are also included as options in the Community Land Model.

In a first step, simulations with CLM^2 will be performed for the European continent to investigate the role of soil moisture and drought for biosphere-atmosphere interactions at the regional scale in present and future climate. This research will build upon previous investigations performed on the analysis of soil moisture-climate interactions using model experiments and observational data (e.g. Seneviratne et al. 2006a,b, Teuling et al. 2008). In particular, the CLM^2 results will be compared to similar simulations performed with the COSMO/CLM model version (Jaeger and Seneviratne *in prep.*), i.e. without a detailed biospheric component. Simulations at 50 km and 20 km resolution (for shorter time slices) will be conducted for the time period 1950-2050.

In a second step, inferences from ECOWAT regarding drought impacts on carbon-water relationships at the local scale and vegetation dynamics at the catchment scale will be used to evaluate the realism of the CLM^2 simulations and sensitivity experiments. Further simulations based on CANOPY data and related findings in Europe, as well as on LPJG-TM results, will be additionally performed and compared to the original CLM^2 experiments.

4. Milestones and deliverables

After 18 months:

- Predictions of drought induced productivity decline in important tree species;
- Simulation results based on revised mortality formulation, assessment of qualitative and quantitative changes compared to previous model version;
- Reference CLM^2 simulations and sensitivity experiments performed for the European continent for the time period 1950-2050.

After 36 months:

- Ranking of tree species' drought susceptibility based on ground and remote sensing data;
- Crop representation implemented in LPJG-TM for selected Swiss catchments;
- Reliable estimates of tree mortality risk under global change scenarios; impacts of global change on catchment-wide balance of C & H_2O (forests & grasslands; with P3.1, P3.2);
- Further CLM^2 simulations based on CANOPY data and related findings in Europe, as well as on LPJG-TM results;
- Quantification of the importance of biosphere feedbacks on the regional climate, with emphasis on drought-mediated impacts (with comparisons to scenarios from P2.1, P2.2).

5. Contribution to the WP3 and collaboration with other NCCR projects

With P1.3: Comparison of findings on drought response; P2.1: Comparison of derived continental-scale feedbacks; P2.3: Scenarios on monthly mean T, P, radiation for the use in LPJG-TM (month 30); P3.1, P3.2: Empirical data and modelling concepts /parameterizations on agricultural Plant Functional Types for LPJG-TM.

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WP4 Integrated assessment analysis of global climate change, economy and society

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1. Three Key Questions Addressed by WP 4

1. How do international trade policies and climate policies interact and what are the effects on global climate change and regional welfare?
2. What is the optimal mix of adaptation, mitigation and technological change, and what are the roles of governments and insurance companies in climate policies?
3. What will be the implications and the evolution of the international climate policy regime that will be enacted after 2012?

2. Contribution to the NCCR Climate

WP4 contributes to the NCCR climate by evaluating climate change and its impact from an economic and legal point of view, while particular aspects of international trade regulation are taken into account. Insights from the interaction of international trade and climate policies will be used in theoretical and applied analyses on the economic costs of combating climate change. Integrated assessments of global climate change with an adequate representation of international law will be undertaken. Our strength in assessing climate change and its impacts from an economic and legal point of view enables us to evaluate and devise national and international climate policies. We expect to contribute to national and international conferences, which also involve scientific researchers from other WPs, and to advise the Swiss Government Departements (FOEN, SECO) on climate policy issues.

3. Integration and Cohesion within the WP

For the development of integrated assessment models with an adequate representation of international trade law, both P4.2 and P4.3 will use insights gained from P4.1 on issues of trade and international law, focusing on the problem of border tax adjustment. The results will be incorporated in the models used for the analysis of endogenous discounting and population growth within the context of global climate change, the examination of sustainable energy strategies and for the assessment of the evolution of international climate policies. In turn, P4.1 will use the insights from the analyses on optimal climate protection measures and feasible climate policies. There are strong linkages between P4.2 and P4.3 as concerns the assessment of economic impacts of climate change and adaptation measures in Switzerland (P4.3: Task 2) on the one hand, and the analysis of insurance and financial mitigation of natural disaster losses in a historical and economic dimension (P4.2: Task1) on the other. These two tasks complement each other as P4.3 assesses the economic impacts of climate change and focuses on national adaptation policies, whereas P4.2 analyzes how societies have reacted and how they will insure against climate impacts in the future. Moreover, the general equilibrium models used by P4.2 are based on a top-down approach, which enables to validate the results obtained by more complex buttom-up models as they are developed by P4.3. The insights gained from the game theoretic analyses on the strategic interaction between mitigation, adaptation and technological change with special emphasis on technological aid for developing countries (P4.2), may be used for detailed investigations on different architectures of international climate agreements (P4.3) with top-down and buttom-up integrated assessment models at hand. Moreover, we will continue our cooperation in organizing national and international workshops and conferences in order to strengthen scientific networks within and outside the NCCR climate.

4. Interfaces with other WPs and NCCR Trade Regulation

Strong cooperation with WP2 (P2.1 and P2.3, specifically) will provide updated information on climate change scenarios that is used to assess the economic impacts of climate change as well as for analyzing optimal mitigation strategies and therewith, for the assessment of a sustainable energy system. WP3 (P3.1, P3.2) provides information about ecosystem and adaptation possibilities, which is used for the economic valuation of climate impacts and for the assessment of adaptation measures for Switzerland. Overall, we update other WPs with information on climate change and its impacts from an economic point of view, and we provide results from analyses of the economic effects of potential post-Kyoto climate agreements, where trade issues and the participation of developing countries are taken into consideration. P4.1 will closely cooperate with a WP on climate change and climate change mitigation to be submitted for the second phase of the NCCR Trade Regulation. The projects envisaged will be able to build upon insights and results of P3, and will formulate lessons for international trade regulation.

5. Expected Impact of the WP

International Level:
Our projects are involved in various international research networks. There is collaboration among others with EU FP6 project TOCSIN, the US Department of Energy and the International Energy Agency. As in Phase 2, we will continue to strengthen the scientific cooperation among researchers within the field of climate economics with the organization of international as well as national workshops and conferences and will therewith further manifest “NCCR Climate” in institutions outside the NCCR. We will disseminate our research results through presentations at international conferences and workshops and will publish our research in international reputable journals.

National level:
We will continue to hold up our networks among and cooperation with Swiss researchers in the field of climate economics and industry groups and associations. Our strength in assessing climate economic issues enables us to evaluate and devise national climate policies. We expect to frequently contribute to national conferences, which also involve scientific researchers from other WPs and to advise the Swiss Administration on climate policy issues.

P 4.1 CITEL
Climate change and international trade from an economic and legal perspective

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1. The three research questions of the project

- What does the law of the World Trade Organization (WTO law) say about border tax adjustment measures (BTA measures) for regulations, technical standards and taxes on climate-related process and production methods (climate-related PPM)?
- Is there a potential conflict of proposed BTA measures for carbon tax or emissions trading systems with WTO law and how can WTO law be used to justify various BTA measures in climate change mitigation systems?
- How and to what extent does international trade and trade policy measures affect the economic costs of combating global climate change?

2. Research Summary

This project connects economic and legal research and aims at analyzing the interaction between international trade, trade regulation and climate policies from a theoretical and applied perspective. The project is limited to issues of mitigation of greenhouse gas emissions. It does not address adaptation to climate change, which entails issues of food security and human rights. These matters are planned to be considered in the 2nd Phase of **NCCR Trade Regulation**, in collaboration with researchers of NCCR Climate WP2, WP3 and WP4.

Task1: International Trade and Global Climate Policy

Global climate change affects national economies in at least two different ways: (1) directly through market and non-market damages climate change, and (2), indirectly through costs and benefits of policy interventions as well as through damages from economic spillovers. The last type of potential indirect effects is an outcome of the increasing globalization and the resulting close international interdependence of national economies.

Based on the work of Manne and Stephan (1999), Schenker (2008) showed within the framework of an almost consistent Integrated Assessment Analysis that a country, which is strongly exposed to climate change, might react to climate change induced damages by changing the terms of trade. That means that climate damages can be reallocated across countries through international trade. In fact, countries, which are directly affected by climate change, can export market damages up to a certain level. Thus, mitigation and adaptation are not the only policy options for reacting to climate change. A country always has the option to reduce the economic impact of global climate change through adjusting its trade policy. In doing so, it is bound by international agreements and commitments limiting the scope of action. Therefore, analysis of the interplay between trade and climate policies is an important issue when dealing with the economic implications of global climate change. We focus on the interaction of trade policies on the one hand side and mitigation on the other, while neglecting the issue of adaptation.

Task2: Interaction of International Trade Regulation and Climate Policy

The relationship between the evolving international environmental law on climate and international trade regulation is increasingly attracting attention (*inter alia* Pauwelyn, 2007; Sindico, 2006; Charnovitz, 2004). Regardless of how the post-Kyoto regime will be shaped, there is intrinsic demand for research focusing on this relationship. Within the framework of our project we propose, as a a priority issue, to analyze the conformity of climate policy-related Border Tax Adustment (BTA) measures with WTO law. BTA allows off-setting domestically imposed taxes on imports at borders irrespective of commitments taken to reduce import tariffs.

BTA measures are among the central issues of climate mitigation policy. Instead of serving their traditional fiscal function, BTA measures for climate purposes are rather designed to prevent so-called “carbon leakage”: reallocation of production from countries with carbon reduction commitments to countries with no emissions restrictions. Such leakage might considerably decrease the effectiveness of global climate change mitigation efforts. Furthermore, BTA measures could help solve the problem of integrating developing countries into the Kyoto and post-Kyoto international climate policy system.

Recently, a number of proposals to introduce BTA measures in various national and regional carbon taxation and emissions trading systems were put on the table on governmental level (Hennig, 2008). These proposals include a carbon tax on imports, emissions standards and a requirement to the importers to surrender emission allowances at the time or point of importation. However, the introduction of climate policy-related BTA measures is deemed quite problematic both from economic, legal and political perspectives (Cosbey, 2008; Ismer and Neuhoff, 2007). The proposed research will mainly focus on the legal issues of BTA measures, particularly their justification under WTO law. In doing so, it is expected that a number of other closely related, but still unsolved BTA measures' issues will have to be dealt with. These issues might include, among others, the clarification of the concept of BTA measures under WTO law and the specification of WTO law provisions on BTA measures for regulations and taxes on climate-related Process and Production Methods (PPMs). The research is scheduled for three years and will result in a PhD thesis in law.

The task assigned to P4.1 (the CITEL project) is in line with the subject and research goals of WP4 (Integrated assessment analysis of global change, economy and society), and contributes to the fulfilment of WP4 tasks by analyzing the efficiency and consistency of trade-related climate change mitigation measures from the legal perspective. With its focus on mitigation (adaptation is dealt with by the NCCR Trade Regulations) the CITEL project contributes to the core of the NCCR Climate Phase 3 and strengthens the capabilities to advise national and international policy makers.

3. Data and methods

Task1: International Trade and Global Climate Policy

Task 1 bases on the multi regional, multi sector dynamic trade model, which was developed in WP4.2 during Phase 2 (see Schenker 2008). However, since the approach developed by Schenker focuses on a cost-effectiveness analysis for given climate scenarios, for studying the interaction between mitigation and trade policies and thus, to accomplish Task 1, the model must be expanded into a full Integrated Assessment model. This in particular implies including a carbon cycle representation in order to analyse the effects of mitigation. The data for the international trade model are based on the GTAP dataset.

Task 2: Interaction of International Trade regulations and Climate Policy

Empirical data on BTA measures in climate change mitigation systems will be collected and hypotheses of WTO compliance of BTA measures will be tested. In testing the compliance hypotheses the researcher will use scientific methods of comparison and generalization, will interpret public international trade law and will conduct case-law analysis.

4. Milestones and deliverables

After 12 months:

- Stocktaking: BTA measures in climate change mitigation systems (Working paper 1)

After 24 months:

Task 1:

- Development of a multi regional integrated assessment model with international trade,

Task 2:

- Analysis of the treatment of taxes on climate-related PPMs under the WTO law and peculiarities of BTA measures in climate change mitigation systems (Working paper 2).

