Documentation of MeteoSwiss Grid-Data Products

Daily, Monthly and Yearly Norm Temperature (1991-2020): TnormD9120, TnormM9120 and TnormY9120

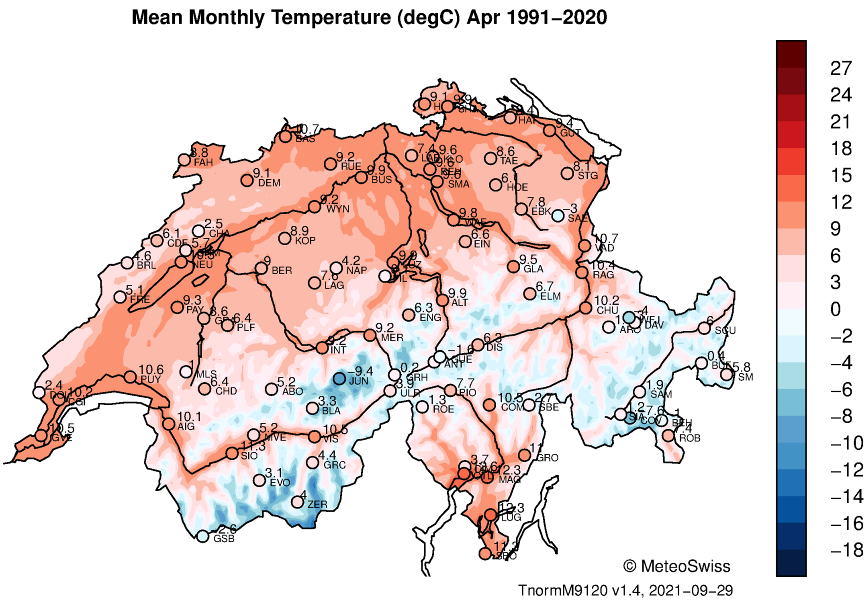

Figure 1: Norm temperature for the month of April (1991-2020, degrees C).

Variable Climatological mean of temperature (in degrees Celsius) on calendar days, for months and the year (period 1991-2020) covering the territory of Switzerland.

Application Agriculture and ecology, civil engineering, tourism.

Overview TnormD9120, TnormM9120 and TnormY9120 are spatial analyses of surface temperature averaged over a 30-year period (1991–2020) for calendar days, months and for the year. They are based on standard norm values at about 90 climatological stations of MeteoSwiss. The temperature distributions are estimated using a km-scale digital elevation model, a non-linear vertical temperature profile and non-Euclidean distance weighting. The dataset is suitable for planning and design purposes relying on local reference temperatures (e.g. agriculture, heating demands). Compared to earlier datasets, valid for the reference period 1961–1990, the present data products provide a more up-to-date reference for climate conditions around the turn of the century.

Data base

The spatial analyses for the climatological mean temperature products are based on temperature norm values (averages for 1991-2020) at about 90 climatological stations in Switzerland. Station norm values were derived from measurement time series by correcting for effects from partial temporal coverage and from station and instrument changes. Details of the preparation of climatological norm values at MeteoSwiss are given in Begert et al. (2003) and in Begert and Frei (2018).

The climatological stations used for the analysis are evenly distributed across Switzerland (see Fig. 1). There are a few clusters of stations in the Alps (e.g. the Gotthard region), which encompass nearby sites on mountain peaks and in valleys. Generally, slope conditions are comparatively underrepresented in the station network. (See MeteoSwiss 2010 for details on the measurement networks.)

Method

The spatial interpolation of temperature norm values is calculated independently for each calendar day, calendar month and for the year, following the two-step procedure described in Frei (2014): In a first step, temperature variations are modeled by a vertical profile that varies smoothly in space. To this end a non-linear profile function is fitted to the station values by non-linear least squares. The profile function is parameterized as a superposition of a lapse rate with an inversion zone of variable depth and amplitude.

In a second step, deviations away from the fitted vertical profile (anomalies) are interpolated spatially. This is accomplished using a weighting scheme with non-Euclidean distances to “surrounding” stations. Distances are determined depending on the elevation differences that have to be surmounted and depending on the vertical layering of the anomalies. Finally, the interpolated fields from the vertical gradient and the anomalies are composed to yield the resulting temperature interpolation. This analysis method in this step builds on ideas from Deng and Stull (2005). See Frei (2014) for details.

