

Topics for BSc or MSc theses in Climatology, Spring Semester 2021

Forest Fires

Title	Forest fire and its relationship to large-scale atmospheric circulation
Level	MSc
Prerequisites	interest in large-scale atmospheric dynamics and extreme weather, interest in scientific and statistical programming (python/R)
Methods	Statistical analysis in python/R
Description	<p>Forest fires are becoming more frequent and devastating with climate change. It is therefore of great interest to understand the occurrence of fire and its main drivers. Since the large-scale atmospheric circulation modulates the day-to-day surface weather, it could be a potential dynamical driver for the occurrence of increased fire risk. The goal of this project is to investigate the spatiotemporal characteristics of forest fire and its relationship to large-scale atmospheric flow patterns such as weather regimes, atmospheric blocking and anticyclones. In a first step, it is investigated how observed forest fires and situation of increased fire danger in different European regions are linked to weather regimes and blocking using ERA5 reanalysis data. Based on your interests, it is envisaged to either i) investigate the role of weather regimes as source of predictability on subseasonal to seasonal time-scales or ii) expand the analysis to other regions (for example Australia or North America).</p> <p><i>References</i> Di Giuseppe, F., Pappenberger, F., Wetterhall, F., Krzeminski, B., Camia, A., Libertá, G., & San Miguel, J. (2016). The Potential Predictability of Fire Danger Provided by Numerical Weather Prediction, <i>Journal of Applied Meteorology and Climatology</i>, 55(11), 2469-2491 Grams, C.M., Beerli, R., Pfenninger, S., Staffell, I. and Wernli, H. (2017). Balancing Europe's wind-power output through spatial deployment informed by weather regimes. <i>Nature Climate Change</i>, 7(8):557-562. Pfahl, S., and Wernli, H. (2012). Quantifying the relevance of atmospheric blocking for co-located temperature extremes in the Northern Hemisphere on (sub-)daily time scales, <i>Geophys. Res. Lett.</i>, 39 Turco, M., Jerez, S., Doblas-Reyes, F.J. et al. (2018). Skilful forecasting of global fire activity using seasonal climate predictions. <i>Nat Commun</i> 9, 2718 Vitolo, C., Di Giuseppe, F., Barnard, C. et al. (2020). ERA5-based global meteorological wildfire danger maps. <i>Sci Data</i> 7, 216.</p>
Supervisor	Olivia Romppainen-Martius, Stefan Brönnimann, stefan.broennimann@giub.unibe.ch
Advisor	Daniel Steinfeld and Christian Grams (KIT)

Title	The „Calanda Fire“
Level	MSc
Prerequisites	R, programming, climatology, historical interest
Methods	Case study, statistical analyses, modeling
Description	<p>In addition to statistical analyses (see topic above), rare events such as forest fires also require in-depth case studies. The arguably largest forest fire in recent Swiss history (in terms of area burnt) was the „Calanda fire“ in 1943, ignited by military shooting. The goal of this project is to study the meteorological and environmental conditions that led to this fire. In addition to historical reanalysis data meteorological data from Switzerland, it is envisaged, depending on the level and interest of the student, to use the numerical model „WRF-Fire“ to simulate this episode. This would contribute towards establishing WRF-Fire as a modeling tool in Switzerland.</p>
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Advisor	

Title	Public perceptions of urban heat-stress
Level	BSc or MSc (Deutsch oder Englisch)
Prerequisites	GIS (basics); R (basics); climatology
Methods	Spatial interpolation and analyses in GIS, statistical analyses,
Description	Understanding people's awareness about climatic risks is a key aspect for the design of adequate, target-specific communication strategies. Although urban heat island effects have been studied for more than 200 years, it is unclear how aware the general public in specific cities is about the problem. In order to reveal lay people's conceptions and mental maps of urban heat variability within the city of Bern, a pilot study consisting of short interviews with pedestrians was conducted during a heatwave in summer 2019. This thesis aims at comparing the hereby assessed mental maps and questionnaire data with maps of urban heat island intensities (air temperature). This will include the digitisation of the analogue maps, spatial interpolation and analyses in GIS, as well as – if possible – basic statistical analyses.
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Advisor	Moritz Gubler, moritz.gubler@giub.unibe.ch Moritz Burger, moritz.burger@giub.unibe.ch