- Assessment of consistency of climate-related existing and proposed BTA measures (i.e. carbon tax, technical standards, emissions allowances purchase requirements) with WTO law (Working paper 3).

After 36 months:

Task 1:

- A detailed analysis of the relation between climate policies and trade policies.

Task 2:

- Proposals for justification of existing and proposed climate-related BTA measures under WTO law (Working paper 4).

5. Contribution to WP4 and collaboration with other NCCR projects and 3rd parties

Synergies are expected both within the work package (WP) as well as between different WPs. In particular, co-operation with P4.2 will take place when dealing with peculiarities and efficiency issues of taxation on emissions for climate change mitigation purposes. Outcomes of P4.3 work on designing and testing different architectures of international climate agreements and emissions trading schemes might be needed to analyze BTA measures' proposals with respect to their conformity with WTO law. Collaboration with WP2 (P 2.1 and P 2.3, specifically) is fundamental to analyze effects of international trade on climate change and for guidance on the development of future climate change, where this information is used for defining mitigation targets, which are to be analyzed.

There is a large potential for research through co-operation between two NCCRs. The co-operation includes the mutual concertation of economic and legal research in these areas.

Furthermore, an exchange of ideas is expected with academics from other academic institutions working on climate change issues, such as A. Cosby (IISD), J. Pauwelyn (HEI) and others, as well as representatives of national administrations dealing with climate policy.

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P 4.2 CVR
Climate Vulnerability, Risk assessment and management in a Post-Kyoto World

PI: Gunter Stephan
Co-PI: Seraina Buob
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1. Three research questions of the project

- What is the role of governments as well as of insurance companies in combating global climate change?
- How do climate change, discounting and population growth interact?
- What are the interrelationships between mitigation, adaptation and aiding technological change?

2. Research Summary

Task1: Insurance and financial mitigation of climate risk and disruption

An important issue in analyzing the implications of climate risks and disruptions is to answer the question on how societies politically and economically have reacted and might react in the future to severe climate disasters. In particular, it is intended to analyse: (1) how governments react, if their budgets are existentially threatened by recurring disasters, and (2) how insurance companies act in order to cope with the risk of climate change. Based upon research of Phase 2, we aim (1) to assess, how governmental authorities, insurance companies and other private actors have mitigated in the past, and in following up, and (2) to use these insights for establishing a framework which allows to forecast, how these actors might interact in the future for reducing losses caused by natural disasters.

Thereby it is by no means clear, how much we can learn from history, in particular since the global climate is expected to change more rapidly even in the near distant future than it has changed in the past. However, one answer of the society to potential natural disasters was the invention of insurance. Therefore, a closely related issue is the analysis of why some insurance companies set incentives for greenhouse gas reductions and for investments into adaptation by private. Is this pure marketing or can these incentives be effective tools for combating climate change?

Task 2: Global climate change, endogenous discounting and population growth.

Two great issues in climate economics are the interplay between population size and atmospheric greenhouse gas concentration as well as the question of an appropriate social discount rate. Regarding the first issue the literature exhibits a polar view. Some argue that population growth raises emissions, causes common pool externalities and therefore is an externality itself. Others take the view that increased population has had, and may continue to have predominantly beneficial effects. The debate is confusing in particular because of the lack of an appropriate and explicit model for evaluating the impacts of various decisions. Recently, Golosov et al. (2007) offered a formal model that incorporates both a public bad or a good externality stemming from pollution and related endogenous child-bearing decisions. Based on the seminal work of Becker and Barro (1986) and the Integrated Assessment approach of Stephan and Müller-Fürstenberger (1999) this task aims to develop an integrated assessment model of climate change with endogenous population growth. Using a dynastic overlapping generation structure the choice of the discount rate is examined, since it depends on the degree of altruism as well as on the number of children.

Task 3: Interaction between strategies to combat global climate change.

It has become apparent that climate policies must include mitigation as well as adaptation. Furthermore, investments into R&D and the transfer of clean (low-carbon and energy-efficient) technologies from the industrialized to the developing countries are viewed as key elements in combating climate change, since technological innovation can enhance and foster cheap climate protection. In discussing optimal climate policies in a post Kyoto World, it is therefore important to understand: (1) how these instruments interact, and (2) under which conditions aiding technological change is incentive compatible in the sense that it stipulates greenhouse gas abatement. In particular, based on our work on the strategic interaction between mitigation and adaptation as well as on technological change in Phase 2, we aim at: (1) Extending the analyses on the strategic interactions between climate policies by incorporating technological change, (2) analyzing the effects of technology spill-overs and technological aid, and (3) building a basis for the design of mechanisms such that global climate targets can be met.

Task 4: Mitigation and sustainable energy strategies under global uncertainty.

Strategies for climate change mitigation and the achievement of a sustainable energy system in Switzerland are affected by a range of external factors, such as the availability and diffusion of new technologies, global/regional climate change mitigation policies (such as those identified in P4.3), and energy market and trade developments such as leakage, embodied carbon, and broader issues identified elsewhere in P4.2 (e.g. Task 2) and P4.1. At the same time, significant long-term uncertainty exists over the direction of technological change, availability of energy resources, and patterns of economic development. Therefore, this research seeks to understand how optimal energy policy and technology choices for sustainable climate change mitigation in Switzerland are affected by some of these external factors and uncertainties. The results will identify robust domestic energy and mitigation policy options, in addition to providing some guidance in terms of industry, trade and international climate policy.

3. Data and methods

Task1: Insurance and financial mitigation of natural disaster losses in a historical and economic dimension.

Task 1 is based on the examination of past and future financial adaptation to floods in Switzerland in Phase 2 (Gülden and Poliwoda, 2008). With a stylized model, where government and insurance companies are players, the incentive compatibility of insurance instruments in reducing the risk of climate change will be analyzed. With a literature survey and data from insurance companies Task 1 will be accomplished.

Task 2: Global climate change, endogenous discounting and population growth.

Based on the seminal work of Becker and Barro (1986) and Stephan and Müller-Fürstenberger (1998) an integrated assessment model with endogenous population growth will be developed. While incorporating an overlapping generation structure the interaction between population growth, the discount rate and global climate change.

Task 3: Interaction between strategies to combat global climate change.

Starting point are the game-theoretic models to analyse the strategic interactions of mitigation and adaptation developed in Phase 2 (Buob and Stephan, 2007; Buob and Stephan, 2008). We will then assess the key characteristics of technological change and incorporate these in a game-theoretical model such that the interaction between the main climate policies and technological change with special emphasis on technological aid can be investigated.

Task 4: Mitigation and sustainable energy strategies under global uncertainty.

This research will be realized by extending the global MERGE model, which already incorporates energy technology and technology dynamics (Kypreos 2007), to include a disaggregated representation of the Swiss energy system (based on Schulz 2007). Scenarios of the global factors described above and representing a range of uncertainties will be developed and analyzed using this modeling framework to identify robust domestic energy and mitigation policy options.

4. Milestones and deliverables

After 18 months:

Milestones: Identification of past reaction to climate risks and disruption on a national basis; development and analysis of an Integrated Assessment model with endogenous population growth; extension of existing models for analyzing the strategic interactions between adaptation, mitigation and technological change in addition; development of the MERGE model with a disaggregated representation of Switzerland.

Deliverables: An assessment of climate risks management as a basis for decision making of firms and government (Task 1); a game theoretical model of the strategic interactions between adaptation, mitigation and technological change (Task 3); a report describing the Swiss MERGE model including some preliminary findings.

After 36 months:

Milestones and deliverables: Analysis of mechanisms for optimal climate policies, where the knowledge gained from Tasks 1, 2, and 3 are incorporated as well as the design of mechanisms such that global climate targets can be met; A PhD dissertation describing: improvements to analytical tools and framework; policy, technology and scenario analysis; and policy recommendations and options. These reports will provide inputs to domestic energy policy development, guidance for the negotiation of future international abatement targets, and identification of technology support needs.

5. Contribution to the WP4 and collaboration with other NCCR projects and 3rd parties

The proposal envisages collaboration activities within WP4 including alternative post-Kyoto regimes (P4.3) and international trade and global climate policy from P4.1. Further, it is expected that the climate change scenarios developed in WP2 (P2.1, P2.3 specifically) will provide broad guidance as to what constitutes dangerous climate change, providing a basis for defining mitigation targets to be analyzed in Task 4. The proposal also contributes substantially to the overall aims of the NCCR Climate, particularly those related to understanding climate change mitigation, the economy and society as well as exploring post-Kyoto perspectives in climate policy.

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P 4.3 MIADAC
Modelling Climate Change Policies: Mitigation, Adaptation, and Acceptance

PI: Philippe Thalmann
Co-PI: Juan Carlos Altamirano-Cabrera
EPFL-Research Group on the Economics and Management of the Environment (REME)

1. Three research questions of the project

- What will be the implications and the evolution of the international climate policy regime that will be enacted after 2012?
- How could national and international climate policies be made more acceptable?
- What will be the costs and benefits related to climate change for Switzerland and what is the role of adaptation in national climate policies and their acceptance?

2. Research Summary

Task 1: Analyze the evolution of international climate policy

Independently of the shape of the agreement that might be reached in Copenhagen for the commitment period after 2012, there is scope to investigate the mechanisms that will be enacted under the renewed climate regime. Thus, we will continue our work of phase 2 on testing different architectures of international climate agreements in order to identify their environmental and economic consequences at the Swiss, European and global levels. In particular we will:

- Analyze the evolution of international climate policy.
- Evaluate the role of technology transfer and developing country participation for agreements in the long run.
- Investigate the interactions between international trade and climate agreements (e.g. border tax adjustments, terms of trade and industry relocation).
- Evaluate the possible strategic reaction of major countries to future climate policy, such as their use of market power in emission trading markets.
- Analyze the political economy side of national and international climate policy, in particular decision making by policy makers and voters and the influence of lobby groups, particularly those related to business interests.

Task 2: Assess compliance costs and opportunities for voluntary efforts in Switzerland

Stringent climate policy in Switzerland will require stronger instruments and credible substantial voluntary efforts. The coupled top-down/bottom-up model developed in phase 2 can be put to good use to:

- Compare estimated compliance costs with the findings of our previous research on voluntary approaches (Baranzini and Thalmann, 2004; Thalmann and Baranzini, 2008) to identify what sectors are most likely to oppose a restrictive climate policy.
- Compute the costs of sectorial targets that are enforced via a tax or permits and compare these with the related compliance costs to determine whether policy "threats" are sufficient to obtain voluntary compliance.
- Extend the analysis from CO_2 to other GHG such as methane.
- Link the information about sectors most likely to oppose to stringent climate policies with our current research on the influence of firms carried under the current CCES project ClimPol.

Task 3: Assess economic impacts of climate change and adaptation measures in Switzerland

We will extend our phase 2 work on adaptation measures (Gonseth, 2008) and refine existing estimates of impact costs for the Swiss economy (Ecoplan - Sigmaplan, 2007) in order to achieve more comprehensive estimates of future costs and benefits of climate change for the most vulnerable economic sectors in Switzerland.

- Aggregate and extrapolate our phase 2 survey of estimates of physical impacts of climate change (Matasci, 2008) and suitable related estimates to obtain indicators that are meaningful for an economic analysis on a regional or national scale.
- Provide an economic valuation of impacts of climate change.
- Identify what is needed to overcome the barriers to bring adaptation issues to the front of political discussions.
- Characterize priorities in policy terms for adaptation in areas such as risk awareness, conflict of interests, entangled responsibilities, financing restrictions, myopic views, and lack of information.

3. Data and methods

Task 1: Analyze the evolution of international climate policy

We will use the CGE model of the world economy (GEMINI –E3) developed in Phase 1 and updated in phase 2 to analyze the economic and environmental impacts of long-term climate treaties. Our model allows simulating the strategic interaction of countries and the implications of technological cooperation. This task will be complemented by extending the results of our EU FP6 project TOCSIN, which also deals with these issues. Furthermore, we will use public choice and game theoretical methods (Grossman and Helpman, 2001; Altamirano Cabrera, 2007) to investigate the political-economy side of the negotiations and its impact on the resulting climate regime.

