18. Climatology

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18.1
Atmospheric Contribution to Multidecadal Flood Variability in Europe

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Analyses of historical streamflow records and documentary data indicate clear multidecadal changes of flood frequency in Europe. Floods were more frequent in Central Europe in the 19th century than during the mid-20th century, and an increase is also noted since the 1970s. The causes for these multidecadal variations are not well understood. In this contribution I will focus on the atmospheric contribution to multidecadal flood variability, such as changes in atmospheric circulation. Long streamflow records are analysed together with daily weather data from reanalyses and from weather type classifications, with monthly data from climate reconstructions and with atmospheric model simulations. Results show that atmospheric circulation variations as well as climate change contribute to multidecadal flood variability and change.

18.2
Evaluating the seasonal robustness of snow climate indicators using a unique set of parallel snow data

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It is well known that measurements of snow can heavily depend on the measurement location and can differ even over short distances. A data set of 25 station pairs with parallel manual snow measurements, gathered by two separate institutes in Switzerland, provides a unique opportunity to analyse the local-scale variability of typical snow climate indicators. The independent daily measurements date back several decades and cover at least 25 years and an altitude range from 490 to 1800m a.s.l. The parallel locations are usually separated by less than 2 km in terms of distance and less than 100 metres in terms of elevation. In contrast to many other meteorological variables, the manual snow measurement instruments have not changed over time. However, the data series almost certainly encountered one or several changes in the exact measurement location or observer, which may have not been documented in the metadata.
A sensitivity analysis was carried out to look for snow climate indicators, such as mean snow depth, sum of new snow, maximum snow depth or number of days with snowfall, with the smallest variations among the station pairs.
Results show that there are only small differences in the sensitivity of the various snow climate indicators with regards to, usually unknown, local changes. However, the indicators number of days with snow on the ground as well as the maximum snow depth and the sum of new snow are least affected by local influences and changes at station level. Median values of all station pairs reveal relative differences of about 7% for the number of days with snow cover and 11-16% for all other indicators. However, there are clear seasonal differences, which can be much larger in extremes cases.
These experiences will help to define application-dependent robust snow climate indicators and will also help to interpret suspicious snow data series from locations without parallel measurements and without documented changes in the metadata and thus contribute to the generation of homogenous snow climatological time series.

18.3
Precipitation response to ozone depletion in the Southern Hemisphere

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A mature body of research examines the influence of stratospheric ozone changes on Southern Hemisphere climate and circulation. Stratospheric ozone depletion, which has its strongest signal over Antarctica in austral spring, is believed to be the dominant driver of austral summer atmospheric circulation changes in recent decades. These changes include a poleward shift of the lower-tropospheric midlatitude jet, the poleward expansion of the subtropical edge of the Hadley Cell, as well as a shift of the Southern Annular Mode (SAM) into its positive phase.

In terms of surface impacts associated with these circulation changes, the Ozone Assessment (2014) suggested that observed changes in extratropical and subtropical austral rainfall may be linked to ozone depletion. However, only a few studies have investigated this link and mostly on regional scales. Moreover, most have not been able to clearly isolate the effect of the ozone forcing from other anthropogenic forcings and internal climate variability, due to a lack of appropriate experiments and/or model output.

This study focuses on the isolation of the ozone forcing from other forcings using individual forcing simulations of the CESM1-CAM5 Large Ensemble (CESM-LE) and tries to further identify its impact on austral summer precipitation in the Southern Hemisphere as well as the influence of/on changes in the SAM. The additivity of the precipitation response to individual forcings is explored within this large ensemble, which allows for better quantification of the role of internal variability.

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18.4
Trends in bioclimatic indices for the coming decades in the Neuchatel vineyard

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Weather conditions are known to be the most important factor for vitiviniculture (Jones and Davis 2000, van Leeuwen et al. 2004). Numerous studies have shown that climate change influences the phenological development stages of grapes (e.g. Duchêne and Schneider 2005, Cook and Wolkovich 2016) and of the wine composition (Spayd et al. 2002, Jones and Webb 2010). Thus, wines tend to have more sugar and alcohol levels and less acidity in connexion with warmer temperatures. RCPs scenarios provide an essential tool to anticipate future climatic conditions and their impacts on wine production. They help to develop long-term adaptation strategies to climate change. These strategies may consist in an altitudinal shift of the traditional cultivated varieties and/or in the introduction of new varieties (Jones et al. 2005).