Title	Validation of Bern's local climate zone classification
Level	BSc (Deutsch oder Englisch)
Prerequisites	GIS (basics); interest in urban climatology
Methods	Field work, basic analyses and visualizations in GIS
Description	The local climate zone (LCZ) framework is globally used in urban climatology to describe local-scale characteristics of urban structures and surfaces. It serves as a basis for various applications and analyses regarding the urban atmospheric processes such as urban heat island assessments. For Bern, a LCZ classification has been recently conducted based on an automatic satellite image processing tool. In order to evaluate the quality and applicability of the resulting LCZ map, the task of this thesis will be to validate it against different data sources. Besides analyses of existing land cover data (i.e. vegetation), the potential BSc-student will be asked to assess a set of urban structure characteristics (i.e. building types) at multiple locations across the city of Bern and compare it to the LCZ classification. In a second step, potential discrepancies will be identified and improved in order to retrieve a reliable LCZ map visualized in GIS.
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Title	Urban heat island mapping from space
Level	MSc (Deutsch oder Englisch)
Prerequisites	Geoprocessing/Remote sensing, climatology
Methods	Satellite remote sensing
Description	Urban heat islands have become a topic of major interest in climate change adaptation planning, which generates the need for high-resolution maps of the urban heat island. The climatology group runs a dense monitoring network in the city of Bern, from which heat maps have been generated. It also uses numerical models. Another methodology is to use satellite remote sensing data. Various sensors deliver surface temperature products. However using satellites requires a trade-off between high temporal and high spatial resolution. The goal of the thesis is to develop a method to map surface temperatures for the city of Bern using satellite remote sensing data. By nesting Landsat-8 (which has a high spatial resolution) into AVHRR (which has a high temporal resolution), sequences of surface temperature maps will be constructed.
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Title	Assessing the effects of vegetation on urban heat island intensity of Bern
Level	BSc or MSc (Deutsch oder Englisch)
Prerequisites	Statistics and statistical modelling (R or equivalent); basics in GIS (QGIS or ArcGIS) and remote sensing techniques; background in meteorology and/or climatology; interest in urban climatology
Methods	Statistical analyses, numerical modelling, visualization in GIS
Description	Urban vegetation is one of the key factors driving intra-urban air temperature variability. In order to mitigate future urban heat excesses and related heat stress for the urban population during summertime, a detailed understanding of the effects of the so-called “green infrastructure” on spatiotemporal air temperature variability is crucial. This thesis aims at contributing to this by using high-resolution vegetation data from different sources (e.g. city administration, satellite data) and statistically comparing it with urban air temperatures assessed by the city-wide heat monitoring network in Bern. In detail, the task will be to calculate and visualize a set of vegetation indices (e.g. NDVI) based on remote sensing data, combine it with other vegetation data sources, and statistically analyse its effects on the urban heat island intensities. The potential MSc or BSc candidate is sought to have basic experience in statistical analyses of climatological/ meteorological data, basic skills in using GIS, as well as an interest in interdisciplinary challenges.
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Title	Connecting urban heat island perspectives: From surface to canopy layer assessments
Level	BSc or MSc (Deutsch oder Englisch)
Prerequisites	Solid background in statistics (R or equivalent); basics in GIS (QGIS or ArcGIS) and remote sensing techniques; interest in urban climatology
Methods	Statistical analyses and modelling, analyses of remote sensing data and land-cover data in GIS
Description	Since 2018, the Climatology Group maintains an urban heat monitoring network consisting of 65–85 low-cost temperature sensors within and around the city of Bern to capture the spatiotemporal variability of air temperatures within the urban canopy layer (more information: https://www.geography.unibe.ch/research/climatology_group/research_projects/urban_climate_bern/index_eng.html). Despite the relatively high density of the network, such “fixed” measurement approaches lack of information about temperature variability in between sensor locations. Surface air temperature assessments by high-resolution remote sensing techniques may fill this gap and linking the two data sources may thus contribute to a more detailed understanding of fine-scaled urban heat stress in Bern. The main goal of this thesis will be to develop and test statistical transfer functions being able to inter-connect air temperature data assessed by the measurement network and surface air temperatures retrieved by the high-resolution (ca. 100 m) satellite data. In detail, the task will consist of using statistical techniques (i.e. regression modelling) to predict urban air temperature variability with a set of different land-cover variables, building parameters, and satellite-based surface temperature data. The potential candidate is sought to have experience in statistical analyses of climatological/meteorological data, basic skills in using GIS, as well as an interest in interdisciplinary challenges.
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Title	Historical Swiss meteorological series
Level	preferably MSc (several theses)
Prerequisites	Historical interest or background, statistics, R, climatology
Methods	Historical analysis, archive work, data processing, statistical analyses,
Description	Meteorological observations in Switzerland prior to the start of the „official“ network in December 1863 have never been systematically compiled until recently. Over the past four years we have imaged and digitised many of these. The task of these MSc or BSc theses (each thesis will cover one series) is to assess, quality check and evaluate the time series. This includes compiling metadata, such as descriptions and literature on these series, or comparisons to other series. The choice is between two very interesting series: The short series of Johann Heinrich Lambert in Chur, 1749-1756, one of the oldest Swiss records (an perhaps later measurement of Lambert in Berlin) and the long record of Johann Christoph Schalch in Schaffhausen, 1794-1845.
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Advisor	Yuri Brugnara (yuri.brugnara@giub.unibe.ch)