Main sources of data: i) international data from the GTAP database (Univ. of Purdue), the US Department of Energy, and the International Energy Agency (IEA/OECD); ii) Swiss data from the OFEV/BAFU and from the Swiss Federal Statistical Office

Task 2: Assess compliance costs and opportunities for voluntary efforts in Switzerland

We will extend the use of our coupled model to refine the assessment of climate policies and to compute the compliance costs for crucial sectors. Moreover, we will make use of direct methods, such as interviews and analysis of parliamentary notes, to provide an idea of the kind of political pressure from those sectors more concerned about compliance costs.

Main sources of data: OFEV/BAFU, Swiss Federal Statistical Office, industry groups and associations, parliamentary minutes, Climate Cent Foundation

Task 3: Assess economic impacts of climate change and adaptation measures in Switzerland

We take as a starting point our phase 2 survey of estimates of physical impacts of climate change (Matasci, 2008). We will assess key sectors most vulnerable to climate change such as agriculture, tourism, energy production and distribution, as well as the potentially most damaging extreme weather events, e.g. heat waves, droughts and floods. For the identified sectors and events we will use data gap analysis, evaluate the feasibility of extrapolation with significant informative values, and advanced aggregation and extrapolation methods. Finally, for each impact category we will select and apply appropriate valuation techniques (Freeman, 2003) depending on theoretical adequacy and data availability.

Main sources of data: existing forecasts of consequences from climate change (e.g. from other WPs), studies from the PNR 31, WSL, OcCC/Proclim (2007) report, Ecoplan/ Sigmaplan (2007) study, OFEV/BAFU.

4. Milestones and deliverables

After 18 months:

Milestones

- Proposals for long-term ('post-Copenhagen') international climate policy with particular attention to permit trading, technology transfer and developing country participation.
- Identification of sectors that are most likely to oppose climate polices and the

mechanisms of political pressure available to them.
- Identification and economic estimation of climate change impacts in Switzerland.

Deliverables

- Updated global bottom-up/top-down model (GMC).
- Policy recommendations and conclusions for future climate treaties.
- Game theoretical model of political economy aspects on climate change policy.
- Preliminary economic estimates of climate change impacts in Switzerland.

After 36 months:

Milestones

- Final economic estimates of climate change impacts in Switzerland.
- First estimates of national and sectorial adaptation costs.
- Main implications of adaptation for long-term treaties and acceptable adaptation national policies.

Deliverables

- Estimates of compliance costs for different sectors with and without enforcement via a tax or permits.
- Final estimates of adaptation costs and consequences.
- Recommendations for policy priorities and acceptable national climate policies with adaptation.

5. Contribution to the WP4 and collaboration with other NCCR projects and 3rd parties

We envisage strong cooperation with P2.1 and P2.3 for updated information on climate change scenarios; with P3.1 and P3.2 for information about ecosystem impacts and adaptation; and with P4.1 and P4.2 for issues of trade, international law and technology transfer. Outside the project, we envisage cooperation with other European Universities to identify management options for adaptation. Finally, we will continue our collaboration with ORDECSYS to keep developing the GEMINI model and its extensions.

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R1 Climate Lessons from radiocarbon data (CLER)

[depending on funding available; 1 PhD only in relation to WP1 and WP3]

PI: Fortunat Joos
University of Bern, Climate and Environmental Physics

1. Three research questions of the project

- How did cosmogenic radiocarbon (^{14}C) production and solar activity vary over the last millennium and how did solar variability contribute to decadal-to-century scale variability in climate and atmospheric CO_2?
- What is the magnitude of the current radiocarbon production by cosmogenic particles?
- How do soil-climate-greenhouse gas feedbacks and permafrost variations affect past and future greenhouse gas concentrations?

2. Research Summary

The role of solar variability for climate change and the vulnerability of soil carbon to climate change and related soil-greenhouse gas-climate feedbacks are quantified. The overarching theme is to quantify the production of ^{14}C and its redistribution in the earth system (i) to infer the role of solar variability in driving earth system variability of the past, and (ii) to learn about soil overturning time scales and soil-climate-greenhouse gas feedbacks. We are in the unique position of having a carbon cycle-climate model that includes the relevant carbon reservoirs both on land and in the ocean in 3-dimensions and that is cost-efficient to allow for the millennial-scale simulations required to model the ^{14}C distribution within the Earth System. The research will be performed in close collaboration with the partner NCCR project R2 SOLAR (PI J. Beer) to exploit the complementary strengths of the two groups and two proxies (^{14}C and ^{10}Be).

3. Data and methods

A) Model: The Bern3D-LPJ climate-carbon cycle model includes an energy-balance atmosphere, a geostrophic-frictional balance 3-d ocean model (Tschumi et al. 2008), the Lund-Potsdam-Jena (LPJ) Dynamic Vegetation Model (Strassmann et al. 2007), ocean sediments, and representations for the global cycling of carbon and its isotopes as well as a suite of ventilation time scale, biogeochemical, and water mass tracers, a marine foodweb model, and a marine N_2O and Fe cycle, and a representation of anthropogenic land use and terrestrial methane emissions. The LPJ model will either be applied fully coupled to the Bern3D atmosphere-ocean component or run offline forced with precipitation and temperature data from observation or from AOGCM output (Frölicher et al. 2008).

B) Solar and Earth system variability: Solar forcing over the past millennium will be reconstructed on the basis of annually to decadally-resolved radiocarbon data by updating and improving earlier work in this direction (Muscheler et al. 2005, Muscheler et al. 2007). Climate-carbon simulations will be carried out for the past and the future. The individual taks are: 1) The current radiocarbon production rate will be estimated from atmospheric and oceanic ^{14}C data (e.g. Müller et al. 2008) and Bern3D-LPJ model derived inventory estimates for sediments and land and the ^{14}C decay rate. The observationally-constrained production record will provide a benchmarch for mechanistic cosmogenic isotope production models (Masarik and Beer 1999). 2) The latest INTCAL ^{14}C tree ring records for the Northern and for the Southern Hemisphere will be prescribed in the Bern3D-LPJ to deconvolve the ^{14}C production rate. The model will be spun-up over the past 25,000 years to properly account for the long life time of ^{14}C (8267 years). In turn, the ^{14}C production rate is used to reconstruct solar activity and to estimate solar forcing. 3) The reconstructed solar forcing is applied in combination with other forcing factors to simulate carbon cycle-climate variability during the last millennium (Gerber et al. 2003, Ammann et al. 2007). Step 2 and 3 will be done iteratively to account for the potential impact of climate-carbon cycle feedbacks on deconvolved radiocarbon production and to take into account the results from the ^{10}Be analysis of J. Beer (NCCR Project SOLAR) and coworkers. Specifically, the separation of the ^{14}C and ^{10}Be production records into a solar and Earth System component will be evaluated with a state-of-the art radiocarbon model.

C) The vulnerability of soils: The future evolution of the global climate system depends to a substantial degree on the nature and magnitude of the feedbacks between the physical climate system and the global carbon cycle (Solomon et al. 2007). Yet, these feedbacks are presently not well understood. Here, the task is to investigate the processes governing soil overturning and their sensitivity to climate and land use change. 1) Soil radiocarbon data will be used to evaluate soil overturning time scales (Perruchoud et al. 1999) in LPJ. 2) Land use maps from the HYDE data base will be applied to quantify the impact of anthropogenic land use changes (pasture, cropland, and built-up) on past and future climate-carbon cycle variability and the loss of soil carbon due to land use. 3) An important intermediate- to long-term goal is to include a more detailed process-oriented parameterization for permafrost soils in LPJ to account for the potential contribution of deep soil layers to the ^{14}C cycle and to the production of CH_4 and CO_2 under global warming. This last task is challenging and represents an ambitious goal that may not be achieved within the time frame of this project.

4. Milestones and deliverables

After 18 months:

- Present-day ^{14}C production rate diagnosed. Modelled and measured soil ^{14}C compared;
- Solar forcing reconstruction based on ^{14}C available for other groups.

After 36 months:

- Last millennium simulations with the latest solar forcing and land use data available;
- Soil-climate-greenhouse gas feedbacks and their uncertainties estimated;

5. Contribution and collaboration with other NCCR projects and 3rd parties

The solar forcing reconstruction will be done in close collaboration with the NCCR Climate Project SOLAR (also reserve) by J. Beer. Combined solar forcing data are provided to WP1 (P1.1 MONALISA-3 and P1.2 PALVAREX-3) as model input and output from WP1 can be used to drive LPJ. Global soil carbon modelling of CLER (this project) will benefit from exchange with WP3 and their work on soil carbon at different spatial and temporal scales (P31, P32, P33).

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R2 Solar Forcing and Climate Change of the last 1000 years SOLAR

[Depending on funding available; 1 PhD only in relation to WP1]

PI: Jürg Beer
Eawag

1. Three research questions of the project

- How can the high-resolution solar variability during the last millennium be quantified?
- How can solar variability be converted into solar forcing?
- How can solar forcing be detected and attributed in climate records?

2. Research Summary

Cosmogenic radionuclides such as ^{10}Be in ice cores and ^{14}C in tree rings have proven to be useful proxies for long-term solar variability (Vonmoos et al. 2006) (Steinhilber et al. 2008a). However, these radionuclides reflect not only production changes induced by heliomagnetic and geomagnetic variability. They are also influenced by system effects (transport and deposition processes in the case of ^{10}Be; the global carbon cycle in the case of ^{14}C (transport and deposition processes in the case of ^{10}Be; the global carbon cycle in the case of ^{14}C Muscheler et al. 2000; Project R1 CLER). In previous work we developed a technique to separate the solar signal and the system effects by combining two ^{10}Be records with the ^{14}C record. Applying this technique to a new annual ^{10}Be record from North GRIP combined with an existing annual ^{10}Be record from Dye3 in Southern Greenland and the ^{14}C record from tree rings will enable us to produce a new high-resolution solar variability record (Beer et al. 2007) (Abreu et al. 2008).

In a second step this new solar variability record is used to derive the solar forcing function in terms of Wm^{-2}.

In the final step the solar forcing function is used for model runs (P1.1. Monalisa) and compared with paleorecords of climate change (P1.2. Palvarex-3) The ^{14}C system component derived in step 1 is compared with carbon cycle changes (Project R1 CLER) *and the* ^{10}Be component with model runs using ECHAM-HAM (Heikkila et al. 2008).

3. Data and methods

A) Data: Since all records of a single cosmogenic radionuclide are composed of a production component reflecting solar and geomagnetic modulation of the cosmic rays and a system component reflecting the transport from the point of production in the atmosphere to the site of storage in an ice core (^{10}Be) or a tree (^{14}C), combining ^{10}Be and ^{14}C records provides a means to separate these two components because both records contain a common production signal (Masarik and Beer 1999), but a different system signal (^{10}Be is attached to aerosols and removed from the atmosphere within 1-2 years while ^{14}C forms $^{14}CO_2$ and enters the global carbon cycle). The geomagnetic production component can be removed using paleomagnetic records based on remanence measurements in lava and sediments. This procedure which is based on the PCA (principal component analysis) has been successfully applied to low resolution (40 y) long-term records (1-9 kyr BP) of ^{10}Be from ice cores and ^{14}C from tree rings (Beer et al. 2007) (Abreu et al. 2008).

Using the annual ^{10}Be records from Dye 3 (South Greenland) (Beer et al. 1990) (Beer et al. 1994) and a new annual ^{10}Be record from NGRIP (North Greenland) (Berggren et al. 2008) in combination with partly annual ^{14}C data from tree rings (Reimer et al. 2004) the same approach is used to produce a high-resolution solar variability record for about the past 600 years reflected by the first principal component (Abreu et al. 2008). The second principal component reflects the ^{14}C system variations. Whenever the ^{14}C signal deviates significantly from the production signal this is an indication of a change in the carbon cycle. A detailed analysis of the second principal component will be done in close collaboration with F. Joos making use of the Bern 3D-LPJ climate-carbon cycle model (Project R1 CLER).

