Alpine Precipitation Grid Dataset

A spatial analysis of precipitation over the territory of the European Alps and adjacent flatland regions (4.8-17.5°E / 43-49°N, 47.6°N in France). The distribution of precipitation (rainfall plus snow water equivalent, in mm) is estimated for all days of the period 1971-2008. Estimates are based on measurements at high-resolution rain-gauge stations (more than 8500 in total) from meteorological and hydrological services. The analysis is provided on a regular grid in the ETRS89-LAEA coordinate system, with a grid spacing of 5x5 km. The high density of the observational input data contributes to quantitative accuracy and high effective resolution (approx. 10-20 km) of precipitation estimates in the source region of four major European rivers. A detailed description of and climatological analyses with this dataset are available in Isotta et al. (2014).

Dataset characteristics

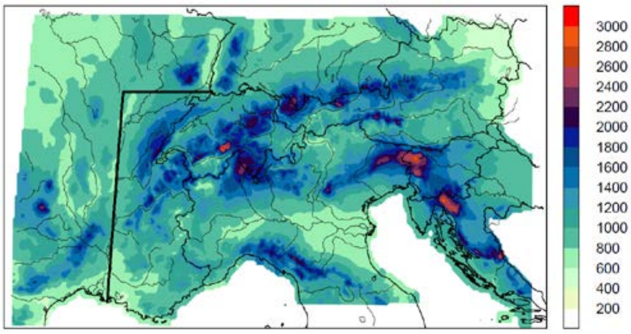

Figure 1: Mean yearly precipitation (mm, 1971-1990) for the Alpine region. Over France, the gridded Alpine precipitation dataset is available for the south-eastern portion only (thick black line).

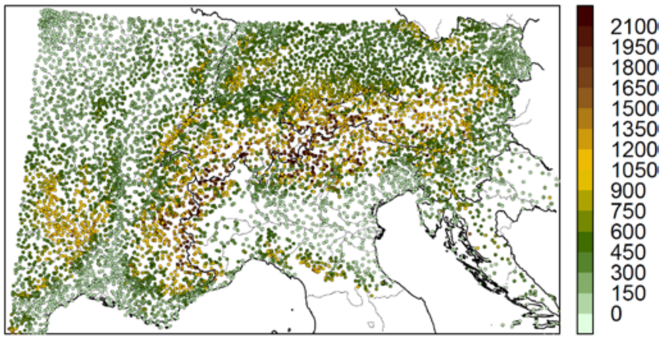

Figure 2: Rain gauge stations from which data was used for the spatial analysis. Colors indicate the height of the stations (in mMSL).

Infobox

SPECIFICATIONS

Output data sets
Precipitation (rainfall plus water equivalent of snowfall).

Data
Spatial resolution: 5 km
Temporal resolution: daily
Grid: ETRS-LAEA
Format: netcdf

Availability
Area: 4.8-17.5°E, 43-49°N (47.6°N in France), see Figure 1.
1971-2008 (daily)
Available from: www.meteoswiss.ch search for “Alpine precipitation”.
Restricted to scientific non-commercial use.

Reference
Isotta et al. 2014: The climate of daily precipitation in the Alps: development and analysis of a high-resolution grid dataset from pan-Alpine rain-gauge data. Int. J. Climatol., 34 (5), 1657-1675.

Dataset DOI
10.18751/Climate/Griddata/APGD/1.0

Evaluation
Leave-one-out crossvalidation and comparison to other gridded precipitation datasets.

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Examples of usage:

- Environmental modeling in a broad range of fields (hydrology, agriculture, glaciology, etc.)
- Water resources and hydropower management
- Trans-national analysis of heavy precipitation events (e.g. Fig. 3)
- Monitoring and climatology of precipitation extremes (e.g. Fig. 4)
- Evaluation of weather forecasting and regional climate models and regional re-analyses
- Climate change downscaling

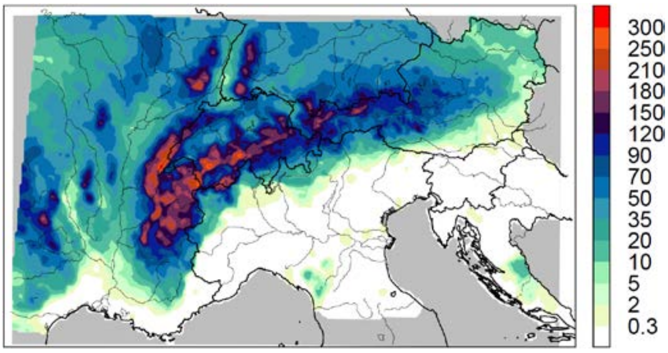

Figure 3: Two-day precipitation total for an episode of heavy precipitation in the Alps (13.2-14.2.1990).