The digital elevation model used is the USGS GTOPO30 (see http://eros.usgs.gov) for the 2-km version (longitude-latitude grid) and the SRTM (Farr et al. 2007) for the 1-km version (in Swiss coordinates).

Target users

TnormD9120, TnormM9120 and TnormY9120 are fields of time invariant reference temperatures. They are addressed to planning tasks relying on long-term averages only, i.e. where temporal variations are of minor relevance or unfeasible to be considered. Possible areas of application are agriculture, forestry, tourism and civil engineering (heating demands, construction standards).

Many practical applications are traditionally based on long-term reference climate. Nowadays, the availability of time-varying datasets allows more advanced computational modeling, where effects of variability and extremes, can be phased in. Users relying on a reference climate traditionally, may want to consider the advanced possibilities offered by the time-variable data products, e.g. those from TabsD and TabsM.

Like in many regions of the globe, mean temperatures in Switzerland have increased during the last decades (Rebetez & Reinhard 2007; Ceppi et al. 2010). Between 1961 and 2020 the warming amounts to more than 2 degrees. Therefore, the reference provided by the current norm values is not representative for conditions in earlier periods. Users requiring mean temperatures for the old reference period 1961-1990 can request products TnormD6190, TnormM6190, TnormY6190, which are similar but valid for the previous norm reference period.

Accuracy and interpretation

The spatial interpolation procedure is designed to cope with the characteristic features of temperature variability in Switzerland. Indeed, the climatological inversion over the Swiss Plateau and cold anomalies in major valleys are evident in the resulting fields for winter. Moreover, warm anomalies in major Föhn valleys in spring and autumn as well as anomalous heating of inner-Alpine valleys in summer can readily be recognized in the results.

Nevertheless, users should be aware, that small-scale temperature variations related to lake effects, urban heat islands, slope exposition or vegetation and land use were not explicitly modeled. Hence such effects are poorly represented in the analyses. Again, it is to be expected that temperature interpolations in un-instrumented valleys are less accurate. Altogether, the magnitude of local temperature variability is likely to be underestimated, i.e. the fields are “too smooth”.

Analyses of a “leave-one-out” cross-validation for TnormM9120 reveal that interpolation errors are considerably smaller than the spatial temperature variability: The explained fraction of spatial temperature variance is 85% in winter months and 98% in summer months. In winter the interpolation error (standard deviation across the station sample) is 0.6 degrees over the Swiss Plateau/Jura and 1.6 degrees in the Alps/Ticino. Errors are smaller in summer: 0.4 degrees over the Swiss Plateau/Jura, 0.8 degrees in the Alps/Ticino. The corresponding standard errors for annual mean temperature (TnormY9120) are 0.4 and 1.0 degrees for the Plateau/Jura and the Alps/Ticino respectively.

It is to be noted that TnormY9120 is interpolated from the annual norm values at stations. Non-linearities in the analysis scheme lead to slight differences between TnormY9120 and the average of the monthly fields (TnormM9120). It is recommended to use TnormY9120 in applications where a yearly mean is sufficient.

Related products

TminnormM9120, TmaxnormM9120, TminnormY9120, TmaxnormY9120: Norm value analyses for daily minimum and daily maximum temperature.

TanomM9120 and TanomY9120: Anomalies of monthly and yearly mean temperature, relative to the mean of 1991-2020.

TabsD, TabsM and TabsY: Mean surface temperature for individual days, months and years.

There is consistency of TnormM9120 and TnormY9120 with these related products. In fact temperature anomalies (TanomM9120, TanomY9120) are calculated as the difference between absolute values (TabsM / TabsY) and the norm.

Grid structures

TnormD9120, TnormM9120 and TnormY9120 are available in the following grid structure:

ch02.lonlat, ch01r.swiss.lv95

Versions

Current versions: TnormD9120 v1.4, TnormM9120 v1.4, TnormY9120 v1.4

Previous versions:

TnormD8110 v1.2, TnormM8110 v1.2 and TnormY8110 v1.2 were calculated with a less robust estimation procedure for vertical profiles and the layering scheme.

TnormM8110 v1.0 and TnormY8110 v1.0 were derived with an older method using a less flexible parametric function for the vertical profile.

Update cycle

TnormD9120, TnormM9120 and TnormY9120 (as well as the corresponding products for daily minimum and maximum temperature) are, in principle stationary fields. Still, changes to station norm values over time can happen, because these are corrected to the most actual location (instrumentation) of the station. As a result, the norm value products are updated once per year (in late winter). The variations are, however, very minor.

References

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