B) Solar forcing: A quantitative high resolution solar forcing function is fundamentally important not only to model past climate changes, but also to distinguish between natural and anthropogenic forcing during the present and the future global warming. There are at least three reasons why the establishment of such a quantitative forcing in Wm^{-2} is difficult: 1. Direct measurements of the total solar irradiance (TSI) form satellite based radiometers are limited to the past 30 years, a period of comparatively high solar activity (Frohlich and Lean 2004). In particular, direct measurements for grand solar minima such as the Maunder Minimum (1645-1715) are missing. 2. The observed changes over an 11-year Schwabe cycle during the past 30 years are only about 0.1%. 3. The underlying physical processes relating the solar magnetic activity to the TSI are only rudimentary known. Nevertheless, there is growing evidence that the TSI is controlled by the magnetic fields in the convective zone and at the solar surface. Since it is the open magnetic solar field that modulates the cosmic ray intensity in the heliosphere cosmogenic radionuclides turn out to be a good tool to reconstruct past solar magnetic activity and a promising candidate for a proxy of the TSI (Steinhilber et al. 2008b).

C) Detection and attribution of solar forcing: The quantitative solar forcing function together with the annual ^{14}C and ^{10}Be system records derived from the PCA analysis provide a unique data set to study solar forcing and climate change. Putting the TSI record together with other forcing functions (e.g. volcanic forcing) into climate models will enable us to compare modelled and observed spatial and temporal climate variability. This will be done in close collaboration with P1.2. PALVAREX-3 (observations) and MONALISA-3 (modelling). In addition, the third principal component which is related to the transport of ^{10}Be and the second component related to the global carbon cycle will be interpreted in terms of climate forcing and climate change. The analysis in the time domain will be complemented by spectral analysis in the frequency domain.

4. Milestones and deliverables

After 18 months:

- Separation of production and system effects based on ^{10}Be in 2 ice cores and ^{14}C in tree rings using PCA.
- High-resolution record of solar variability for the past 600 years
- Quantitative solar forcing in Wm^{-2} with estimated uncertainties

After 36 months:

- Comparison of spatial and temporal variability of model runs with observations
- Interpretation of the second and third principal component in terms of global carbon cycle changes and ^{10}Be atmospheric transport.
- Publications

5. Contribution to the WP1 and collaboration with other NCCR projects and 3rd parties

The interpretation of the PCA will be done in close collaboration with the project R1 CLER (F. Joos). A (combined ^{14}C and ^{10}Be) solar forcing is provided to P1.1 MONALISA-3 and compared with observations P1.2 PALVAREX-3.

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3. Other aspects

3.1. Knowledge and technology transfer, communication

KTT and communication during Phase 3 will build on the achievements of Phase 2 and carry forward those instruments and measures that have proven to be successful. According to the overall budget, the activity level of the NCCR Climate communication is also reduced. We distinguish three levels:

KTT and communication within the NCCR
The importance of this aspect has been underestimated in Phase 1. Significantly more weight was put onto this aspect in recent years. By now it appears that collaboration and interaction across the NCCR program (exchange of data, expertise, shared laboratory facilities, etc.) seems to become natural. Successful measures are regular meetings at the WP level, platforms for *ad hoc* working groups for specific topics, proactive communication with formalized internal exchange, and proactive contact between the Management Centre and the individual research groups. Particular emphasis is given on the integration of the new members.

KTT with the international scientific community
Phase 3 will see the continuation of leadership in international research initiatives (EU FP7, COST, IPCC, UNFCCC COPs, IGBP-PAGES and other programs). A particular focus will be put on participation of WP4 researchers in such efforts.
In order to increase the profile (visibility) of the NCCR Climate, a series of high-profile international conferences will continue into Phase 3 (the series starts in early 2009 with the WP 4 conference on “The International Dimensions of Climate Policy” 21-23 January 2009) in collaboration with the Oeschger Centre of Climate Change Research (U Bern), the Centre for Climate Systems Modeling (ETH Zurich) and other partner institutions of the NCCR or outside the NCCR (specifically with ProClim).

KTT with 3rd Parties
As it appears from Section 2.4, a number of projects will carry out research that is specifically designed for operational use or stakeholders. Examples are the operational tools developed for end users in P2.3. at MeteoSwiss, research in WP3 about adaptive strategies designed to support stakeholder decisions in Swiss agriculture (risk management and adaptation) and forestry (Projects AGRISK and ECOWAT); WP4 research that is designed to advising national and international policy makers; research carried out in WP4 targets incentive regimes for transfer of technology in the Trade-Related Aspects of Intellectual Property Rights (TRIPs) Agreements and the Kyoto (or Post Kyoto) Protocol, which may result in drafting of treaty and legislative proposals. This might be of practical use for BafU (Federal Department of the Environment), eventually also for SDC/DEZA (Swiss Development Cooperation). All ‘communications’-related issues are naturally coordinated and/or co-organized with ProClim and OcCC.

At the current stage of negotiations, the engagement of SwissRE and BafU (see 8th Intermediate Report) is expected to be proportional to the SNSF Funding in Phase 3, i.e. approximately half of the amount during Phase 2.
As suggested by the Review Panel, two institutions of the NCCR Climate have substantially diversified the collaboration with 3rd Parties and the industry, and achieved a longer-term perspective: COOP is substantially supporting the C2SM, Mobiliar has signed a contract with the University of Bern to establish a Professorship at the Oeschger Centre for Climate Change Research (Uni Bern), and Swiss RE has sponsored a Professorship at ETH Z. Although this 3rd Party involvement in favour of climate research is not directly linked to the NCCR Climate, the spillovers and benefits to the NCCR Climate are obvious.

3.2. Education and training

The declared target of Phase 3 is to consolidate the recent major developments of the study programs both at U Bern (Graduate School) and ETHZ, and to consolidate the successful educational series for PhD and postdoctoral researchers at the national level (Young Researchers Meetings) and at the international level (International NCCR Climate Summer School). The goal of Phase 3 is to make both series financially independent of the NCCR Climate and thus to guarantee their continuation beyond 2012.

The M.Sc. Study Programs

Two specialized M.Sc. programs (one at U Bern and one at ETH Z) emerged from the NCCR Climate and started in 2006. There is still a wide potential for tuning and improving the programs at the operational level. For purely practical reasons both programs exhibit ample permeability for all the course work and joint teaching by topics, while the administrative part is strictly separated (two different certificates). It is anticipated that the advantages and disadvantages of a complete marriage of both programs will be evaluated very carefully. This is open for the moment.

Ph.D. and Postdoctoral education

The yearly “Young Researchers Meetings” (soft skills, excellent platform for networking and collaboration) as well as the yearly “International NCCR Climate Summer Schools” will continue. All of these courses are immediately evaluated by the participants regarding scientific content, format and administrative handling. Based on our experience and constant optimization of the courses, we do not anticipate significant changes in this respect. The Summer Schools will continue with a focus on each of the NCCR Climate Work Packages (WP1 in 2009; WP4 in 2010; WP3 in 2011 and WP2 in 2012).

Continuation of both series beyond 2012 is guaranteed by the Leading House and the Oeschger Centre for Climate Change Research (Uni Bern), possibly with other partners (e.g. C2SM ETHZ among others).

3.3. Advancement of women

Overall the proportion of female researchers (at Ph.D., postdoctoral and senior researcher levels) and young parents engaged in the NCCR Climate has steadily increased during the past years. It is difficult to assess whether or not measures taken by the NCCR Climate made a difference.

However, based on (i) interviews with NCCR Climate individuals and (ii) the extended questionnaire survey by NCCR Neuro (August 2007), the successful and already implemented instruments will continue through Phase 3:

- The NCCR Climate recognizes that for women and young parents, flexibility is more important than compensation. The NCCR Climate provides flexible working conditions;
- Financial support for childcare continues;
- Special Workshops for women organized jointly with NCCR N-S and NCCR Trade Regulations are continued;
- Equal gender representation in the Summer Schools will be achieved;
- Applications of females for academic positions are actively encouraged;
- Individual mid-term career plans (mentoring) will be pursued.

4. Structural aspects

4.1. Plans for Phase 3

4.1.1. Structural measures at Uni Bern

As a consequence of the contract between the SNSF and the University of Bern regarding the structural measures related to the NCCR Climate (May 2005, Annex IV), the University of Bern, leading House of the NCCR Climate has made significant structural achievements in the years 2007 and 2008:

- The Oeschger Centre for Climate Research (OCCR) at the University of Bern has been founded and is operational since October 2007; it is an independent University unit;
- **The OCCR receives direct financial support from the University on the order or 2 M CHF annually (including Self Funding Home Institution for the NCCR Climate);**
- The OCCR supports the research groups of Uni Bern that are part of the NCCR Climate and operates the Graduate School of Climate Sciences, University of Bern (Specialized M.Sc. and Ph.D. program);
- The participating research groups carry out concerted research along four strategic lines (concerted with the NCCR Climate);
- The pending replacements and new professorships are on track: Prof. W. Tinner (Assistant Professor TT Fast Track) is the new professor in Paleoecology; Prof. Hubertus Fischer has started the new Chair in Experimental Climate Physics. The position of H. Wanner is on track: ratification of the ranked short-list (three candidates) by the Faculty is expected for the end of the Fall Semester 2008; the position of a new Professorship in Climate Economics has been advertised; interviews were held and a decision is expected for the beginning of 2009; the Chair of Christian Pfister (Historical Institute) has been advertised with a similar profile; a short-list is currently being made; Prof. Martin Grosjean has been promoted to Full Professor (aOP) as of November 1, 2008. An agreement between PSI and UniBE is currently being negotiated to promote PD Margit Schwikowski to (Tit.) Professor;.
- It is expected for 2009 or 2010 that further key researchers at U Bern (Prof. F. Joos) be upgraded to Full Professor (aoP).
- Mobiliar Versicherungs-Genossenschaft has sponsored a new Professorship (Ass. Prof. TT; open rank) at the Oeschger Centre for climate impact and climate risk research (for 10 years).
- The educational programs (Specialized M.Sc. and Ph.D.) under the umbrella of the Graduate School of Climate Sciences are in place and structurally consolidated. The same holds for the management of the Oeschger Centre, which is for practical reasons almost identical with the NCCR Climate Management Centre (although the funding and accounting is strictly separated from the NCCR Climate). This ensures coordination and optimum use of synergies between the NCCR Climate and the Oeschger Centre. KTT and communication is secured beyond the NCCR Climate.
- Naturally the OCCR will cooperate with the partners at ETH Z and other Swiss research institutions (as it developed through the NCCR Climate framework, including ProClim and OcCC). The OCCR may also formalize cooperation agreements with strategic high-profile partner institutions abroad.
- Please note: Regarding the administration, the OCCR has a Global Budget as of January 2008 and provides the “Self-Funding Home Institution” (Financial Support by the Home Institution) in favour of the NCCR Climate for Phase 3 from its own budget (Leistungsauftrag der Universitätsleitung an das Oeschger Centre 2007 – 2011, Art. 2 “Grundauftrag”).

In summary, the structural measures as planned for Phase 2 and beyond NCCR Climate, i.e., including Phase 3 (contract Annex IV, Chapters 2 and 3; pages 1-2) are accomplished from the side of the University of Bern, the Leading House. The Oeschger Centre is a sustainable and powerful new structure in the Swiss university landscape and may be regarded as a direct structural result of the NCCR Climate.

