How to use the power of AI to reduce the impact of climate change on Switzerland

Recommendations for the Swiss society and economy to become more resilient against the impact from a radically changing climate

Make key technologies broadly available and overcome challenges through key methodologies in climate- and AI-related fields.

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4 Impact of climate change on Swiss society, economy and ecosystem

In a climate change context, several climate extreme events are expected to become more frequent and intense. It is essential to assess climate physical risk properly in order to be able to design appropriate adaptation strategies. On the other hand, climate change mitigation through limitation of greenhouse gas emissions is crucial.

This chapter reviews the main impacts due to climate change in Switzerland, describes the affected stakeholders and the key actors in the development of climate services, and discusses the issues of adaptation and mitigation towards a net-zero economy.

4.1 Climate-change impacts in Switzerland

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4.1.1 Observed changes in meteorological and hydrological variables

Climate change is in full swing worldwide, as shown by Figure 4.1. On 17 November 2023, the global mean surface temperature anomaly with respect to the 1850–1900 period exceeded for the first time in history the 2°C threshold (+ 2.07°C). The effects of climate change are also clearly visible in Switzerland, where the mean temperature over the 2014–2023 decade has been 2.7°C above the 1871–1900 average as displayed in Figure 4.2, and the eight warmest years since 1864 were all recorded after 2010[3]. Related to this, the height of the zero-degree line has been substantially increasing, especially since 1990 (MeteoSchweiz 2023, Fig. 5.15, p.76), which has resulted in a thinner and shorter snow cover (FOEN 2021). Since in the winter months more precipitation falls as rain than snow due to rising temperatures, runoff increased in most catchments. In contrast, a decrease in average runoff was generally observed in summer - except in highly glaciated catchments (FOEN 2021, p.33). Hundreds of streams, rivers and lakes are subject to fundamental changes in the water cycle (Höge et al., 2023).

[3] https://www.meteoswiss.admin.ch/climate/climate-change.html

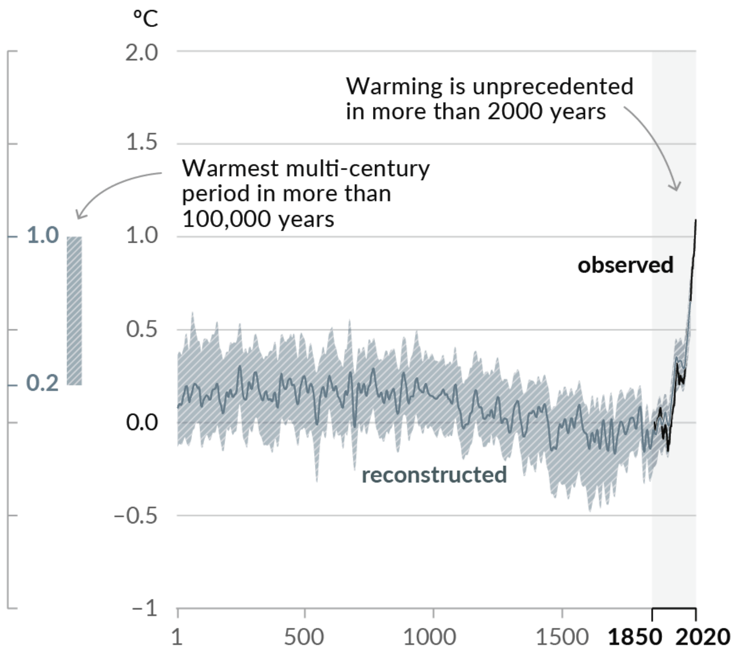

Figure 4.1: Changes in global surface temperature relative to 1850–1900 as reconstructed (1–2000) and observed (1850–2020). Source: IPCC (2021, Fig. SPM.1(a)).

