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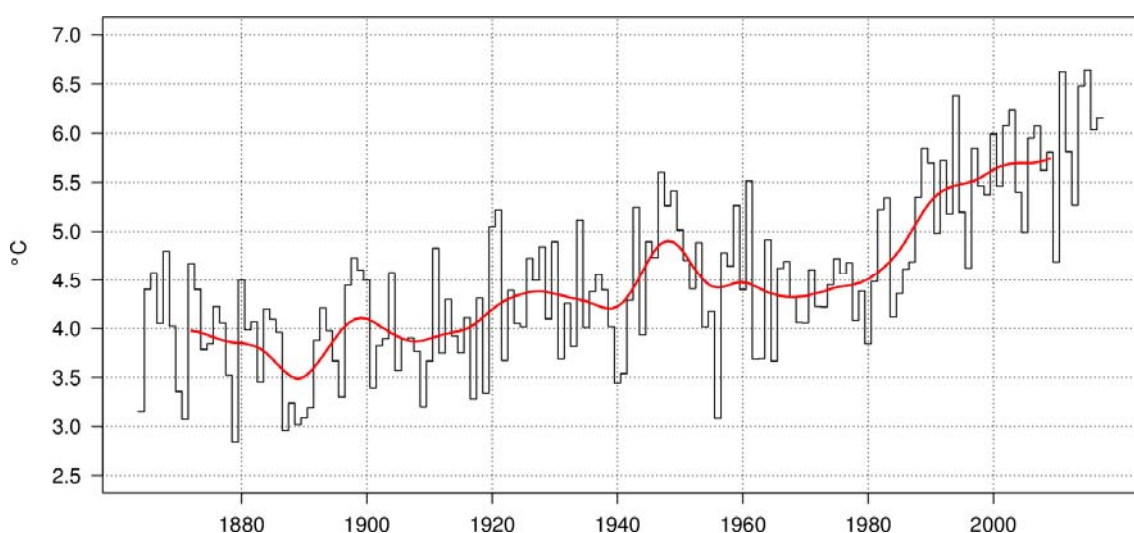Documentation from MeteoSwiss data products

Swiss temperature mean

Figure 1: Annual Swiss temperature mean from 1864 to 2017. Shown are the individual annual values (black) and the general development smoothed with a 20-year low-pass filter (red).

Measured parameter
Average value across all of Switzerland of the monthly temperature mean (in degrees Celsius measured at 2 m above the ground). Mean values for various periods (seasonal, semi-annual, annual) are formed on the basis of the monthly values.

Application
Climate monitoring, categorisation of individual values in long-term development.

Overview
The Swiss temperature mean describes the temperature measured on average across the entire area of the country and at the various altitudes of Switzerland. The data from different measuring stations is combined depending on how representative it is. The Swiss temperature mean is used to analyse and communicate changes in temperature in Switzerland over a period of many years.

Data basis
Data from the measuring stations in the SwissMetNet is used to calculate the Swiss temperature mean. The SwissMetNet currently consists of 160 automatic land-based measuring stations of MeteoSwiss. For climatological applications, 29 stations were selected from this total that have series of measurements extending back as far as 1864 and pooled in the Swiss National Basic Climatological Network (Swiss NBCN; Begert et al., 2007). The determining criteria for selecting the NBCN stations were the length of the series of measurements, spatially representative distribution across Switzerland and long-term availability of various measured parameters, but also the future prospects of the location and data quality. As a result of compromises that had to be made during the selection process, continuous temperature measurements are available from only 19 NBCN stations from as far back as 1864. The Swiss temperature mean is formed on the basis of the homogeneous measurement series of these 19 stations. It is important to use homogeneous data

in the context of developments and climate monitoring over a period of many years. Homogeneous series of measurements are adjusted for the effects of station relocations, changes in measuring instruments and other changes in the measurement conditions. The methodology used at MeteoSwiss for homogenisation is documented in Begert et al. (2003, 2005).
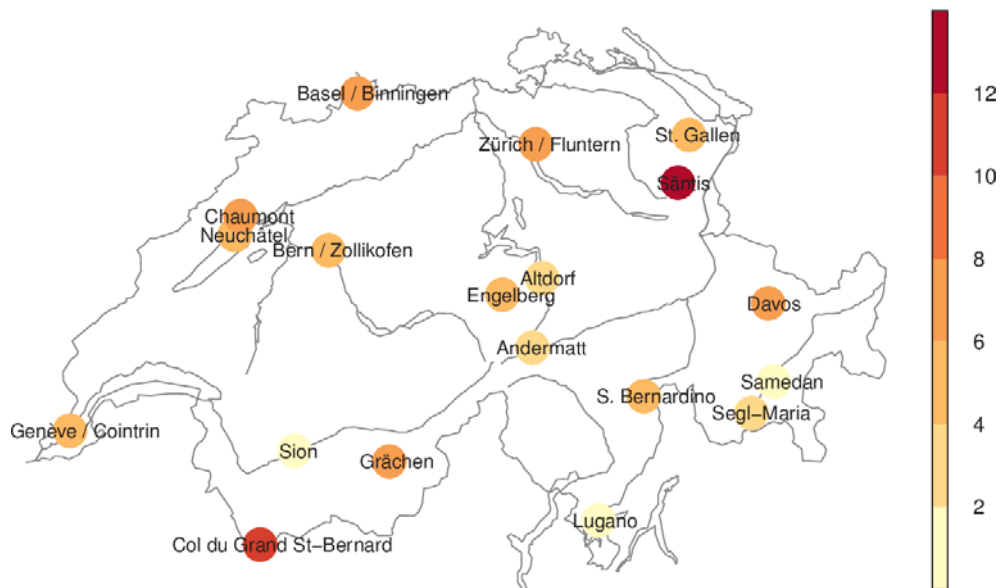

Figure 2: Measuring stations in the Swiss National Basic Climatological Network with continuous temperature measurements since 1864 and their weighting (as a %) in the Swiss temperature mean.