4.1.2. Structural measures at ETH Zürich

ETH Zürich has taken major steps to strengthen its profile in climate research:

- During the last 4 years, ETH has successfully appointed a series of new professors related to physical aspects of the climate system. This includes Prof. Nicolas Gruber (biogeochemistry, replacement for Prof. D. Imboden), Assistant Professors Sonia I. Seneviratne (land-climate interactions) and Reto Knutti (climate physics) as replacements for Prof. A. Ohmura, Prof. Gerald Haug (climate geology, replacement for Prof. J. McKenzie), and Prof. Sean Willet (sedimentology, climate and erosion).
- The position of Prof. H.C. Davies (retiring in 2009) has been advertised and interviews have been hold with 5 candidates. The recommendation of the selection committee has been forwarded to the president of ETH, and a decision is expected within a few months.
- ETH Zürich has also strengthened its climate link in energy research and has founded in 2005 the Energy Science Center (ESC). The Energy Science Center aims to contribute to the realization of a sustainable energy system. It involves about 20 ETH professors and is active in a wide range of areas.
- The ETH Master Program in Atmospheric and Climate Science has started in 2006. The MSc in Atmospheric and Climate Science benefits from a collaboration of several ETH departments (in particular D-UWIS and D-ERDW) and an NCCR-related collaboration with the University of Berne and MeteoSwiss.
- In close collaboration with partner institutions in the Zurich area (MeteoSwiss Zürich, Empa Dübendorf, ART Reckenholz), ETH Zürich is leading a new initiative in climate modelling. The Centre for Climate Systems Modeling (C2SM) is a focused response to the pressing science challenges posed by the changing climate. It has been inaugurated in November 2008. Its research focus is on "multi-scale interactions within the climate system". C2SM will enable participants to conduct comprehensive simulations over a wide range of temporal and spatial scales; facilitate the exploitation of key (national and international) data sets by developing enhanced data sets and state-of-the-art analysis and data management tools; provide a platform to exploit the next generation of high-performance computers; complement other Swiss activities in the realm of climate research; and serve as a partner and focal point in major international collaborative modeling programs. Funding for C2SM is provided by the partner institutions. In addition the ETH Zurich Foundation supports C2SM with a considerable amount, which in turn is based on a grant of the company Coop.

4.1.3. Structural measures at other institutions

Federal Office of Meteorology and Climatology MeteoSwiss: Influenced by the developments of the first two phases of NCCR Climate, MeteoSwiss has undertaken several structural measures. It has reorganised its climate services department and thereby created two new permanent positions securing the continuity and know-how transfer into operations. MeteoSwiss has strengthened its collaborations with partner institutions (such as ETH) and thereby taken over an active role in the new Centre for Climate Systems

Modeling (C2SM). For the third phase of the NCCR Climate, the board of MeteoSwiss has decided to fund the C2SM and to increase its overall NCCR Climate related funding substantially (attached to Project 2.3). Research will focus on the development of new tools and datasets for high-quality climate monitoring and improved climate scenarios to support basic and applied research, political decisions and to be linked with end-user applications.

Agroscope Reckenholz-Taenikon ART decided to increase the Self-Funding contributions (matching funds) in favour of research related to NCCR Climate (Project AGRISK, P. Calanca/J. Fuhrer). Self-funding of currently one full research position in the research group Air Pollution/Climate at ART (J. Fuhrer) will be increased by an additional new staff position devoted to climate impact modelling starting 1 April 2009. The position will be filled by Dr. Annelie Holzkaemper, presently working as a post-doc at the Catchment Science Center of Sheffield University. Also, ART has signed the contract for a membership in C2SM at ETHZ with an annual financial support for the next four years.

4.1.4. Structural measures at the national level ("Swiss Climate Research")

While the implementation of structural measures at the individual institutions (e.g., Uni Bern, ETHZ, others) had highest priority so far, discussions, evaluations and negotiations for adequate structural measures at the national level are at early stages only. This will be the priority for the upcoming years. At the current stage of exploration, a concrete result is not (yet) on the horizon.

In our view the NCCR Climate made a very strong case in favour of an efficient, high-profile national climate research program (Section 2-4). Undoubtedly, in the light of recent developments of climate research programs in Europe and elsewhere, Switzerland needs a competitive national program to stay at the forefront.

4.2. Outlook beyond NCCR

At **Uni Bern** (Leading House of the NCCR Climate), the Oeschger Centre will gradually take over the responsibility and support for the research groups at U Bern and provide a solid and sustained institutional background for research and education. The Graduate School of Climate Sciences (M.Sc. and Ph.D. Program, including the "Young Researchers Meetings" and the "Summer Schools") is consolidated and secured. No further measures are needed or envisaged at the Leading House for the moment; the University of Bern went as far as an individual research institution can go. Maintaining a national program or a national network (such as the NCCR Climate) is beyond the possibilities and also beyond the interests of a Leading House.

At **ETH Zurich, MeteoSwiss and ART,** the Centre for Climate Systems Modeling (C2SM) plays a similar catalytic role. It will strengthen the existing and internationally acknowledged expertise and collaboration in climate modelling, and will coordinate climate research efforts – with particular regard to the generation and exploitation of climate change scenarios. In parallel, the newly formed ETH MSc in Atmospheric and Climate Science will provide a corresponding educational environment.

At the **strategic level (Federal level**) NCCRs were designed and implemented to initiate and pursue three long-term processes:

(i) to enhance the top-class profile of Swiss research in strategic areas such as "Climate and climate impact research" (decision by the Department of the Interior 1999);

(ii) to build a national research network for cost-effective collaboration and innovation across institutions and,

(iii) to consolidate the momentum created by the NCCR program through adequate structural measures and carry this impetus beyond 2013, i.e. the latest end of the NCCR Climate.

While the NCCR Climate Phase 2 was very successful in consolidating the momentum and network at the "domestic level" (OCCR at University of Bern; C2SM at ETHZ; see 4.1.1), the structural effort during the years 2009 – 2013 will target **research network structures at the national level ("Swiss Climate Research")**.

This national level is fundamental for three reasons:

(i) the nature of the problem under investigation ('Climate Change and Society') requires concerted (oriented) research within and across disciplines;

(ii) 3rd Party stakeholders (e.g., Federal Administration, policy and decision makers, the Private Sector) benefit from the contact with a national network (NCCR Climate, aspect of KTT) instead of dealing with many individual groups; a national program provides visibility and a clear profile, which in turn adds momentum to individual researchers; it bundles, structures and coordinates Swiss research in a natural and cost-effective way;

(iii) a tangible and powerful cross-institutional research network is a precondition to enforce cross-institutional coordination and, ultimately cost-effectiveness through collaboration. Most European countries became aware of this issue and increased massively funding for multiple programs (oriented research) targeting climate and climate impact research (see 2.1. Portfolio analysis) while, at the same time Switzerland is significantly decreasing funding for the only and unique national research program, the NCCR Climate.

These genuine achievements stimulated by the NCCR Climate are at risk with the termination of NCCR Climate Phase 3 (2012-2013). In particular the reason (iii) "to enforce cross-institutional coordination" is an assignment that is beyond the possibilities and interests of an individual institution (e.g., Leading House of an NCCR) but instead an intrinsic task for the bodies responsible for sustainable research policy making at the Federal level (SER, SNSF and SUK).

5. Budget and comments

The budget for Phase 3 is based on the 50 % level of Phase 2 (i.e. 5.0 M CHF, letter of 25 August 2008), and on a possible increase of 500 kCHF (total 5.5 M CHF; formal communication of the decision by the Research Counsel is still pending). The final budget for Phase 3 will be adjusted accordingly (as soon as we will have taken notice of the formal final decision from SNF).

In accordance with the Pre-Proposal, the Full Proposal foresees the Research Activities for the first three years (YR 1-3) while the 4th year will be used to phase out the NCCR Climate and to shut down the NCCR programme. EDU and KTT activities will be maintained throughout the 4 years period. This is the reason why the NCCR Climate budget is not evenly distributed across the 4 years (2009 – 2013).

Self Funding from Home Institution (Leading House), Self Funding from Home Institutions (network) and Self Funding Groups remain unchanged compared with the Pre-Proposal (5 M CHF Budget).
3rd Party Funding and Self-Funding Groups (network) directly in favour of the NCCR Climate is also reduced proportionally to the NSF Funding (typically 50% compared with Phase 2).
However, funding from 3rd Parties and Self-Funding that flows into the 'Follow-up Structures" of the NCCR Climate (specifically the Oeschger Centre and the C2SM-ETHZ) is not reported here. This includes, among others, the contract with Mobiliar Versicherungs-Genossenschaft (Assistant Professorship Tenure Track for 10 years; for details see Chapter 4.1. Structural Aspects).

Technical comments: Bemerkungen zu den NIRA-Tabellen

Projektbezeichnungen
Bis zum Abschluss der 2. Phase benötigen wir noch die aktuellen Projektbezeichnungen. Deshalb erscheinen die in Phase 3 weitergeführten Projekte noch unter den in Phase 2 gültigen Bezeichnungen. In ***Beilage 1*** werden die neuen Projektbezeichnungen mit Principle Investigators (PI), Deputy PIs, Co-PIs and affiliations in Beziehung gebracht zu den aktuellen Projektbezeichnungen in NIRA.

Phase 3 Budget
Die NIRA-Reports (Financial Overview ***Beilage 2***) sind nicht ganz korrekt. In den beiden Reports *Funding sources (full version)* und *Allocation* stimmen die Totale der Reserve beim SNSF- und 3rd-party-funding nicht (um CHF 250'000 bzw. CHF 134'063 zu hoch).

Übersichten
Zudem legen wir eine eigene Übersicht des SNSF-funding (***Beilage 3***) sowie eine Gesamtübersicht der Funding Sources (***Beilage 4***) bei.

6. Annexes:

- Support letter(s)

  - Support letter of the President Oeschger Centre

- Form "Eigenleistung der Heiminstitution"

Annexes 1 – 4 Budget
- Project list (Phase 2 and Phase 3)
- NIRA Reports
- Budget SNSF Funding
- Overview Funding Sources

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**UNIVERSITÄT
BERN**

Bern, 21. Dezember 2008

Unterstützungsschreiben NFS Klima Phase 3

Gestützt auf die “Rahmenordnung für das Oeschger Centre for Climate Change Research OCCR” (20. September 2007) und auf den “Leistungsauftrag der Universitätsleitung an das Oeschger Centre for Climate Change Research 2007 - 2011” nimmt das Oeschger Centre die Verpflichtungen der Universität Bern gegenüber dem Schweizerischen Nationalfonds betreffend NFS Klima Phase 3 wahr.

Das Oeschger Centre verpflichtet sich, den Eigenleistungen gemäss „NFS-Formular: Eigenleistungen der Heiminstitution“ (Annex Full-Proposal) für die Phase 3 des NFS Klima nachzukommen.

Mit der Gründung des OCCR und den gemäss Proposal bereits erfolgten oder bis 2009 geplanten Massnahmen ist die Strukturbildung an der Universität Bern betreffend NFS Klima weitgehend abgeschlossen und bezüglich dem Vertrag mit dem Schweizerischen Nationalfonds vom 2. Mai 2005 (Anhang IV) für die Phase 2 erfüllt.

Mit freundlichen Grüssen

Heinz Wanner
Prof. Dr., Präsident OCCR

FNSNF
SWISS NATIONAL SCIENCE FOUNDATION

www.snf.ch
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NFS-Formular: Eigenleistungen der Heiminstitution

1. Basisdaten

Name des NFS	NCCR Climate
Name der Heiminstitution	Universität Bern, Oeschger Center
Förderperiode	Phase 3: April 2009 - März 2013

2. „Cash"-Beitrag der Heiminstitution

Definition: Gelder, die die Heiminstitution direkt auf ein Konto des NFS überweist und die durch den NFS verwaltet werden. Die anrechenbaren Eigenmittel[1] sind in NIRA unter der Rubrik „Self-funding Home Institution" einzugeben.