In this study, we analysed present and future climatic conditions in the wine region of Neuchatel. We used temperature data from 1980 to 2019 and two RCPs scenarios. We focused on two bioclimatic indices, which are critical for viticulture: the Huglin heliothermal index and the growing season temperature average. We also analysed the frequency and intensity of heat waves occurrences during the summer season and the trend in night temperature during the period prior to harvest. The results should help winegrowers to develop their own strategies to adapt to climate change.

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18.5
Detecting and attributing climate change impacts in terrestrial systems

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Monitoring and understanding the impacts of climate change on terrestrial systems is essential for adapting our societies to the changing world we live in. In contrast to many other drivers of environmental impacts, which can be pin-pointed at local scales (e.g. land management), the influence of climate change is often masked by high degrees of internal climate variability, the complexity of terrestrial systems and the interplay with socio-economic changes. Assessing climate change impacts in the observational records therefore requires a continental to global perspective that offers a more favorable signal to noise ratio. Recent advances in assembling international collections of in situ observations (e.g. of river flow) together with ongoing progress in using data-driven and model based approaches for reconstructing large-scale dynamics of essential environmental variables (e.g. terrestrial water storage) allow now for detecting ongoing environmental change at the global scale. Here we provide an overview on shifts in several components of the global terrestrial system that include indicators of freshwater resources, lake ice dynamics and permafrost. Subsequently, we use approaches that combine observational evidence with process knowledge encoded in global models to uncover the degree to which observed shifts in terrestrial systems can be attributed to anthropogenic climate change. Our results highlight that rivers, lakes and permafrost across the globe are already deeply impacted by historical climate change, calling for careful scruteny of their evolution in the coming decades.

18.6
Reconstructing AMOC strength by simulating the transport of Pa/Th isotopes in the ocean

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The Atlantic Meridional Overturning Circulation (AMOC) is a critical component of the climate system due to its large capacity to redistribute heat, nutrients, and carbon between the hemispheres. Reconstructions indicate that the strength of the AMOC is tightly coupled to climate and it experienced major perturbations in the past during northern hemispheric cold periods. Studies predict that the AMOC may also slow down under future anthropogenic warming.

In order to infer past AMOC strength, the ratio between the radionuclides protactinium-231 and thorium-230 (hereafter Pa/Th ratio) is used as a proxy. These rare metals are naturally formed in the ocean from uranium decay and are preserved in ocean sediments. Pa typically binds less than Th to particles that sink to the ocean bottom and therefore Pa is transported away if ocean circulation is strong. Due to the complex behaviours of Pa and Th in the ocean, models can be of great value to assess possible interpretations of the Pa/Th ratio as a proxy for AMOC strength by simulating secondary processes and disentangling them from the presumed AMOC strength signal. We simulate Pa and Th in the ocean following previous work by Rempfer et al. 2017 with an updated version of the Bern3D earth system model.

A prevailing open question is the contradicting relation between Pa/Th and AMOC strength in different regions. Both sediment measurements and models show a Pa/Th ratio that is anti-correlated with AMOC strength in the deep Northwest Atlantic (Bermuda Rise), but positively correlated in other regions, e.g., shallower regions or regions further north (Rempfer et al. 2017, Süfke et al. 2020). Whereas the former behaviour confirms the classical idea of this proxy, our goal is to investigate why many other regions show an ‘inverted behaviour’. Answering this question would improve the interpretation of Pa/Th and therefore provide a better understanding of how changes in AMOC are coupled to changes in climate.

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18.7
A monthly paleo-reanalysis of the atmosphere between 1603-2005

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Data assimilation techniques are becoming increasingly popular for climate reconstruction. They benefit from estimating past climate states both from observation information and from model simulations.

The atmospheric paleo-reanalysis (EKF400v2) is generated by blending observations into model simulations via an offline data assimilation technique. EKF400v2 builds on its predecessor (EKF400v1) which utilized the ensemble Kalman fitting (EKF) paleoclimate data assimilation technique.