MeteoSwiss uses the SwissMetNet measurements to calculate spatial analyses of temperature across Switzerland on a grid with a resolution of 2 km. Since 1981, this grid data has a consistently high level of accuracy due to the constant and relatively high number of stations. The grid data for the monthly mean temperature from 1981-2014 was used as a reference to calibrate a statistical method which estimates a spatial mean for Switzerland based on the data from the existing measuring stations. The grid data and the methodology of the grid are described in the respective product description on the MeteoSwiss website (www.meteoschweiz.ch) and in Frei (2014).

Method

The Swiss temperature mean of a month is estimated by means of linear combination (weighted mean) of the temperature measurements at 19 NBCN stations. The stations used as well as the coefficients (weightings) are independent of the time. The coefficients were determined using the statistical methods of the principle components analysis and multiple linear regression, whereby the spatial mean values of the temperature grid in the period 1985 to 2004 served as reference values (target value of the linear regression). To eliminate the effect of the annual cycle, the linear model was modelled to the mean value of the period 1981-2010 for the temperature deviations.

It was possible to remove the collinearity of the explanatory variables (station measurement series) with the principle components analysis and thus limit the number of explanatory variables in the regression model. The linear relationship between the retained principal components and the grid mean was determined using the multiple regression. The weightings of the individual stations were derived from the coefficients of the regression model and the loadings of the principal component analysis. The Swiss temperature mean is a weighted mean of station measurements which estimates the grid mean as closely as possible.

Switzerland is divided into different climate regions. In terms of temperature development over many years, the differences between the north side of the Alps and the south side as well as the different altitudes are interesting. A temperature mean is therefore calculated for the following three subregions using the same methodology as for all of Switzerland: north side of the Alps below 1000 m, north side of the Alps above 1000 m, south side of the Alps. The south side of the Alps includes, in addition to the Canton of Ticino, the Simplon region and the southern Grison valleys. All existing 19 stations are also included for the subregions. If there is only a minor effect on a subregion, the respective weightings are very low. Negative weightings due to inverse spatial patterns of the temperature distribution in Switzerland are possible. A detailed description of the methodology used to calculate the Swiss temperature mean is published in Begert & Frei (2018).

Target audience	See Application
Accuracy and interpretation	From the period with available, high resolution grid data from 1981 to 2014, only 20 years were used to determine the weightings of the measuring stations. The remaining 14 years were available to assess the accuracy of the Swiss temperature mean estimated from the stations compared to the spatial mean of the grid data. It is shown that the monthly values of the Swiss temperature mean provided can deviate by around ±0.1 degrees from the "real" grid mean (root mean squared error). The error is generally even smaller in summer and for the aggregates (seasonal, semi-annual, annual).

The uncertainty for the mean values of the subregions lies in the same range as for the mean of the entire area of the country with one exception. For the south, there are slightly larger errors of around ±0.2 degrees. The errors in summer are generally smaller than in winter in the subregions as well.

The subregion of southern Switzerland has high mountain regions (Alpine main crest) and is therefore colder on average than northern Switzerland below 1000 m. This fact must be accounted for in the interpretation of the regional mean compared to the other regions.

Due to their limited spatial resolution (2 km), small-scale structures of the Swiss topography such as mountain peaks and smaller cold-air pools are not included in the grid data. As a result of this as well as uncertainties in the spatial interpolation, the temperature mean determined from the grid data can deviate from the actual mean. For the large areas analysed (all of Switzerland and the subregions), these differences are probably minor, but ultimately unclear. The errors mentioned above may therefore slightly underestimate the actual uncertainties.

Related products	Graphics of the Swiss precipitation mean are also shown on the MeteoSwiss website. This is still currently the unweighted average of station data on the basis of deviations from a reference period. The plan is to fine-tune the methodology for precipitation the same way as for temperature.

On the basis of grid data starting in 1981 and long-term series of measurements consistent high-resolution grid datasets are reconstructed for Switzerland back to 1864 at MeteoSwiss. The methodology of the *reduced space optimal interpolation* described in Schmidli et al. (2001) and Schiemann et al. (2010) is used. A time series of grid means of these datasets would be conceivable as an alternative to the presented station mean. However, our comparisons show that the differences to the weighted station mean are very small. The average difference (root mean squared error) lies below ±0.1 degree Celcius for all seasons.

Versions   http://www.meteoswiss.admin.ch/home/climate/swiss-climate-in-detail/Swiss-temperature-mean/Data-on-the-Swiss-temperature-mean.html

Availability   The Swiss temperature mean is published in a text file on the MeteoSwiss website. The dataset is clearly identified by a DOI (Digital Object Identifier). The data series is completed at the beginning of each month with the monthly value of the previous month. The historic values remain unchanged here. At the beginning of a new year, however, the results of the homogenisation work are made official at MeteoSwiss. Due to changes made to adapt to the new measure conditions historical homogeneous values of a measuring station can change. These changes can manifest themselves in some cases in the Swiss temperature mean. The dataset is issued a new DOI in this case. Older versions of the dataset continue to be available on the MeteoSwiss website.

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