Kalenderjahr	2009	2010	2011	2012
Betrag total (CHF)	262'500	262'500	262'500	262,500
			Total	1,050,000

Verwendungszweck

Art	**Total über die gesamte Periode (CHF)**
☒ Personal im NFS-Management ☒ Freistellung NFS-Leiter/in ☐ Finanzierung von Assistenzprofessuren ☐ Aufstockung der Doktorandenpauschale des SNF ☐ Wissenschaftliche Apparate/Einrichtungen ☐ Material für Forschungszwecke [2] ☒ Andere: Bitte spezifizieren! Management, Education and KTT (Sachmittel 75 k/yr) * Personal im MC: 35% Exec. Dir, 25% Sci Officer, 40% Administration für 4 Jahre	600,000* 150,000 (16% Dir) 300,000

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[1] Gemäss Budgetrichtlinien der NFS dürfen die Anschaffungs- und Betriebskosten der materiellen Grundausstattung (soweit sie üblicherweise auf dem betreffenden Fachgebiet zur Forschungseinrichtung gehört und für die Administration des NFS nötig ist), insbesondere erforderliche Gebäude, Einrichtungen und Apparate, PCs, sowie Büromaterial, Telefonbenutzung etc. nicht im Eigenbeitrag enthalten sein. Gemeinkosten, d.h. Kosten wie Abschreibungen, Strom, Wasser, Gebäudeunterhalt oder allgemeine Verwaltungskosten dürfen ebenfalls nicht verrechnet werden.

[2] Labor, Erhebungen/Befragungen, medizinische Untersuchungen etc.

3. Sachleistungen der Heiminstution („in kind contribution“)

Definition: Anrechenbare Kosten (vgl. Cash-Beitrag), die die Heiminstitution direkt bezahlt (z.B. Salärkosten, Kosten für spezielle Apparate/Grossgeräte). Die anrechenbaren Eigenmittel sind in NIRA unter der Rubrik „Self-funding Home Institution“ einzugeben.

Kalenderjahr	2009	2010	2011	2012
Betrag total (CHF)	25,000	25,000	25,000	25,000
			Total	100,000

Verwendungszweck

Art	**Total über die gesamte Periode (CHF)**
☐ Personal im NFS Management ☒ Freistellung des/der NFS-Leiters/-Leiterin ☐ Finanzierung von Assistenzprofessuren ☐ Aufstockung der Doktorandenpauschale des SNF ☐ Wissenschaftliche Apparate/Einrichtungen ☐ Material für Forschungszwecke ☐ Andere: Bitte spezifizieren!	100,000 (10% Belastung)

4. Geplante und laufende Strukturmassnahmen an der Heiminstitution

Bitte listen Sie gestützt auf das geltende Strukturpapier (Anhang IV des geltenden Vertrags) die geplanten und laufenden Strukturmassnahmen auf, die die Heiminstitution unterstützt. Hier können auch Eigenleistungen wie Infrastrukturleistungen etc. aufgelistet werden, die nicht im Budget (NIRA) enthalten sein dürfen.

bereits realisiert	**geplant**
Oeschger Centre for Climate Change Research:	
(Budget 2009ff: 2.0 M CHF) etabliert	
Ass.Prof.TT Paleoökologie: etabliert (W. Tinner)	Promotion zu aoP 2011 vorgesehen
oP Experimental Physik: etabliert (H. Fischer)	
Nachfolge Wanner: gesichert, Verfahren läuft	Rücktritt Wanner September 2010
Nachfolge Pfister: gesichert, Verfahren läuft	Besetzung erwartet für 2009/2010
aoP Prof. Grosjean: etabliert	
Professur Klimaökonomie: Verfahren läuft	Besetzung erwartet für 2009
	Ernennung F. Joos zum aoP in Vorbereitung

Das Rektorat/Direktorium bestätigt die Richtigkeit der Angaben in diesem Dokument.

Ort, Datum:
Bern, den

Unterschrift:

NCCR Proposal for continuation

NCCR CLIMATE
Swiss Climate Research

Project list

Workpackage / Project names Phase 3	**actual NIRA project names**
WP1 Reconstructing and modelling past drought variability WP Leader: **Jürg Luterbacher** (University of Bern, Institute of Geography)	
P 1.1 Modelling and Reconstruction of the North Atlantic Climate System Variability **(MONALISA III)** PI: **Thomas F. Stocker**, Co-PI: Christoph C. Raible (University of Bern, Climate and Environmental Physics)	R1 Stocker Thomas P1.1
P 1.2 Paleoclimate Variability and Extreme Events **(PALVAREX-3)** PI: **Jürg Luterbacher[1]**, Co-PI: Margit Schwikowski[2] ([1] University of Bern, Institute of Geography; [2] PSI, Villigen)	R1 Wanner Heinz P1.2
P 1.3 Drought effects and PDSI reconstruction from Southern and Central European trees **(DE-TREE)** PI: **Jan Esper**, Co-PI: David C. Frank (Swiss Federal Research Institute WSL, Birmensdorf)	R1 Esper Jan P1.4
WP2 Future Climate WP Leader: **Christoph Schär** (ETH Zurich, Institute for Atmospheric and Climate Sciences)	
P 2.1 Intensification of the water cycle: Scenarios, processes and extremes (**HyClim)** PI: **Martin Wild**, Co-PI: Christoph Schär (ETH Zurich, Institute for Atmospheric and Climate Science)	R1 Schär Christoph P2.2
P 2.2 Global climate processes: Role of cirrus clouds for present and future climate (**CCC**) **Ulrike Lohmann**, Co-PI: Thomas Peter (ETH Zurich, Institute for Atmospheric and Climate Science)	R3 new project
P 2.3 Probabilistic climate change scenarios for mean and extremes in the Alpine region **(PRECLIM)** PI: **Christof Appenzeller[1]**, Deputy-PI: Mark Liniger[1], Co-PI: R. Knutti [2] ([1] MeteoSwiss; [2] ETH Zurich, Institute for Atmospheric and Climate Sciences)	R1 Appenzeller Christof P2.5

NCCR Proposal for continuation

Project list

Workpackage / Project names Phase 3	**actual NIRA project names**
WP3 Ecosystem Impacts and Adaptation WP Leader: **Jürg Fuhrer** (agroscope Reckenholz-Tänikon Research Station)	
P 3.1 Drought effects on Swiss grasslands and adapted plant mixtures as management options under changing climate conditions **(PLANT/SOIL)** **Urs Feller[1]**, Co-PI: Nina Buchmann[2] (1 University of Bern, Institute of Plant Sciences; [2] ETH Zürich, Institute of Plant Sciences)	R2 Feller Urs P3.1
P3.2. Climate change and agricultural production risks **(AGRISK)** **Pierluigi Calanca[1]**, Deputy-PI: Jürg Fuhrer[1], Co-PI: B. Lehmann[2] ([1] Agroscope Reckenholz-Tänikon Research Station, Zurich; [2] ETH Zurich, Institute for Environmental Decisions)	R1 Fuhrer Jürg P3.2
P 3.3 Impacts of changing drought conditions on catchment ecology and water cycle (**ECOWAT)** PI: **Harald Bugmann[1]**, Co-PI: Christian Körner[2], Sonia Seneviratne[3], Annett Wolf[1] ([1] ETH Zurich, ITES; [2] University Basel, Institute for Botany; [3] ETH Zurich, Institute for Environmental Decisions)	R2 Bugmann Harald P3.4
WP4 Integrated assessment analysis of global climate change, economy and society WP Leader: **Gunter Stephan** (University of Bern, Department of Economics)	
P 4.1 Climate change and international trade from an economic and legal perspective **(CITEL)** PI: **Thomas Cottier[1]**, Deputy-PI: Gunter Stephan[2], Co-PI: Kateryna Holzer[1] and Oliver Schenker[2] ([1] University of Bern, World Trade	R3 new project
Institute; [2] University of Bern, Department of Economics)	
P 4.2 Climate Vulnerability, Risk assessment and management in a Post-Kyoto World **(CVR)** PI: **Gunter Stephan**, Co-PI: Seraina Buob (University of Bern, Department of Economics)	R2 Stephan Gunther P4.2
P 4.3 Modelling Climate Change Policies: Mitigation, Adaptation, and Acceptance **(MIADAC)** PI: **Philippe Thalmann**, Co-PI: Juan Carlos Altamirano-Cabrera (EPFL, Research Group on the Economics and Management of the Environment)	R2 Thalmann Philippe P4.3

NCCR Proposal for continuation

NCCR CLIMATE
Swiss Climate Research

Project list

Workpackage / Project names Phase 3	**actual NIRA project names**
Reserve projects	
R1 Climate Lessons from radiocarbon data **(CLER)** PI: **Fortunat Joos (**University of Bern, Climate and Environmental Physics)	R3 new project
R2 Solar Forcing and Climate Change of the last 1000 years (**SOLAR)** PI: **Jürg Beer** (Eawag)	R3 new project

Financial Overview: Funding sources (full version)

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001	
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)
Home Institution of NCCR:	Universität Bern			Version of NIRA: 3.4.0

Funding sources	**Year 9 01.04.2009 until 31.03.2010**	**Year 10 01.04.2010 until 31.03.2011**	**Year 11 01.04.2011 until 31.03.2012**	**Year 12 01.04.2012 until 31.03.2013**	**Total**	**%**
SNSF-funding	1'798'700	1'739'200	1'803'600	158'500	**5'570'000**	47.8
Self-funding from Home Institution	287'500	287'500	287'500	287'500	**1'150'000**	9.9
Self-funding from Home Institutions (network)	100'000	100'000	100'000	0	**300'000**	2.6
Self-funding from Groups	480'000	442'400	275'700	0	**1'198'100**	10.3
Self-funding from Groups (network)	1'013'100	918'600	671'300	0	**2'603'000**	22.3
Self-funding other	0	0	0	0	**0**	0.0
Self-funding other (network)	0	0	0	0	**0**	0.0
Third-party-funding	200'000	200'000	200'000	100'000	**834'063**	7.2
Total	**3'879'300**	**3'687'700**	**3'338'100**	**546'000**	**11'655'163**	100%

Signature of NCCR Director: ....

This report dates from 19.12.2008 - 12:48

Annex 2

Financial Overview: Allocation

Title of NCCR: Climate
Name of the NCCR-Director: Stocker Thomas
Home Institution of NCCR: Universität Bern

Start Date of NCCR: 01.04.2001
Calculation Type: Phase 3 Budget (locked)

Version of NIRA: 3.4.0

	Allocation 4 Year Period	**Year 9** **01.04.2009 until 31.03.2010**	**Year 10** **01.04.2010 until 31.03.2011**	**Year 11** **01.04.2011 until 31.03.2012**	**Year 12** **01.04.2012 until 31.03.2013**	**Total**	**%**
M	Management	161'100	161'200	161'200	161'300	**644'800**	5.5
M	Knowledge and Technology Transfer	123'350	123'450	123'450	122'350	**492'600**	4.2
M	Education	163'350	163'450	163'450	162'350	**652'600**	5.6
M	Reserve	170'000	170'000	170'000	100'000	**814'063**	7.0
L	R1 Stocker Thomas P1.1	353'900	321'800	299'400		**975'100**	8.4
L	R1 Wanner Heinz P1.2	238'200	251'400	264'300		**753'900**	6.5
L	R2 Feller Urs P3.1	176'500	185'300	145'200		**507'000**	4.4
L	R2 Stephan Gunter P4.2	337'200	188'500	129'400		**655'100**	5.6
L	R3 Cottier Thomas P4.1	178'300	185'300	143'400		**507'000**	4.4
L	R3 Joos Fortunat R1	46'500	50'000	53'500		**150'000**	1.3
N	R1 Appenzeller Christof P2.5	245'900	228'100	206'100		**680'100**	5.8
N	R1 Fuhrer Jürg P3.2	309'800	289'900	270'000		**869'700**	7.5
N	R1 Schär Christoph P2.2	599'200	581'300	559'400		**1'739'900**	14.9
N	R2 Bugmann Harald P3.4	183'100	191'900	152'000		**527'000**	4.5
N	R2 Esper Jan P1.4	176'500	185'300	145'200		**507'000**	4.4
N	R2 Thalmann Philippe P4.3	187'400	167'500	147'400		**502'300**	4.3
N	R3 Beer Jürg R2	46'500	50'000	53'500		**150'000**	1.3
N	R3 Lohmann Ulrike P2.2	182'500	193'300	151'200		**527'000**	4.5
Total		**3'879'300**	**3'687'700**	**3'338'100**	**546'000**	**11'655'163**	100%

Signature of NCCR Director: ....