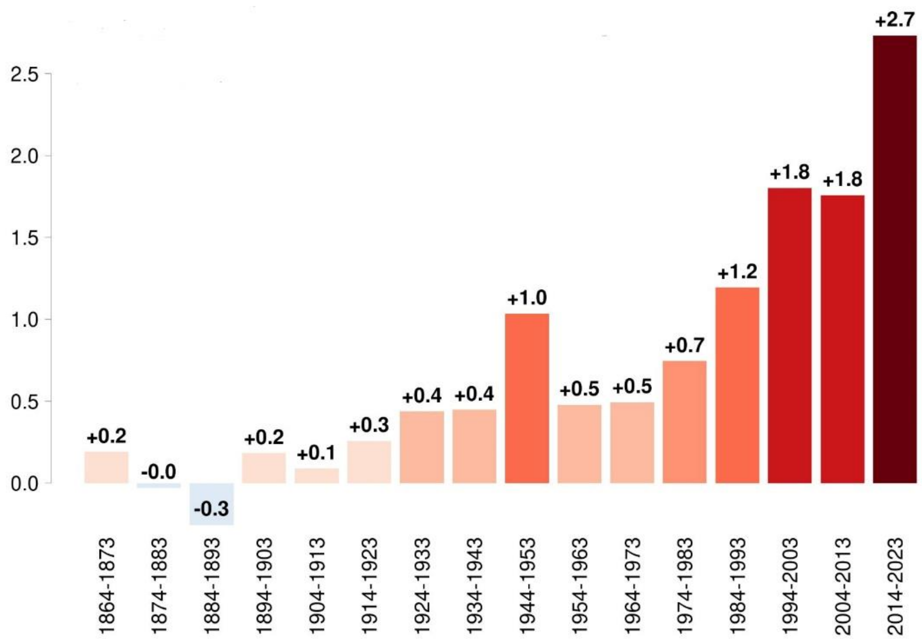

Figure 4.2: Deviation (in °C) of nationwide mean temperature relative to 1871–1900 for the 16 decades since records began. Source: MeteoSwiss website[3].

Observations further show that not only is the mean temperature changing, but also that extreme weather events are becoming more frequent. Days with extremely high temperatures have increased (MeteoSchweiz 2023), as have the frequency and intensity of extreme precipitation events in the past decades (Scherrer et al., 2016); see Meteoschweiz[4] for trends in further climate indicators. Drought conditions in recent summers have led to very low river discharge with enormous consequences for

[4] https://www.meteoschweiz.admin.ch/service-und-publikationen/applikationen/ext/climate-indicators-public.html

aquatic life, record melting of glaciers, and long-lasting high wildfire danger conditions; see, e.g., BAFU[5]. Figure 4.3 summarizes the main observed changes.

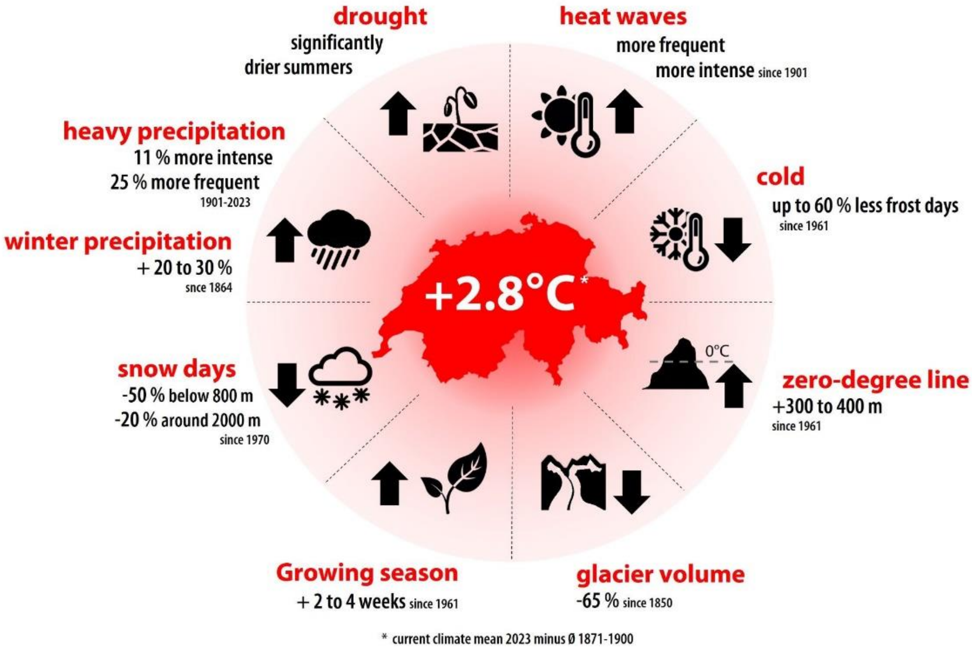

Figure 4.3: Key changes observed in Switzerland. Source: MeteoSwiss website[3].

