Documentation of MeteoSwiss Grid-Data Products

Daily Precipitation (final analysis): RhiresD

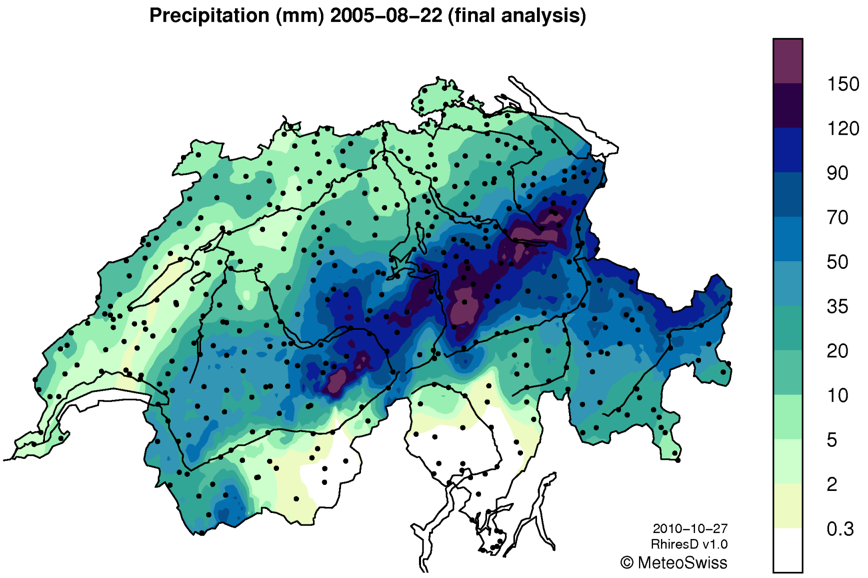

Figure 1: Daily precipitation total (mm) for 22. August 2005. Analysis derived from automatic and manual measurements.

Variable

Daily precipitation on day *D*, corresponding to rainfall and snowfall water equivalent accumulated from 06:00 UTC of day *D* to 06:00 UTC of day *D+1*. In millimeters (equivalent to liters per square meter).

Application

Water resources and hydropower management. Hydrology, agriculture, engineering and tourism. Natural hazards prevention. Climate monitoring. Climate change downscaling.

Overview

RhiresD is a spatial analysis of daily precipitation covering the entire territory of Switzerland and extending over a multi-decadal period (1961-present). It provides detailed spatial information and high accuracy by exploiting all available (i.e. automatic and manual non-realtime) measurements (typically 420 each day). Apart from basic monitoring, RhiresD serves a broad range of planning tasks where quantitative process models with precipitation input are used. The data product is typically available with a delay of 3-6 weeks.

Data base

RhiresD is based on daily precipitation totals measured at the high-resolution rain-gauge network of MeteoSwiss. It uses all quality checked station measurements available for a particular day to ensure maximum effective resolution and accuracy. Therefore, the station base varies slightly from day to day. Over the long term, the number of stations increased from 420 in the early 1960ies to about 520 in the mid 1970ies and gradually decreased thereafter, reaching 430 after 2005.

The geographical distribution of rain-gauge stations in Switzerland is reasonably balanced in the horizontal (see e.g. Fig. 1), but there is a clear imbalance in the vertical, with regions above 1200 mMSL being comparatively under-represented (see e.g. Frei and Schär 1998, Konzelmann et al. 2007).

The majority of the rain gauges operated since 1961 are/were manual Hellmann type gauges with an orifice of 200 cm^2 positioned 1.5 m above ground. Since the early 1980ies approximately 70 stations are equipped with automatic tipping bucket gauges.

Method

The precipitation analysis for day D is obtained in several steps: (1) Spatial interpolation of the climatological mean precipitation measurements for the calendar month of day D (reference period 1971-1990); (2) Calculation of relative anomalies of station measurements on D with respect to the climatological mean from step 1; (3) Spatial interpolation of relative anomalies; (4) Multiplication of the resulting anomaly field with the climatological mean field.

The interpolation in step 1 adopts regionally varying precipitation – topography relationships, estimated by local weighted linear regression. A version of the PRISM algorithm by Daly et al. (1994, 2002) is applied and adjusted for the Alpine region (Schwarb et al. 2000, Schwarb et al. 2001). The purpose of using a climatological reference field for the interpolation of daily precipitation is to reduce the risk of systematic errors due to the under-representation of measurement stations at high elevations (Widmann and Bretherton 2000).

The interpolation in step 3 adopts a weighting scheme, which emphasizes the contribution of measurements which are close to the analysis point and/or which exhibit a high degree of directional isolation in the neighborhood of the analysis point. For this purpose a modified version of the SYMAP algorithm by Shepard (1984) is employed. Details of the interpolation scheme are described in section 4.1 of Frei et al. (2006) and in Frei and Schär (1998).