Here, in the production of EKF400v2 the EKF technique was further developed by implementing methodological improvements such as better estimation of the background-error covariance matrix and a better localization scheme.

Furthermore, new observational sources were added to the assimilation process contributing to an extended observational network and helping to obtain a more skillful reconstruction both in space and time.

The EKF400v2 paleo-reanalysis can be used to study the dynamics associated with past extreme events and to analyze large-scale circulation changes on time scales raining from monthly to multidecadel.

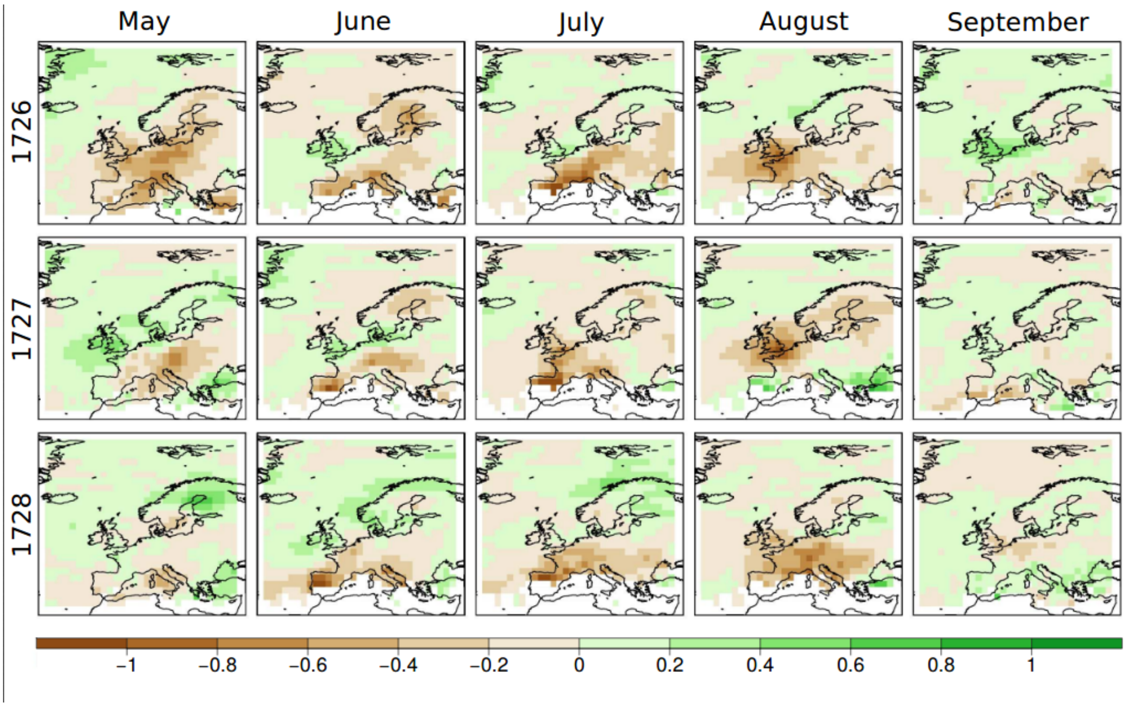

Figure 1. Monthly relative anomalies of precipitation from May to September over Europe for the dry summer years between 1726-1728 in EKF400v2. The areas left blank in the Mediterranean are regions where monthly precipitation amount is less than 10 mm in the climatology.

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18.8
Towards a conditional representation of heat wave probability in large ensemble climate model data

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Single-model initial condition large ensembles provide novel opportunities to study the physical drivers and risks of large-scale climate extremes in a changing climate. The probability of extremes such as weekly heatwaves, here quantified as seven-day maximum temperature (Tx7d), are usually approximated with a general extreme value distribution that is stationary or accounts for non-stationarity of a warming climate. However, estimating the occurrence probability of very rare climate extremes in the presence of large internal variability further benefits from the integration of process-based covariates characterising the preceding and concurrent climate conditions both at global and local scale.