Title	The Italian precipitation network of Toaldo
Level	preferably MSc
Prerequisites	Historical interest of background, Italian language, statistics, R, climatology
Methods	Historical analysis, archive work, data processing, statistical analyses,
Description	In the late 18th century, Giuseppe Toaldo, Director of the Astronomical Observatory in Padua, built up a precipitation measurement network in Italy that operated between 1778 and 1810. The data from this network have been digitised in the PALAEO-RA project. The aim of this thesis is to document the network and analyse the precipitation data. During the late 18th century, several other networks existed in Europe, such that a detailed view of climate becomes possible.
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Title	A Historical Weather Diary from David Grebner, Wroclaw, 1692-1710
Level	MSc
Prerequisites	Historical interest or background, statistics, R, climatology
Methods	Historical analysis, archive work, data processing, statistical analyses,
Description	Weather diaries may contain categorisable or even quantifiable information that may be used for weather reconstruction. This thesis deals with a weather diary from David Grebner from Wroclaw, 1692-1710 (which can be compared to one from Nürnberg, 1695-1704). The diary should be described and contextualised. Quantifiable information (e.g. wind direction, rain/norain) will be digitised, for others such as cloud cover a categorisation will be sought. Eventually, this information will be combined with other available information to produce daily weather type reconstructions using a machine learning approach.
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Title	Weather reconstruction using machine learning
Level	MSc
Prerequisites	Statistics, R, climatology
Methods	Data processing, statistical analyses,
Description	The goal of this work is to reconstruct day-to-day weather for severe winters and summers in the past such as the winter 1708/9, the winter 1684/5 or the summer of 1695. Sparse instrumental measurements will be combined with weather diaries and wind observations from ships. Eventually, in collaboration with the DKRZ in Hamburg, a machine learning approach will be used to reconstruct weather maps for every day. This thesis will focus on training data sets towards that aim, i.e., generate the same data in a period in the more recent past for which daily weather fields are available.
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Meteorology