Target users

RhiresD addresses needs for environmental planning and monitoring in a broad range of fields (water resources, hydrology, agriculture, hydropower, etc.). The daily time resolution together with the long-term coverage permits for statistical analyses on the frequency of regional heavy precipitation, and, in combination with runoff models, the occurrence of extreme water levels in lakes and high stream flow conditions in rivers. RhiresD has contributed to the analysis and physical understanding of recent flooding events (Bezzola and Hegg 2007, 2008; Bezzola and Ruf 2009). Applications in climatology and meteorology include the analysis of precipitation variability and trends, the evaluation of weather forecasting and climate models, and climate change downscaling.

Accuracy and interpretation

The accuracy of RhiresD depends on the accuracy of the underlying rain-gauge measurements and the capability of the interpolation scheme to reproduce precipitation at ungauged locations.

Measurement errors: Measurements by rain gauges are subject to systematic errors. Wind-induced deflection of hydrometeors over the gauge orifice results in an underestimation of true precipitation. The “gauge undercatch” is comparatively larger during episodes with strong wind, or at wind-exposed stations and during weather with small rainfall intensity or with snowfall (Neff 1977, Yang et al. 1999). Sevruk (1985) estimates the systematic measurement error in Switzerland to range from about 4% at low elevations in summer to occasionally more than 40% above 1500 mMSL in winter. RhiresD must therefore be expected to generally underestimate precipitation, particularly during days with snowfall and at wind-exposed locations.

Interpolation errors: The magnitude of interpolation errors depends on how the analyses are interpreted by the user. If gridpoint values are expected to represent local point estimates, interpolation errors are substantial: A “leave one out” cross-validation reveals that the standard error is in the order of a factor of 1.7 for light precipitation (< 20% quantile) and a factor of 1.3 for intense precipitation (> 90% quantile). Errors are slightly larger (smaller) in summer (winter). There is a general tendency (i.e. a systematic error) to overestimate light and underestimate intense precipitation. If gridpoint values are interpreted as area mean values (e.g. over one or several grid cells), the magnitude of the error is smaller. It is difficult to derive error statistics for this line of interpretation because of the lack of an appropriate evaluation reference. A model-based analysis for the heavy precipitation days in August 2005 revealed errors in the order of 5-30% if gridpoint estimates were interpreted as 15x15 km^2 area mean values (Frei et al. 2008). These numbers are however sensitive to the nature of the precipitation. Larger errors are to be expected for days with localized thunderstorms.

Grid spacing vs. effective resolution: The substantial interpolation errors for point estimates pinpoints to the limited effective resolution of RhiresD (in fact of any gridding from station data only). The km-scale gridpoint spacing does not imply that these scales are resolved. The effective resolution of RhiresD is in the order of 15-20 km or larger (typical inter-station distance). The user should be careful in relying on estimates at single or very few gridpoints. In particular, RhiresD is not suitable to obtain statistics on local precipitation extremes.

Temporal homogeneity: Temporal variations in the station network (see section *Data base*) invoke climatological inhomogeneities in RhiresD. These can affect long-term variations, especially in high-frequency statistics (e.g. frequency of wet days, exceedance of thresholds). Users requiring high climatological homogeneity with daily resolution can contact MeteoSwiss to investigate options for a dedicated homogenous regional data product.

Related products

RhydchprobD: A probabilistic daily precipitation analysis, based on the same high-resolution rain-gauge network, but presented as an ensemble of possible spatial distributions. This product allows to trace interpolation uncertainty into applications (ensemble), it reproduces the statistics of extremes more accurately, and it also encompasses areas outside Switzerland that are linked hydrologically to Switzerland. See also Frei & Isotta, 2019.

RprelimD: A preliminary estimate of the distribution of daily precipitation based on a much smaller sample of stations but available in quasi real time (i.e. with a delay of one day). RprelimD is addressed to users with a need for real-time daily data. RhiresD is clearly more accurate than RprelimD and it is recommended to supersede the latter with the update, as soon as it becomes available.

RhiresM / RhiresY: Similar to RhiresD but for the monthly / yearly precipitation sum. There is no strict consistency between these products. E.g. adding the daily analyses of RhiresD does not reproduce RhiresM exactly. This is due to differences in the underlying measurement data, when stations only cover part of the month. Differences are small in practice.

CPC: An hourly precipitation dataset obtained from a formal statistical combination of simultaneous radar and rain-gauge measurements. This data product is available in near real-time. Aggregation of CPC over one day does not replicate RhiresD.

TabsD / SrelD: Daily analyses for temperature and sunshine duration, together with those for daily precipitation, provide comprehensive information on weather and climate in Switzerland and are, in combination, useful for many environmental modeling tasks.

Grid structures

RhiresD is available in the following grid structures:

ch02.lonlat, ch01r.swisscors, ch.cosmo1.rotpol, ch.cosmo2.rotpol, ch.cosmo7.rotpol

Versions

Current version: RhiresD v1.0

Previous versions: none

Update cycle

RhiresD is updated once every month to include all available manual measurements and the results of the regular processing of data quality control. The update for all daily fields of a month is available typically on the 25th of the following month.

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December 2019