We use more than 6000 years of stationary pre-industrial and 2xCO_2 control simulations and an ensemble of 84 transient historical and RCP8.5 simulations performed with the Community Earth System Model CESM1.2 to develop and robustly test methods of quantifying extreme events under a broad range of climatic conditions. The generalised extreme value distribution is parametrised such that it can account for changing environmental circumstances, ranging from large-scale thermodynamic non-stationarity due to climate change, regional-scale dynamic forcing such as atmospheric blocking, or local land-surface conditions such as soil moisture deficits. Fields of covariates are integrated using approaches from statistical learning theory, accounting for the spatio-temporal correlation inherent in climate data. How well the respective statistical model generalises is tested with respect to further simulations of the US CLIVAR Working Group on Large Ensembles. The relevance of different covariates can inform both detection and attribution as well as risk assessment how their respective statistical models can be further refined to account for the influence of physical drivers under present and future climate conditions.

P 18.1
Global monthly sea surface temperature and sea ice reconstruction for historical simulations

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Variability in Sea Surface Temperature (SST) is one of the prime sources of intra-annual variability, and also an important boundary condition for Atmospheric General Circulation Models (AGCMs). In many AGCM simulations, SST and Sea Ice Concentration (SIC) are prescribed. While SSTs are specified according to observations available in recent period of instrumental records (1850 – present), SIC depends on climatological averages with less variability prior to the inception of satellite measurements. This limits our understanding of large-scale climate variations in the past.
In this study, we augment multi-proxy reconstructed annual mean temperature of Neukom et al. (2019) with intra-annual variability from HadISST (v2.0), for 850 years (1000 – 1849). Intra-seasonal variability, such as the phase-locking of El-Nino Southern Oscillation, Indian Ocean Dipole and Tropical Atlantic SST indices to annual-cycle, are utilized. The intra-annual component of HadISST and SST indices estimated from the multi-proxy reconstructed annual mean, are used to develop grid- based multivariate linear regression models using the Frisch-Waugh-Lovell theorem, in a monthly stratified approach. Furthermore, we introduce a scaling technique to ensure homogeneous mean and variance, similar to that of the target. SST observations obtained from ship measurements by ICOADS before 1850, will be integrated in an off-line data assimilation approach.
Similarly, we reconstruct SIC via analogue resampling of HadISST SIC (1941 – 2000), for both hemispheres. We pool our analogues in four seasons, comprising of 3 months each, such that for each month within a season, there are 180 possible analogues. The best analogues are selected based on correlation coefficients between reconstructed SST and its target.

P 18.2
The overlooked hot summer of 1947

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During the summer of 1947, western Europe experienced several heat-waves and severe drought conditions, which led to considerable socio-economic impacts on a society that was only recovering from the second world war. Despite this, the summer of 1947 has only received little attention regarding its temperature records and atmospheric conditions. Between June and September 1947, in total, five hot periods were registered, which show a remarkable spatial consistency in their onsets and ends. A comparison of indices for maximum temperature based on station data for western Europe in the period 1930-2015 shows that the year 1947 ranks among the top three warmest summers for most of the indices (e.g. mean temperature anomaly, number of days above the 95th percentile, daily heat-wave magnitude index) together with the years 2003 and 2015. However, regarding indices based on minimum temperature, the summer of 1947 appears less extreme. Meteorological conditions were very conducive to the development of hot periods throughout the summer. All five hot periods were related to blocking situations, which occurred during June- September 1947 by a factor of two more frequently than during a usual summer. A heat budget analysis of the levels 1000hPa to 500hPa shows, that the high temperatures of the first four hot periods were rather related to diabatic processes than to advection of warm air. This is however not the case for the last hot period in September. Further, we put the summer of 1947 into a climatological perspective regarding drought conditions.

P 18.3
Can we build 260-year-long instrumental climate records for Bern and Zurich?

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Long climate records are fundamental to understand past multidecadal variability. In Europe, regular meteorological measurements of temperature and pressure (and less commonly, precipitation and humidity) began in the 18th century in most countries and allow climatologists to build climate series spanning over two centuries. Switzerland is no exception and such series were published in the past for Basel and Geneva for daily temperature means.

There exist, however, records for numerous other Swiss cities (e.g., Aarau, Bern, Schaffhausen, St. Gall, Zurich) that span back to the 18th or early 19th century and that have not been used by modern researchers. In the past years these records were collected and digitised at the University of Bern in the framework of multiple projects, involving a considerable amount of time-consuming archive and transcription work.