Title	Coding of a Rossby wave breaking detection algorithm in Python
Level	MSc
Prerequisites	interest in large-scale atmospheric dynamics and extreme weather, interest in scientific programming (python/R)
Methods	Python programming
Description	<p>Breaking Rossby waves can be associated with extreme surface weather, in particular heavy precipitation. They also exert a strong influence on the jet streams, affecting both the position and the strength of the jets. The goal of the MSc thesis is to translate an existing Rossby wave breaking detection code from Fortran to Python and to apply it to a climate data set (e.g., the new CMIP6 data) to analyse the frequency of Rossby wave breaking and future changes. This project is ideal for someone who enjoys programming and would like to deepen their Python programming skills.</p> <p>References:</p> <p>Martius, O., E. Zenklusen, C. Schwierz, and H. C. Davies, 2006: Episodes of Alpine Heavy Precipitation with an Overlying Elongated Stratospheric Intrusion: A Climatology. <i>International J. Climatol.</i> , 26, 1149-1164.</p> <p>de Vries, A., 2020: A global climatological perspective on the importance of Rossby wave breaking and intense moisture transport for extreme precipitation events. <i>Weather and Climate Dynamics Discussions</i>.</p> <p>Barnes, E. A., and D. L. Hartmann, 2012: Detection of Rossby wave breaking and its response to shifts of the midlatitude jet with climate change. <i>Journal of Geophysical Research-Atmospheres</i>, 117.</p>
Supervisor	Olivia Romppainen-Martius
Advisor	Dr. Daniel Steinfeld

Climate Dynamics

Title	Observed interannual and decadal variability in historical SST reconstruction
Level	BSc (Deutsch oder Englisch) or MSc
Prerequisites	Climatology, Statistics, Python or R, CDO
Methods	Climate Data Analysis
Description	<p>Recently reconstructed global temperature by the PAGES2k consortium does not only provide a global coverage of the field in the past 2000 years, it also gives an indication of the unprecedented interannual and decadal climate variability within this period. The oceans play an important role in climate variability, driving atmospheric circulations on different timescales and providing a basis for numerical weather simulations.</p> <p>The aim of this thesis is to show the variability modes including the evolution of global warming in different time-slices, and compare frequency of occurrences within the period. This would be carried out using reconstructed SSTs from different statistical methods, in an inter-basin approach, which ignores the teleconnection patterns including those lagged in time. The study will consider past variability in the North Atlantic, Equatorial Atlantic, North Pacific, Equatorial Pacific, South Pacific, South Atlantic, Indian Ocean and the Southern Ocean. Furthermore, in recent periods where instrumental records are available, we would compare the reconstructed SSTs with observations. Influence of the number of available proxies in different basins within each time-slice, on SST variability in space and time would also be investigated.</p>
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Title	Evaluation of long climate series from observations and reconstructions
Level	BSc (Deutsch oder Englisch) or MSc
Prerequisites	Statistics, R, meteorology or climatology
Methods	R time series analysis
Description	A recent climate reconstruction based on data assimilation methods provides global monthly fields of temperature, precipitation and other parameters back to 1600. This was based on long measurement series, weather diaries and tree rings. In the mean time further long measurement series have become available. The goal of this BSc thesis is to compare these long series with the corresponding series from the reconstructions. The analysis will be used to address inhomogeneities in the series and for the evaluation of the reconstruction.
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Advisor	Prof. Dr. Stefan Brönnimann, room 506, stefan.broennimann@giub.unibe.ch

Title	How well is Russian snow represented in updated climate reconstructions?
Level	BSc (Deutsch oder Englisch)
Prerequisites	Statistics, R, meteorology or climatology
Methods	R time series analysis
Description	A recent climate reconstruction based on data assimilation methods provides global daily fields of snow depth and snow cover back to 1806. A good snow representation is important for hydrology, the surface albedo and seasonal temperature evolution. The goal of this BSc thesis is to compare the snow representation of this reconstruction with previous efforts and independent long snow time series from the Russian Meteorological Service. This analysis will be used to address strength and weaknesses of the snow reconstruction and will help future studies to argue for or against using this data set.
Supervisor	Dr. Martin Wegmann
Advisor	Prof. Dr. Stefan Brönnimann, room 506, stefan.broennimann@giub.unibe.ch