Annex 2

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget (locked)
Home Institution of NCCR:	Universität Bern	Version of NIRA:	3.4.0

Period: **01.04.2009 until 31.03.2010**		**Human resources**						**Material and other expenditures**				**Reserve**	
		Number of PM											
		Academics	Doctoral Students	Other staff	**Total**	Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	Total of salaries, social charges/employers' shares, material/expeditures
M	Management	5.14	0.00	5.20	10.34	117'350	18'750	5'000	0	7'500	12'500	0	**161'100**
M	Knowledge and Technology Transfer	2.57	0.00	2.60	5.17	58'925	9'425	0	0	13'000	42'000	0	**123'350**
M	Education	2.57	0.00	2.60	5.17	58'925	9'425	0	0	43'000	52'000	0	**163'350**
M	Reserve	0.00	0.00	0.00	0.00	0	0	0	0	0	0	170'000	**170'000**
L	R3 Joos Fortunat R1	0.00	12.00	0.00	12.00	39'600	6'300	0	0	600	0	0	**46'500**
L	R3 Cottier Thomas P4.1	242.40	12.00	0.00	254.40	151'000	24'200	0	0	3'100	0	0	**178'300**
L	R2 Stephan Gunter P4.2	14.40	48.00	0.60	63.00	286'600	45'800	0	0	4'800	0	0	**337'200**
L	R2 Feller Urs P3.1	2.40	36.00	0.60	39.00	148'600	23'900	0	0	4'000	0	0	**176'500**
L	R1 Wanner Heinz P1.2	3.60	48.00	0.60	52.20	200'000	32'200	0	0	6'000	0	0	**238'200**
L	R1 Stocker Thomas P1.1	15.60	24.00	0.60	40.20	215'900	34'600	0	0	2'000	101'400	0	**353'900**
N	R3 Lohmann Ulrike P2.2	2.40	36.00	0.60	39.00	148'600	23'900	0	0	6'000	4'000	0	**182'500**
N	R3 Beer Jürg R2	0.00	12.00	0.00	12.00	39'600	6'300	0	0	600	0	0	**46'500**
N	R2 Thalmann Philippe P4.3	9.00	24.00	0.60	33.60	159'800	25'600	0	0	2'000	0	0	**187'400**
N	R2 Esper Jan P1.4	2.40	36.00	0.60	39.00	148'600	23'900	0	0	4'000	0	0	**176'500**
N	R2 Bugmann Harald P3.4	2.40	36.00	0.60	39.00	148'600	23'900	0	0	5'600	5'000	0	**183'100**
N	R1 Schär Christoph P2.2	16.60	24.00	0.60	41.20	223'100	35'700	0	0	6'000	334'400	0	**599'200**
N	R1 Fuhrer Jürg P3.2	24.00	24.00	0.60	48.60	265'300	42'500	0	0	2'000	0	0	**309'800**
N	R1 Appenzeller Christof P2.5	14.40	24.00	0.60	39.00	205'100	32'800	0	0	6'000	2'000	0	**245'900**

Legend: M=Management of NCCR, L=Project in the Leading House, N=Project within the Network

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001	
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)
Home Institution of NCCR:	Universität Bern			Version of NIRA: 3.4.0

Period: **01.04.2009 until 31.03.2010**	Human resources						Material and other expenditures				Reserve	Total of salaries, social charges/employers' shares, material/expeditures
	Number of PM											
	Academics	Doctoral Students	Other staff	**Total**	Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
Total	**359.88**	**396.00**	**17.00**	**772.88**	**2'615'600**	**419'200**	**5'000**	**0**	**116'200**	**553'300**	**170'000**	**3'879'300**

Signature of NCCR Director: ....

Financial Overview: Expenditures

Title of NCCR: Climate
Name of the NCCR-Director: Stocker Thomas
Home Institution of NCCR: Universität Bern
Start Date of NCCR: 01.04.2001
Calculation Type: Phase 3 Budget (locked)
Version of NIRA: 3.4.0

Period:	**01.04.2010 until 31.03.2011**	**Human resources**						**Material and other expenditures**				**Reserve**	**Total of salaries, social charges/employers' shares, material/expeditures**
		Number of PM				Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
		Academics	Doctoral Students	Other staff	**Total**								
M	Management	5.14	0.00	5.20	10.34	117'450	18'750	5'000	0	7'500	12'500	0	**161'200**
M	Knowledge and Technology Transfer	2.57	0.00	2.60	5.17	59'025	9'425	0	0	13'000	42'000	0	**123'450**
M	Education	2.57	0.00	2.60	5.17	59'025	9'425	0	0	43'000	52'000	0	**163'450**
M	Reserve	0.00	0.00	0.00	0.00	0	0	0	0	0	0	170'000	**170'000**
L	R3 Joos Fortunat R1	0.00	12.00	0.00	12.00	42'600	6'800	0	0	600	0	0	**50'000**
L	R3 Cottier Thomas P4.1	2.40	36.00	0.60	39.00	157'000	25'100	0	0	3'200	0	0	**185'300**
L	R2 Stephan Gunter P4.2	2.40	36.00	0.60	39.00	159'300	25'500	0	0	3'700	0	0	**188'500**
L	R2 Feller Urs P3.1	2.40	36.00	0.60	39.00	155'800	25'500	0	0	4'000	0	0	**185'300**
L	R1 Wanner Heinz P1.2	3.60	48.00	0.60	52.20	210'800	34'600	0	0	6'000	0	0	**251'400**
L	R1 Stocker Thomas P1.1	15.60	15.00	0.60	31.20	188'100	30'300	0	0	2'000	101'400	0	**321'800**
N	R3 Lohmann Ulrike P2.2	2.40	36.00	0.60	39.00	155'800	25'500	0	0	8'000	4'000	0	**193'300**
N	R3 Beer Jürg R2	0.00	12.00	0.00	12.00	42'600	6'800	0	0	600	0	0	**50'000**
N	R2 Thalmann Philippe P4.3	9.00	18.00	0.60	27.60	142'400	23'100	0	0	2'000	0	0	**167'500**
N	R2 Esper Jan P1.4	2.40	36.00	0.60	39.00	155'800	25'500	0	0	4'000	0	0	**185'300**
N	R2 Bugmann Harald P3.4	2.40	36.00	0.60	39.00	155'800	25'500	0	0	5'600	5'000	0	**191'900**
N	R1 Schär Christoph P2.2	16.60	18.00	0.60	35.20	205'800	33'200	0	0	8'000	334'300	0	**581'300**
N	R1 Fuhrer Jürg P3.2	24.00	18.00	0.60	42.60	248'000	39'900	0	0	2'000	0	0	**289'900**
N	R1 Appenzeller Christof P2.5	14.40	18.00	0.60	33.00	187'800	30'300	0	0	8'000	2'000	0	**228'100**

Legend: M=Management of NCCR, L=Project in the Leading House, N=Project within the Network

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001	
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)
Home Institution of NCCR:	Universität Bern			Version of NIRA: 3.4.0

Period: 01.04.2010 until 31.03.2011	Human resources						Material and other expenditures				Reserve	Total of salaries, social charges/employers' shares, material/expeditures
	Number of PM											
	Academics	Doctoral Students	Other staff	**Total**	Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
Total	**107.88**	**375.00**	**17.60**	**500.48**	**2'443'100**	**395'200**	**5'000**	**0**	**121'200**	**553'200**	**170'000**	**3'687'700**

Signature of NCCR Director: ....

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001	
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)
Home Institution of NCCR:	Universität Bern			Version of NIRA: 3.4.0

Period: **01.04.2011 until 31.03.2012**		**Human resources**						**Material and other expenditures**				**Reserve**	Total of salaries, social charges/employers' shares, material/expeditures
		Number of PM				Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
		Academics	Doctoral Students	Other staff	**Total**								
M	Management	5.14	0.00	5.20	10.34	117'450	18'750	5'000	0	7'500	12'500	0	**161'200**
M	Knowledge and Technology Transfer	2.57	0.00	2.60	5.17	59'025	9'425	0	0	13'000	42'000	0	**123'450**
M	Education	2.57	0.00	2.60	5.17	59'025	9'425	0	0	43'000	52'000	0	**163'450**
M	Reserve	0.00	0.00	0.00	0.00	0	0	0	0	0	0	170'000	**170'000**
L	R3 Joos Fortunat R1	0.00	12.00	0.00	12.00	45'600	7'300	0	0	600	0	0	**53'500**
L	R3 Cottier Thomas P4.1	2.40	24.00	0.60	27.00	121'000	19'400	0	0	3'000	0	0	**143'400**
L	R2 Stephan Gunter P4.2	2.40	28.00	0.60	31.00	108'400	17'400	0	0	3'600	0	0	**129'400**
L	R2 Feller Urs P3.1	2.40	24.00	0.60	27.00	120'800	20'800	0	0	3'600	0	0	**145'200**
L	R1 Wanner Heinz P1.2	3.60	48.00	0.60	52.20	221'300	37'600	0	0	5'400	0	0	**264'300**
L	R1 Stocker Thomas P1.1	14.15	12.00	0.60	26.75	168'500	27'700	0	0	1'800	101'400	0	**299'400**
N	R3 Lohmann Ulrike P2.2	2.40	24.00	0.60	27.00	120'800	20'800	0	0	6'000	3'600	0	**151'200**
N	R3 Beer Jürg R2	0.00	12.00	0.00	12.00	45'600	7'300	0	0	600	0	0	**53'500**
N	R2 Thalmann Philippe P4.3	9.00	12.00	0.60	21.60	124'900	20'700	0	0	1'800	0	0	**147'400**
N	R2 Esper Jan P1.4	2.40	24.00	0.60	27.00	120'800	20'800	0	0	3'600	0	0	**145'200**
N	R2 Bugmann Harald P3.4	2.40	24.00	0.60	27.00	120'800	20'800	0	0	5'400	5'000	0	**152'000**
N	R1 Schär Christoph P2.2	16.60	12.00	0.60	29.20	188'300	30'900	0	0	6'000	334'200	0	**559'400**
N	R1 Fuhrer Jürg P3.2	24.00	12.00	0.60	36.60	230'500	37'700	0	0	1'800	0	0	**270'000**
N	R1 Appenzeller Christof P2.5	14.40	12.00	0.60	27.00	170'300	28'000	0	0	6'000	1'800	0	**206'100**

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001	
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)
Home Institution of NCCR:	Universität Bern			Version of NIRA: 3.4.0

Period: **01.04.2011 until 31.03.2012**	**Human resources**						**Material and other expenditures**				**Reserve**	Total of salaries, social charges/employers' shares, material/expeditures
	Number of PM				Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
	Academics	Doctoral Students	Other staff	**Total**								
Total	**106.43**	**280.00**	**17.60**	**404.03**	**2'143'100**	**354'800**	**5'000**	**0**	**112'700**	**552'500**	**170'000**	**3'338'100**

Signature of NCCR Director: ....

Financial Overview: Expenditures

Title of NCCR: Climate
Name of the NCCR-Director: Stocker Thomas
Home Institution of NCCR: Universität Bern
Start Date of NCCR: 01.04.2001
Calculation Type: Phase 3 Budget (locked)
Version of NIRA: 3.4.0

Period: **01.04.2012 until 31.03.2013**		Human resources						Material and other expenditures				Reserve	Total of salaries, social charges/employers' shares, material/expeditures
		Number of PM				Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
		Academics	Doctoral Students	Other staff	**Total**								
M	Management	5.14	0.00	5.00	10.14	117'450	18'850	5'000	0	7'500	12'500	0	**161'300**
M	Knowledge and Technology Transfer	2.57	0.00	2.50	5.07	58'025	9'325	0	0	13'000	42'000	0	**122'350**
M	Education	2.57	0.00	2.50	5.07	58'025	9'325	0	0	43'000	52'000	0	**162'350**
M	Reserve	0.00	0.00	0.00	0.00	0	0	0	0	0	0	100'000	**100'000**
L	R3 Joos Fortunat R1	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
L	R3 Cottier Thomas P4.1	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
L	R2 Stephan Gunter P4.2	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
L	R2 Feller Urs P3.1	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
L	R1 Wanner Heinz P1.2	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
L	R1 Stocker Thomas P1.1	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R3 Lohmann Ulrike P2.2	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R3 Beer Jürg R2	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R2 Thalmann Philippe P4.3	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R2 Esper Jan P1.4	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R2 Bugmann Harald P3.4	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R1 Schär Christoph P2.2	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R1 Fuhrer Jürg P3.2	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**
N	R1 Appenzeller Christof P2.5	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	**0**

Legend: M=Management of NCCR, L=Project in the Leading House, N=Project within the Network

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001		
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)	
Home Institution of NCCR:	Universität Bern			Version of NIRA:	3.4.0

Period: **01.04.2012 until 31.03.2013**	**Human resources**						**Material and other expenditures**				**Reserve**	Total of salaries, social charges/employers' shares, material/expeditures
	Number of PM											
	Academics	Doctoral Students	Other staff	**Total**	Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
Total	**10.28**	**0.00**	**10.00**	**20.28**	**233'500**	**37'500**	**5'000**	**0**	**63'500**	**106'500**	**100'000**	**546'000**

Signature of NCCR Director: ....