4.1.2 Projected changes in meteorological variables

The magnitude of future climate change depends on the cumulative (past, present, future) worldwide emissions of greenhouse gases (IPCC, 2021). The magnitude of future climate change is therefore ultimately linked to future emissions. Socio-economic scenarios for these emissions cover a range of cases, going from strong to little or no mitigation actions. The severity of climate-related changes in Switzerland across all variables is substantially reduced in the strong mitigation scenario compared to the scenario with little to no mitigation (CH2018, 2018). Thus, rapid and effective mitigation is imperative; see BAFU[6] about the Swiss mitigation strategy.

Under the umbrella of the Swiss National Centre for Climate Services (NCCS), the Federal Office of Meteorology and Climatology MeteoSwiss together with ETH Zurich provide detailed information about projected changes of the physical climate until the end of the 21st century on their data and information portal[7]. The current information on future climatic changes stems from the CH2018 climate scenarios (CH2018, 2018; Fischer et al., 2022). Key expected changes are a continued increase in mean and extreme high temperatures, a decrease in summer mean precipitation, a rise in the duration of the longest precipitation-free period in summer, an increase of the frequency and intensity of heavy precipitation events, and a reduction of the snow falling period and cover in winter (CH2018). New Swiss climate scenarios are currently being elaborated by MeteoSwiss, ETH Zurich and partners, and will be released in 2025 (CH2025 Swiss Climate Scenarios; see Meteoswiss[8]). In addition to climate scenarios, a report by the Swiss Academies of sciences summarizes the relevant findings of

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[5] https://www.bafu.admin.ch/bafu/de/home/themen/wasser/dossiers/hitzewelle-und-trockenheit.html#-329505868
[6] https://www.bafu.admin.ch/bafu/de/home/themen/klima/fachinformationen/emissionsverminderung/verminderungsziele/ziel-2050/klimastrategie-2050.html
[7] https://www.nccs.admin.ch/nccs/de/home/klimawandel-und-auswirkungen/schweizer-klimaszenarien.html
[8] https://www.meteoswiss.admin.ch/about-us/research-and-cooperation/projects/2023/climate-ch2025.html

IPCC's AR5 for Switzerland covering the physical climate, but also climate impacts, adaptation and mitigation issues (Akademien der Wissenschaften Schweiz 2016). Based upon the CH2018 climate scenarios and under the umbrella of the NCCS, a report (FOEN 2021) by the Federal Office for the Environment (FOEN) provides updates on how climate change affects river discharge, groundwater, water temperatures, snow, and glaciers.

AI tools are well suited to complement and extend the existing systems and methodologies as further discussed, e.g., in Section 5.2 in the case of numerical weather prediction and climate model simulations.

4.1.3 Impacts

Climatic changes in Switzerland are expected to have broad and important impact and to affect all sectors. Some of the main risks are increasing heat stress (with detrimental effects for human health and leading to a decline in productivity at work); increasing levels of drought (with related agricultural yield reduction, water shortages, and decrease in summer hydroelectric production); more flooding and slope instabilities (causing injury and property damage); degradation of water, soil and air quality (inducing human health impairment and negatively affecting ecosystem services); spread of pests, diseases and exotic species (detrimental to human health, reducing agricultural yield, and damaging forest products and services). For a detailed overview, see the risk analysis performed by the FOEN in Köllner et al. (2017) and NCCS[9],as well as Akademien der Wissenschaften Schweiz (2016). For additional information about the impacts of climate change, see the links provided by Agroscope[10] and the Federal Office for Agriculture (FOAG)[11] for agricultural production including food supply, the FOEN[12] for forests, theSwiss Financial Market Supervisory Authority (FINMA)[13] for the financial sector, the NCCS[14] for cities, and the NCCS[15] for health. Moreover, the study by Köllner et al. (2017) is currently being updated and re-evaluated, and associated results are expected in 2024 on the NCCS-website[16]. Several new insights regarding the impact of climate change in Switzerland are also expected from the currently running NCCS-Impacts programme[17] that analyzes cross-sectoral impacts and tries to elaborate actionable climate services. Further insights are expected from dedicated research centers such as the Centre for Climate Systems Modeling (C2SM), the ETH AI center, the Weather and Climate Risks Group at ETH Zurich, the Mobiliar Lab for Natural Risks, and the Expertise Center for Climate Extremes (ECCE) at the University of Lausanne.

