1 — Introduction to the CH2014-Impacts initiative

Climate underpins our existence and well-being in subtle, yet important ways. It is an essential ingredient for the identity of any country and its people. If the name "Switzerland" brings to mind snow-capped mountains and cows grazing on green meadows, this image also echoes the climate peculiar to the country.

Awareness of climate change is widespread today, as global warming of the climate system is unequivocal and the observed warming since the mid-20th century is "extremely likely" to be due to human influence (IPCC, 2013). In Switzerland, the warming trend over the last three decades has been about 1.6 times greater than the Northern Hemispheric mean (Begert et al., 2005; Ceppi et al., 2012) and is clearly perceptible.

With global emissions of greenhouse gases steadily rising, climate change in Switzerland and elsewhere is set to continue. The long-term future depends on the political choice between increasingly larger changes in the climate system as a consequence of unabated emissions and the chance to keep change at a moderate level by a speedy trend reversal in emissions. The main greenhouse gas, CO_2, once emitted accumulates in the atmosphere and is only partly absorbed by ocean and land sinks, even on centennial time scales. Therefore, only an eventual phase out of fossil emissions will stabilize the climate system. Given the past and ongoing emission of greenhouse gases, this implies that some further climate change is unavoidable (IPCC, 2007a).

The impacts of climate change are manifold and anthropogenic warming has had a discernable influence on many physical and biological systems (IPCC, 2007b). Glaring evidence of ongoing climate change is the melting of our mountain glaciers. Rising greenhouse gas levels will lead to an increasing number of severe impacts across many sectors and geographical regions, and are very likely to impose net annual costs that will increase over time as global temperature increases (IPCC, 2007b). Additional costs will accrue due to adaptation to climate change impacts (Stern et al., 2006).

Still, present understanding of the consequences of climate change is fraught with uncertainty, originating from policy decisions, societal and technological development, and the climate system. There is already uncertainty concerning the global scale of warming and this amplifies as the focus is set on associated variables such as precipitation, and on regional to local spatial scales, in particular in areas with complex topography such as Switzerland. Further uncertainties are involved in the step from climate change to specific impacts. These difficulties notwithstanding, a sound understanding of climate change and its impacts, both adverse and beneficial, is a crucial prerequisite for dealing adequately with climate change.

An overview of previous efforts to assess climate change including the institutions involved internationally and in Switzerland is described in the Box on page 20. Since the mostly qualitative national assessment "Climate Change and Switzerland 2050 – Impacts on Environment, Society and Economy" (OcCC, 2007) was published, a new set of climate projections from the European project ENSEMBLES (van der Linden and Mitchell, 2009; with the participation of ETH Zurich; ETHZ and Federal Office of Meteorology and Climatology; MeteoSwiss) has become available and innovations in statistical methods have been made (partly by the National Centre of Competence in Research on Climate; NCCR Climate). Based on these developments, the new "Swiss Climate Change Scenarios CH2011" were elaborated (CH2011, 2011; Chapter 3). The

‹ Dairy cows will increasingly suffer from heat stress, which could affect milk production (photo: imago/ Geisser).

Box: Institutions and previous assessments related to climate change

At the **global level**, the need for a comprehensive assessment of scientific knowledge on climate change to advise international policy was recognized already in the 1980s. The World Climate Research Programme (WCRP), the International Geosphere-Biosphere Programme (IGBP) and an international programme of biodiversity science (Diversitas) were launched to organize scientific activities related to global change. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was established to assess "the scientific, technical, and socioeconomic information relevant for the understanding of the risk of human-induced climate change". The IPCC's role is defined as providing a policy relevant but not policy prescriptive basis for the decision making process.

IPCC's First Assessment Report (FAR; IPCC, 1990) inspired the formation of the United Nations Framework Convention on Climate Change (UNFCCC). Since 1995 – when it entered into force – the UNFCCC continues to provide the essential policy framework for addressing climate change at the international level. The Second Assessment Report (SAR; IPCC, 1995) became the basis for the Kyoto Protocol adopted in 1997 and in force since 2005. The Kyoto Protocol is the only international treaty that sets legally binding obligations on industrialized countries to reduce emissions of greenhouse gases. Subsequent IPCC findings from the Third (TAR; IPCC, 2001), and in particular the Fourth Assessment Report (AR4; IPCC, 2007a;b), informed the negotiations of the 16th Conference of the Parties in Cancun, Mexico in December 2010, which agreed on a warming limit of 2°C above preindustrial levels.

Today, the scientific results assessed by the IPCC again provide the basis for the UNFCCC international negotiations to act on climate change. In addition, the new Structured Expert Dialogue communicates the latest scientific findings such as the IPCC Fifth Assessment Report (AR5; IPCC, 2013). The goal of the ongoing negotiations is to agree on a new, comprehensive binding treaty by the end of 2015 as a successor to the Kyoto Protocol. This instrument is expected to foster reductions in greenhouse gas emissions and subsequently limit the scale of impacts in accordance with the agreed upon long-term target of 2°C warming.