Financial Overview: Expenditures

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001	
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget	(locked)
Home Institution of NCCR:	Universität Bern			Version of NIRA: 3.4.0

Period: **01.04.2012 until 31.03.2013**	**Human resources**						**Material and other expenditures**				**Reserve**	Total of salaries, social charges/employers' shares, material/expeditures
	Number of PM				Gross salaries	Charges / employers' shares	Equipment	Consumables	Travel	Miscellaneous	Reserve	
	Academics	Doctoral Students	Other staff	**Total**								
Total over all periods	**584**	**1'051**	**62**	**1'698**	**7'435'300**	**1'206'700**	**20'000**	**0**	**413'600**	**1'765'500**	**610'000**	**11'451'100**

Project list

Title of NCCR:	Climate	Start Date of NCCR:	01.04.2001
Name of the NCCR-Director:	Stocker Thomas	Calculation Type:	Phase 3 Budget (locked)
Home Institution of NCCR:	Universität Bern	Version of NIRA:	3.4.0

	Project leader **Project title**	**Project institution**	**Project start**	**Duration**	**Total Expenses**	**Total Funding SNSF**
M	Management	Universität Bern Bern	01.04.2001	156	644'800	120'000
M	Knowledge and Technology Transfer	Universität Bern Bern	01.04.2001	156	492'600	180'000
M	Education	Universität Bern Bern	01.04.2001	156	652'600	340'000
M	Reserve	Universität Bern Bern	01.04.2001	156	814'063	280'000
L	R1 Stocker Thomas P1.1 MONALISA	Universität Bern Bern	01.04.2001	132	975'100	400'000
L	R1 Wanner Heinz P1.2 PALVAREX	Universität Bern Bern	01.04.2001	132	753'900	450'000
L	R2 Feller Urs P3.1 PLANT/SOIL	UniBE, ETH Zürich, Uni ZH Bern, Zürich	01.04.2005	84	507'000	300'000
L	R2 Stephan Gunter P4.2 CVR	Universität Bern Bern	01.04.2005	84	655'100	450'000
L	R3 Cottier Thomas P4.1 CITEL	WTI, Universität Bern Bern	01.04.2009	36	507'000	300'000
L	R3 Joos Fortunat R1 CLER	Universität Bern Bern	01.04.2009	36	150'000	150'000
N	R1 Appenzeller Christof P2.5 PRECLIM	MeteoSwiss Zürich	01.04.2001	132	680'100	400'000

	Project leader Project title	Project institution	Project start	Duration	Total Expenses	Total Funding SNSF
N	R1 Fuhrer Jürg P3.2 GRASS	ART, ETH Zürich Zürich	01.04.2001	132	869'700	390'000
N	R1 Schär Christoph P2.2 RECLIM	ETH Zürich Zürich	01.04.2001	132	1'739'900	440'000
N	R2 Bugmann Harald P3.4 ECOHYDRO	ETH Zürich Zürich	01.04.2005	84	527'000	310'000
N	R2 Esper Jan P1.4 EXTRACT	WSL Birmensdorf	01.04.2005	84	507'000	300'000
N	R2 Thalmann Philippe P4.3 MIADAC	EPFL Lausanne	01.04.2005	84	502'300	300'000
N	R3 Beer Jürg R2 SOLAR	EAWAG Dübendorf	01.04.2009	36	150'000	150'000
N	R3 Lohmann Ulrike P2.2 GCC	ETH Zürich Zürich	01.04.2009	36	527'000	310'000
TOTAL					**11'655'163**	**5'570'000**

Legend: M=Management of NCCR, L=Project in the Leading House, N=Project within the Network

Annex 3

NCCR Proposal for continuation

NCCR CLIMATE
Swiss Climate Research

Budget SNSF-funding

Project	**Academics**				**Doctoral students**				**Other staff**				**Travel**	Miscellaneous	***TOTAL***
	PM	Gross salaries	Empl. shares	***Total***	**PM**	Gross salaries	Empl. shares	***Total***	**PM**	Gross salaries	Empl. shares	***Total***			
1.1 Stocker Thomas	29.75	213'700	34'200	*247'900*	36.00	127'800	20'400	*148'200*	0.00	0	0	*0*	1'800	2'100	*400'000*
1.2 Luterbacher Jürg	0.00	0	0	*0*	108.00	383'400	61'300	*444'700*	0.00	0	0	*0*	5'300	0	*450'000*
1.3 Esper Jan	0.00	0	0	*0*	72.00	255'600	40'900	*296'500*	0.00	0	0	*0*	3'500	0	*300'000*
WP1 TOTAL	***29.75***	***213'700***	***34'200***	***247'900***	***216.00***	***766'800***	***122'600***	***889'400***	***0.00***	***0***	***0***	***0***	***10'600***	***2'100***	***1'150'000***
P2.1 Wild Martin	33.60	241'400	38'600	*280'000*	36.00	127'800	20'400	*148'200*	0.00	0	0	*0*	8'900	2'900	*440'000*
P2.2 Lohmann Ulrike	0.00	0	0	*0*	72.00	255'600	40'900	*296'500*	0.00	0	0	*0*	7'700	5'800	*310'000*
P2.3 Appenzeller Christof	28.80	206'900	33'100	*240'000*	36.00	127'800	20'400	*148'200*	0.00	0	0	*0*	8'900	2'900	*400'000*
WP2 TOTAL	***62.40***	***448'300***	***71'700***	***520'000***	***144.00***	***511'200***	***81'700***	***592'900***	***0.00***	***0***	***0***	***0***	***25'500***	***11'600***	***1'150'000***
3.1 Feller Urs	0.00	0	0	*0*	72.00	255'600	40'900	*296'500*	0.00	0	0	*0*	3'500	0	*300'000*
3.2 Calanca Pierluigi	14.80	106'900	17'100	*124'000*	61.00	216'600	34'600	*251'200*	0.00	0	0	*0*	12'000	2'800	*390'000*
3.2 Bugmann Harald	0.00	0	0	*0*	72.00	255'600	40'900	*296'500*	0.00	0	0	*0*	6'000	7'500	*310'000*
WP3 TOTAL	***14.80***	***106'900***	***17'100***	***124'000***	***205.00***	***727'800***	***116'400***	***844'200***	***0.00***	***0***	***0***	***0***	***21'500***	***10'300***	***1'000'000***
4.1 Cottier Thomas	0.00	0	0	*0*	72.00	255'600	40'900	*296'500*	0.00	0	0	*0*	3'500	0	*300'000*
4.2 Stephan Gunter	12.00	86'200	13'800	*100'000*	83.00	294'700	47'100	*341'800*	0.00	0	0	*0*	8'200	0	*450'000*
4.3 Thalmann Philippe	18.00	129'300	20'700	*150'000*	36.00	127'800	20'400	*148'200*	0.00	0	0	*0*	1'800	0	*300'000*
WP4 TOTAL	***30.00***	***215'500***	***34'500***	***250'000***	***191.00***	***678'100***	***108'400***	***786'500***	***0.00***	***0***	***0***	***0***	***13'500***	***0***	***1'050'000***
R1 Joos Fortunat	0.00	0	0	0	36.00	127'800	20'400	148'200	0.00	0	0	0	1'800	0	*150'000*
R2 Beer Jürg	0.00	0	0	0	36.00	127'800	20'400	148'200	0.00	0	0	0	1'800	0	*150'000*
Reserveprojekte TOTAL	***0.00***	***0***	***0***	***0***	***72.00***	***255'600***	***40'800***	***296'400***	***0.00***	***0***	***0***	***0***	***3'600***	***0***	***300'000***
Reserve	0.00	0	0	*0*	0.00	0	0	*0*	0.00	0	0	*0*	0	210'000	*210'000*
Education	0.00	0	0	*0*	0.00	0	0	*0*	11.00	103'500	16'500	*120'000*	140'000	140'000	*400'000*
KTT	0.00	0	0	*0*	0.00	0	0	*0*	5.50	51'700	8'300	*60'000*	20'000	100'000	*180'000*
Management	0.00	0	0	*0*	0.00	0	0	*0*	5.50	51'700	8'300	*60'000*	0	0	*60'000*
Management Centre TOTAL	***0.00***	***0***	***0***	***0***	***0.00***	***0***	***0***	***0***	***22.00***	***206'900***	***33'100***	***240'000***	***160'000***	***450'000***	***850'000***
TOTAL	***136.95***	***984'400***	***157'500***	***1'141'900***	***828.00***	***2'939'500***	***469'900***	***3'409'400***	***22.00***	***206'900***	***33'100***	***240'000***	***234'700***	***474'000***	***5'500'000***

Annex 4

NCCR Proposal for continuation

Overview Funding sources

Funding source	**SNSF**	**Self**			**3rd-party**	*TOTAL*
		Home	**Groups**	**Other**		
1.1 Stocker Thomas	*400'000*	0	275'100	0	300'000	*975'100*
1.2 Luterbacher Jürg	*450'000*	0	303'900	0	0	*753'900*
1.3 Esper Jan	*300'000*	0	207'000	0	0	*507'000*
WP1 TOTAL	***1'150'000***	***0***	***786'000***	***0***	***300'000***	***2'236'000***
P2.1 Wild Martin	*440'000*	0	1'299'900	0	0	*1'739'900*
P2.2 Lohmann Ulrike	*310'000*	0	217'000	0	0	*527'000*
P2.3 Appenzeller Christof	*400'000*	0	280'100	0	0	*680'100*
WP2 TOTAL	***1'150'000***	***0***	***1'797'000***	***0***	***0***	***2'947'000***
3.1 Feller Urs	*300'000*	0	207'000	0	0	*507'000*
3.2 Calanca Pierluigi	*390'000*	300'000	179'700	0	0	*869'700*
3.2 Bugmann Harald	*310'000*	0	217'000	0	0	*527'000*
WP3 TOTAL	***1'000'000***	***300'000***	***603'700***	***0***	***0***	***1'903'700***
4.1 Cottier Thomas	*300'000*	0	207'000	0	0	*507'000*
4.2 Stephan Gunter	*450'000*	0	205'100	0	0	*655'100*
4.3 Thalmann Philippe	*300'000*	0	202'300	0	0	*502'300*
WP4 TOTAL	***1'050'000***	***0***	***614'400***	***0***	***0***	***1'664'400***
R1 Joos Fortunat	*150'000*	0	0	0	0	*150'000*
R2 Beer Jürg	*150'000*	0	0	0	0	*150'000*
Reserveprojekte TOTAL	***300'000***	***0***	***0***	***0***	***0***	***300'000***
Reserve	*210'000*	0	0	0	400'000	*610'000*
Education	*400'000*	312'600	0	0	0	*712'600*
KTT	*180'000*	312'600	0	0	0	*492'600*
Management	*60'000*	524'800	0	0	0	*584'800*
Management Centre TOTAL	***850'000***	***1'150'000***	***0***	***0***	***400'000***	***2'400'000***
TOTAL	***5'500'000***	***1'450'000***	***3'801'100***	***0***	***700'000***	***11'451'100***