Weather reconstruction and application

Long-term changes in spring weather impacts since 1763

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OESCHGER CENTRE CLIMATE CHANGE RESEARCH

Context

- Historical sources report on past climate and weather events that had considerable impacts on society. Studying such events is however often hampered by a lack of spatially and temporally complete weather data.
- For Switzerland, we reconstructed daily temperature and precipitation fields based on early instrumental data for a period from 1763 to 2020 using an analogure resampling approach and post-processing.
- With these fields, we calculate indices that are often closer to impacts and thus, we can relate them to historical sources that may be more widely available for the late 18th and 19th century.

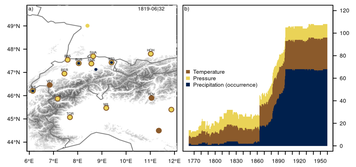
Swiss weather reconstruction

The reconstruction of the daily temperature and precipitation fields is based on three steps:

1 Preprocessing station data

Historical station data from 1763 to 1960: qualtiy control, homogeniztation, deseasonalizing

Reference station data from 1961 to 2020: gap filling, detrending, climate offset, deseasonalizing



a) availabile observations in 1819, b) changes in number of observations throughout reconstruction period.

2 Calculating best analogue days based on Gower distance/RMSE, weather types, and seasons

Resamplin fields from the Meteoswiss 1x1km daily data sets[1,2] according to best analogue days

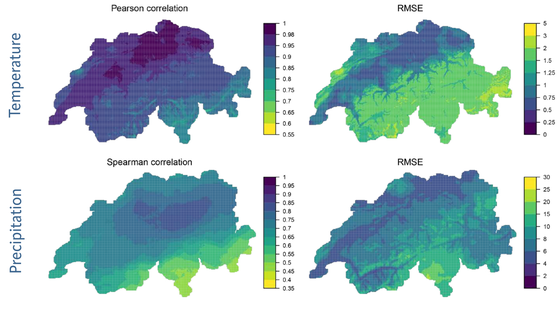
3 Post-processing of resampled fields

Ensemble Kalman fitting for temperature - quantile mapping for precipitation

get article and data:

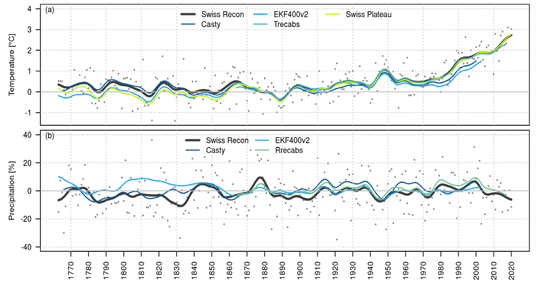
RECONSTRUCTED FIELDS FROM 1763 TO 2020

Cross-validation of reconstruction method



Cross-validation results for annual values from 1961 to 2020 for a network of 32 stations as it is found around 1819. The cross-validation is conducted based on a reconstruction of the reference period by leaving out +/- 5 days around the day of interest.

Long-term assessment of reconstruction

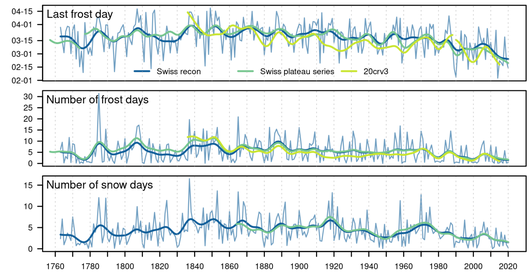


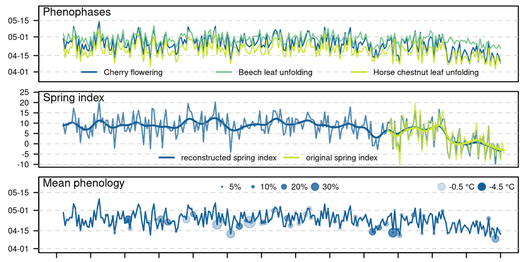
Gaussian smoothed annual anomalies of (a) temperature and (b) precipitation (sigma = 3 years) for the area mean of the Swiss reconstruction, the Swiss plateau series[3], the Casty reconstruction[4], and EKF400[5]. Grey dots show the non-smoothed values. Anomalies are calculated with respect to 1871-1900.

Climate indices & phenophases

Climate indices are calculated for the spring months March to April for the Swiss reconstruction, the Swiss plateau series[3], and 20crv3[6]

- All indices show a rapid decrease at the end of the 20th century





Circles in the last row show frost events after the mean onset of phenology. The shading indicates the average negative accumulated temperature, the size of the circle indicates the percentage of affected area in the Swiss Plateau.

Phenophases are reconstructed with process-based models calibrated with the Swiss phenology network[7]

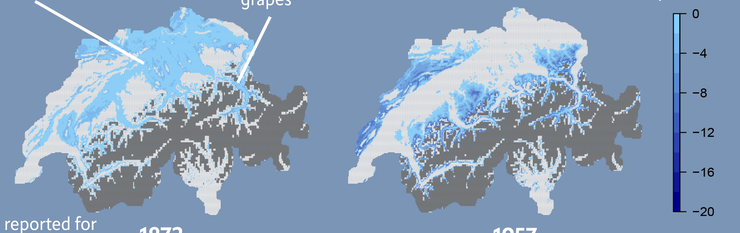
- A spring index derived from the phenophases shows that only few springs started as early as after the abrupt jump around the late 1980s
- Frost events after the mean onset of phenology occurred throughout the 258 years

Late frost events

Sursee: complete damage of cherry tree, large damage on other fruit trees[8]

Marschlins: complete damage of walnut trees, large damage on grapes[8]

~ 75% of apple and pear harvest across Switzerland destroyed[9]



Late snow reported for various locations[8]

1873

1957

Accumulated negative temperatures below 0°C from the mean onset of phenology up to 60 days or 31st of July

Conclusions

- The daily data allows for new evaluations that have so far not been possible.
- The reconstruction demonstrates again the steep climatic changes of the last decades compared to the previouse centuries for climate indices as well as reconstructed phenology.
- Historical sources are a valuable tool to create long-term data set, but also to provide independent qualitative comparison.

[1]Meteoswiss (2021a), Documentation of MeteoSwiss Grid-Data Products. Daily Precipitation (final analysis): RhiresD.
[2]Meteoswiss (2021a), Documentation of MeteoSwiss Grid-Data Products. Daily Mean, Minimum and Maximum Temperature: TabsD.
[3]Brugnara et al. (2022), Pre-industrial temperature variability on the Swiss Plateau, Clim. Past, 18, 2357–2379.
[4]Casty et al. (2007), A European pattern climatology 1766–2000, Clim Dyn, 29, 791–805.
[5]Valler et al. (2022), An updated global atmospheric paleo- reanalysis covering the last 400 years, Geosci. Data J. ,9,89–107.
[6]Slivinskiki et al. (2019), Towards a more reliable historical reanalysis: Improvementsfor version 3 of the Twentieth Century Reanalysis system, QJRMeteorolSoc. , 145, 2876–2908.
[7]Güsewell et al. (2018), Representativeness of stations and reliability of data in the Swiss Phenology Network, Technical Report MeteoSwiss, 267, 100 pp.
[8]MZA (1873) Annalen der Schweizerisch Meteorlogischen Zentralanstalt, 10. Jahrgang, Zurich.
[9]Schweizerisches Bauernsekretariat (1958), Statistische Erhebungen und Schätzungen auf dem Gebiet der Landwirtschaft, 35. Jahresheft, Brugg.