In **Switzerland**, research contributing to IPCC findings has a long and strong tradition. Many academic institutions have been involved, such as the universities, the ETHs, and not least the Swiss Academy of Sciences (through ProClim and the OcCC), catalyzing progress in climate change science through their early support. Already in 1997, the final report of the National Research Programme "Climatic Changes and Natural Hazards (NRP 31)" linked climate change, natural hazards, ecology, and society and highlighted the possible future challenges. In the same year, the Priority Programme Environment (SPPU) dedicated an entire module to climate change (CLEAR – Climate and Environment in an Alpine Region) that communicated its results to the general public and policy makers in several publications.

The National Centre of Competence in Research on Climate (NCCR Climate) established in 2001, further strengthened climate research in all disciplines and all major aspects of climate research, including impacts of climate change. The results of such activities are reflected in the report "Climate Change and Switzerland 2050 – Impacts on Environment, Society and Economy" (OcCC, 2007). This report addresses stakeholders and the general public, and offers an extensive and mostly qualitative assessment of impacts expected around the year 2050, based on existing literature and on climate projections from the PRUDENCE project (Christensen et al., 2002). The ongoing National Research Programme "Sustainable Water Management (NRP 61)" focuses on the capacity of natural systems to absorb the effects of changes in environmental conditions, including climate conditions, as a basis for forward-looking strategies for sustainable and integral water resources management.

Within the national administration, the Federal Office for Environment (FOEN) is in charge of national climate change related activities. This includes the coordination of Swiss mitigation efforts, as well as the development of a national adaptation strategy (FOEN, 2012a). Over the past years, national and cantonal administrations together with the private sector have supported various research activities that focus on issues related to climate change impact and adaptation (e.g., FOEN, 2012b; Holthausen et al., 2011). The CH2014-Impacts report extends these recent activities with a snapshot of the currently available quantitative impact information based on a common set of climate scenarios (CH2011, 2011).

CH2011 scenarios are used as an up-to-date basis for the CH2014 impact studies. On the impact modeling front, major progress was made in representing impact relevant systems and processes quantitatively.

One of the conclusions of the OcCC report (OcCC, 2007) is that "[...] there are no precise estimates of the costs for the adaptations and measures mentioned, which, for some fields, may be of economic relevance." This statement shows that climate change is a cross-cutting issue with natural, societal, and economic aspects. It also implies a need for more quantitative research to fill some of the still remaining gaps in the scientific basis for strategies to address climate change. The advancements in climate data and impact models present an opportunity for multi-sectoral studies that are both quantitative and coherently based on a common foundation of climate data.

Acting on this opportunity, the Oeschger Centre for Climate Change Research (OCCR) of the University of Bern initiated CH2014-Impacts as a community effort to quantify climate change impacts over the 21st century, with support from the Federal Office for the Environment (FOEN), MeteoSwiss, and NCCR Climate (now concluded). An open call was issued through the Forum for Climate and Global Change (ProClim) in December 2011, inviting experts from all relevant fields to participate. The condition for participation was the ability to quantify impacts based on the CH2011 Swiss climate change scenarios. Accordingly, the goal of the CH2014-Impacts initiative is to compile results from currently available impact models, applied to a common set of climate scenarios for Switzerland. This approach is specific to CH2014-Impacts and complementary to existing studies (see Box). It should not be seen as a comprehensive assessment of climate change impacts, which would have to be founded on multiple lines of evidence and a review of the existing literature.

Thanks to the great response to the call for participation in CH2014-Impacts, a broad collection of studies was included in the report. The contributions reach from the physical environment and ecosystems to socio-economic consequences, quantifying selected impacts of climate change related to aspects of the cryosphere, the hydrosphere, biodiversity, forests, agriculture, energy, and health. The result is a "sample of opportunity", based on what has been offered by the Swiss science community. It reflects the current state of the art and present gaps in quantitative impact methods.

The report compiles quantitative information from multiple fields, based on common climate scenarios. As yet limited in scope, it aims to contribute to a future comprehensive quantitative depiction of potential climate change impacts in Switzerland, which the impact community can draw on to inform and support stakeholders and policymakers. This report is thus an effort toward building a set of quantitative scenarios of climate change impacts in Switzerland, in analogy to the CH2011 climate scenarios.

In order to be relevant for a robust assessment of climate risks and opportunities, the report considers the full range of projected outcomes from CH2011, including time horizons from the short term (around the year 2035) to the end of the current century (around 2085), greenhouse gas levels from soaring emissions to stringent climate change mitigation, and the uncertainty originating from the underlying climate models and natural climate variability as quantified in CH2011.

The CH2014-Impacts report was made possible through the enthusiasm of the authors, who contributed their work without additional funding. Over 20 research groups from 15 institutions were involved, including the OCCR of the University of Bern, the Center for Climate System Modeling (C2SM) at ETHZ, MeteoSwiss, the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the Agroscope institutes, the WSL Institute for Snow and Avalanche Research (SLF), the Swiss Federal Institute of Aquatic Science and Technology (EAWAG), the Ecole polytechnique fédérale de Lausanne (EPFL), the Research Institute of Organic Agriculture (FiBL), the University of Applied Science Chur (HTW Chur), and the Universities of Innsbruck (Austria), Fribourg, Luzern, and Zurich. Additionally, the process was accompanied by the Swiss Academy of Sciences via ProClim and the Organe consultatif sur les changements climatiques (OcCC).