Here we show the details and the progresses made for the temperature records of Bern and Zurich, both starting around the year 1760, and describe the challenges involved in building homogeneous 260-year-long climate series, i.e. 100 years longer than currently available for those cities.

P 18.4
Unlocking weather data of the Societas Meteorologica Palatina: a daily reconstruction of the severe winter 1788/89.

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For some decades now, early instrumental observations have increasingly played an important role in climate research. Not only have they shown enormous potential in reconstructing past changes in temperature, pressure, and precipitation, but they also allow for daily-to-decadal variability and extremes to be studied in great detail, particularly for 17th- and 18th-century Europe. The *Societas Meteorologica Palatina* (SMP), or Palatine Meteorological Society, stood out as one of those few networks that efficiently managed to control its members, integrating, refining and publishing measurements taken from numerous stations around Europe and beyond (Kington, 1974). According to T.S. Feldman, the work performed by the SMP "was not surpassed for three-quarters of a century" (Feldman, 1990: p. 154).

A comprehensive understanding and rescue of this early instrumental weather data has great potential for today's climate scientists who wish to explore pre-industrial climatic variations and extreme weather events. The aim of this study is therefore, in a first part, to create an inventory listing the availability and extent of data coverage by the stations that belonged to the SMP's network. The data in the printed records is then digitised; with the help of the Copernicus Climate Change Service (C3S) for Data Rescue (Brönnimann, 2018) raw temperature and pressure observations from a selection of stations are converted and quality-controlled; finally, the time series are homogenised. With these steps the observations are now ready for scientific use.

The second part of the study aims to reconstruct daily temperature and pressure fields for Europe for the extreme winter 1788/89 on a 0.1x0.1 grid using the historical station observations from the SMP and an analogue resampling method (ARM) (see Pfister, 2018). Evaluation experiments will show the skill of the reconstructions, which in turn will give insight into the dynamics that led to the extreme winter.

This statistical reconstruction is one of many ways early instrumental data can be used to explore past climate and weather changes. From the inventory, the generation of time series, to the reconstructed spatial fields, the present study illustrates the full process and potential of climate data rescue. From raw historical measurements to informative statistical reconstructions.

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P 18.5
Past Climate Variations in Early Instrumental Data

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There is a growing need for past weather and climate data to support science and decision-making. This poster or presentation will describe the compilation of global instrumental climate data, with a focus on the 18th and early 19th centuries. In addition to available repositories (GHCN, ISTI, CRUTEM, Berkeley Earth, HISTALP) many of the older series have been digitized within the project. The product will form the most comprehensive global monthly climate data set, encompassing temperature, pressure, and precipitation. These data will be homogenized and analyzed with respect to climate variability and they be assimilated into global climate model simulations to provide monthly global reconstructions.

This is a contribution to the ERC PALAEO-RA-project (https://www.palaeo-ra.unibe.ch/)

P 18.6
Climate change in the vineyard: perspectives for pest species in the region of Neuchatel

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Global warming increases the need for local climatic studies in wine-producing areas. Winegrowers have to develop strategies to adapt their activities to new climatic conditions and to their various effects on vine culture. Among them, distribution and population dynamics of pest species are likely to change. New species could reach the temperate regions, and some native species could create more damages than previously in the vineyards. In Western Europe, the distribution of the American grapevine leafhopper *Scaphoideus titanus* has been observed to shift northwards during the last decades (Boudon and Maixner 2007). Plurivoltin species such as the European grapevine moth *Lobesia botrana* could produce more generations per year (Gutierrez et al. 2018), creating potentially more damages on grapes. To help winegrowers, it is crucial to lead research at local scale, taking into account microclimatic specificities of the vineyards (Mozell and Thach 2014).

In this study, we examine temperature trends during the growing season in the region of Neuchatel and their potential impacts on major vine pest species. We focus on the American grapevine leafhopper and on the European grapevine moth. The American grapevine leafhopper is already established in the Lake Geneva area and could soon reach the Neuchatel area, while the European grapevine moth is already present in the Neuchatel vineyard. We use temperature data over the last 40 years (1980-2019) and two climatic scenarios to assess present suitability for pest development and the perspectives for the next decades.

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