4.1.4 Adaptation

The diverse climatic impacts require adaptation by the Swiss society that will include behavioral, structural, regulatory, legal, and technical measures. In Switzerland, the adaptation strategy adopted by the Federal Council sets out a framework for a coordinated approach on the federal level (see

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[9] https://www.nccs.admin.ch/nccs/en/home/climate-change-and-impacts/analyse-der-klimabedingten-risiken-und-chancen.html
[10] https://www.agroscope.admin.ch/agroscope/en/home/topics/environment-resources/climate-air-quality/agriculture-under-climate-change.html
[11] https://www.blw.admin.ch/blw/de/home/nachhaltige-produktion/umwelt/klima0.html
[12] https://www.bafu.admin.ch/bafu/de/home/themen/wald/fachinformationen/belastungen-im-schweizer-wald/auswirkungen-des-klimawandels-auf-den-wald.html
[13] https://www.finma.ch/en/documentation/dossier/dossier-sustainable-finance/risiken-aus-dem-klimawandel/
[14] https://www.nccs.admin.ch/nccs/en/home/regions/cities-and-municipalities/climate-change-in-cities.html
[15] https://www.nccs.admin.ch/nccs/en/home/the-nccs/priority-themes/human-health.html
[16] https://www.nccs.ch/
[17] http://www.nccs.admin.ch/impacts-en

FOEN[18]). With their pilot programme "Adaptation to Climate Change" (see NCCS[19]), where the second phase ended in May 2023, the Federal Council exemplified good practices in various sectors.

Key to successful adaptation in terms of planning and implementation are high-quality information on future hazards, in-depth knowledge of the current and future vulnerability and resilience of human and natural systems, and details on future exposure. We also need to better appraise how their interactions evolve over time (Simpson et al. 2021). AI provides potentially important tools to address associated gaps (in particular the information gaps in vulnerability and exposure) through effective use of Earth observation data (e.g., Kuglitsch et al. 2023). Challenges in that respect are the spatial and temporal inhomogeneity of data on vulnerability, the exponential increase in data volumes, and ensuring open public access data. For additional insight about the potential use of AI for impact assessment, see Section 5.3.However, waiting for the best possible knowledge to become available is sometimes not an option owing to some adaptation measures having long lead times and due to the shifting landscape of climate risks and their drivers (Garschagen et al. 2021, Simpson et al. 2023). There is also often little agreement amongst planners and decision makers on the objectives of specific adaptation responses, or such objectives are not constant over time (Marchau et al. 2019).

Approaches of decision making under the circumstances of deep uncertainties such as robust decision making (RDM), dynamic adaptive policy pathways (DAPP) and exploratory modeling have gained traction in the past 10 years in Europe and beyond (Kwakkel and Pruyt 2013, Marchau et al. 2019). These approaches foster flexibility, resilience, and the ability to learn and adapt over time. They provide a practical framework for dealing with the complex and unpredictable nature of future challenges, ensuring that adaptation strategies are better suited to navigate uncertainties and changing conditions (Haasnoot et al. 2020, Cradock-Henry et al. 2023).

Currently, key challenges remain for supporting adaptation and decision making under deep uncertainty. For example, the thresholds to which adaptation measures maintain their effectiveness relies on knowledge about which adaptation works and under which conditions, i.e., changes in exposure and vulnerability and their interaction over time. This information is seldomly available and often relies on plausible scenarios of future development and modeling of adaptation (Magnan et al. 2021).

Furthermore, Large Language Models (LLMs) can digest substantial amounts of information for various downstream tasks including climate information retrieval (Koldunov & Jung, 2024). With proper prompt engineering, LLMs can be deployed to improve the assessment of effectiveness and feasibility of specific adaptation responses. This, in turn, guides decision-makers in selecting the most suitable adaptation options and their combinations (Vaghefi et al., 2023).

Finally, in the shorter term, risk management is dependent on effective early warning systems and rapid information provision during and after events (see e.g., Swisstopo[20]). Ideally, warning systems should not only warn of hazards but should also provide an estimate of the expected impacts. With its OWARNA2[21] and Weather4UN[22] programs, MeteoSwiss will continue introducing impact-based warnings and further improve the direct relevance of warnings within existing and well-established communication channels.

[18] https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/adaptation/strategy.html
[19] https://www.nccs.admin.ch/nccs/en/home/measures/pak.html
[20] https://www.swisstopo.admin.ch/en/services/rapidmapping.html
[21] https://www.meteoschweiz.admin.ch/ueber-uns/forschung-und-zusammenarbeit/projekte/2020/owarna2-mch.html
[22] https://www.meteoswiss.admin.ch/about-us/research-and-cooperation/projects/2021/weather4un.html

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