Title	Impact of spring sea surface temperature on European summer climate – A comparison between weather models and tree ring isotopes
Level	MSc
Prerequisites	Interest in climate extremes, teleconnections, climate statistics and a bit of programming
Methods	Large Climate (Gridded) Data Analysis,
Description	Data from a European oxygen isotope network from tree-rings showed a connection of Atlantic and Pacific sea surface temperatures in spring with the following European summer climate. With 400 years of this biologically recorded summer climate, we are confident enough to explore this relationship further, to understand European summer extremes (such as heatwaves) better. The goal of this thesis is to investigate this teleconnection in more detail, using brand new weather/climate model data that predict summer climate coming out of spring.
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Advisor	Dr. Martin Wegmann

Title	Visueller Geographieunterricht anno 1900: Die Glasdiasammlung des GIUB
Level	MSc
Prerequisites	Interesse an Disziplingeschichte und historischem Bildmaterial
Methods	Quellen- und Literaturarbeit
Description	Das GIUB verfügt über eine Sammlung von gegen 10'000 Glasdias aus der Zeit Ende 19. Jh./Anfang 20. Jh. Die Glasdias zeigen Landschaften, Städte, geomorphologische Formen und vieles mehr und wurden im Unterricht verwendet. Die Sammlung wird zur Zeit vollständig digitalisiert. Begleitend dazu wird mit einem Citizen Science Projekt ab Sommer 2021 versucht, zusätzliche Metadaten zu den Bildern zu erhalten. Diese Masterarbeit (in Zusammenarbeit mit der Universitätsbibliothek) soll die Glasdiasammlung wissenschaftlich beschreiben und in einen disziplingeschichtlichen und institutsgeschichtlichen Kontext stellen.
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Advisor	Universitätsbibliothek

Title	Colonial-era climate data, ownership, and restitution
Level	MSc
Prerequisites	climatology, science studies, postcolonial theory (specifics will depend on the choice of topic)
Methods	Qualitative methods including: archives work, policy document analysis, expert interviews
Description	<p>Studying past global climate is considered important for better constraining current and future climatic changes. Yet studying past global climate is based - among other sources - on colonial-era climate data from European colonies. These data are accessible physically in European archives, and over the past decades European climate scientists have digitised these data to make use of the information.</p> <p>In recent years, there have been growing awareness and efforts to redress historical damages from colonialism. For example, in the art world, this has been manifested in efforts to catalog and return colonial-era art from European and North American museums.</p> <p>The topic of this thesis is how to think about colonial-era archive climate data, their ownership, and potential restitution. For example, to what extent / in what ways could the debates and experiences of colonial-era art restitution inform colonial-era climate data? In what sense do concepts such as data ownership and restitution apply when the data concern the natural world?</p> <p>The thesis will develop a theoretical framework to understand the problem of colonial data using different approaches, potentially including science and technology studies and postcolonial studies. It will also explore a specific case study related to questions of colonial data. The research approach may include document analysis of European meteorological agency policies or international agreements; and relevant actor and expert interviews.</p> <p>Brönnimann, S, Wintzer, J. Climate Data Empathy. <i>WIREs Clim Change</i>, 10 (2019), e559. https://doi.org/10.1002/wcc.559.</p> <p>Lehmann, P. Average Rainfall and the Play of Colors: Colonial Experience and Global Climate Data. <i>Studies in History and Philosophy of Science Part A, Experiencing the Global Environment</i>, 70 (2018): 38–49. https://doi.org/10.1016/j.shpsa.2018.05.007.</p> <p>Mahony, M., Endfield, G. Climate and colonialism. <i>WIREs Clim Change</i> 9 (2018), e510. https://doi.org/10.1002/wcc.510</p>
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