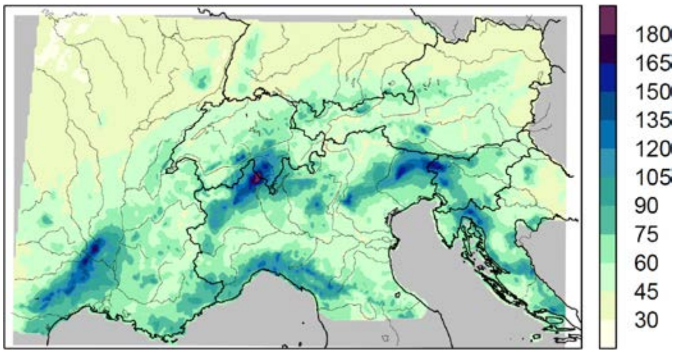

Figure 4: Mean of annual maximum daily precipitation (mm per day), from Isotta et al. (2014).

Method overview:

The Alpine Precipitation Grid Dataset is a spatial analysis of daily precipitation derived from in-situ measurements at more than 8500 rain-gauge stations. To this end data was integrated from the high-resolution station networks of six national meteorological and hydrological services (Austria, Croatia, France, Germany, Slovenia and Switzerland) and of nine regional environmental services in Northern Italy. Prior to spatial analysis, the station data was checked for plausibility (spatial consistency of daily values) by an automated quality control procedure. The dataset has a grid spacing of 5 km, extends over the entire territory of the Alps and covers a multi-decadal period (1971-2008). This dataset is an update of the dataset described in Frei and Schär (1998), at a finer spatial resolution and making use of improved station coverage in previously under-represented regions. A detailed description of the underlying rain-gauge dataset and analysis method is provided in Isotta et al. (2014). What follows is a brief summary:

The analysis for a certain day (hereafter “D”) is obtained in several steps:
(1) Spatial interpolation of the climatological mean precipitation measurements for the calendar month of D (reference period 1971-1990);
(2) Calculation of relative anomalies of station measurements of 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. To this end, a version of the PRISM algorithm by Daly et al. (1994, 2002) was employed (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 exhibit a high degree of directional isolation in the neighbourhood of the analysis point. For this purpose a modified version of the SYMAP algorithm by Shepard (1984) is employed (see also Frei and Schär 1998).

Error sources and accuracy:

The accuracy of the Alpine Precipitation Grid Dataset depends on the accuracy of the underlying rain-gauge measurements and the capability of the interpolation scheme to reproduce precipitation at un-gauged locations. A detailed description of error sources and interpolation skill is provided in Isotta et al. (2014). What follows is a brief summary of the involved error sources and pertinent implications:

- Systematic measurement errors: Measurements by rain gauges are subject to systematic and random errors, arising from wind induced deflection of hydrometeors over the gauge orifice. The associated "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). Estimates of the systematic measurement error in the region of the Alps are given in Sevruk (1985) and Richter (1995).

- Random measurement errors: Random errors can arise from the malfunctioning of automatic instruments and by reading/transmission errors. Most of the data used in this analysis was quality checked by the provider of the original data. An additional automatic plausibility check is conducted with all the station data using criteria of spatial consistency (see Isotta et al. 2014). Gross measurement errors were largely identified (and removed) with these procedures, however, errors may still be present, especially in areas with low station density, where the power of automatic procedures is limited.

- Interpolation errors: The magnitude of interpolation errors depends on how the analyses are interpreted by the user:
  - If gridpoint values are interpreted as local point estimates, interpolation errors are substantial, depending on precipitation intensity, season and station density. One way of evaluating the accuracy of the adopted interpolation procedure in this case, is by leave-one-out cross-validation. Results of a cross-validation for three regions are shown in Fig. 5. The dependence of the error on station density, topographic complexity and season is evident. Particularly noteworthy is the systematic error component with underestimates at light and overestimates at high precipitation intensities. This reflects the effect of smoothing by interpolation and its attendant underestimation of spatial variability.
  - If gridpoint values are interpreted as area averages (e.g. the mean over catchments), the magnitude of the error is smaller, but it is difficult to quantify error statistics for this line of interpretation. As a general rule, the error magnitude (both for the random and the systematic component) decrease with domain size of averaging (see also Frei et al. 2008).

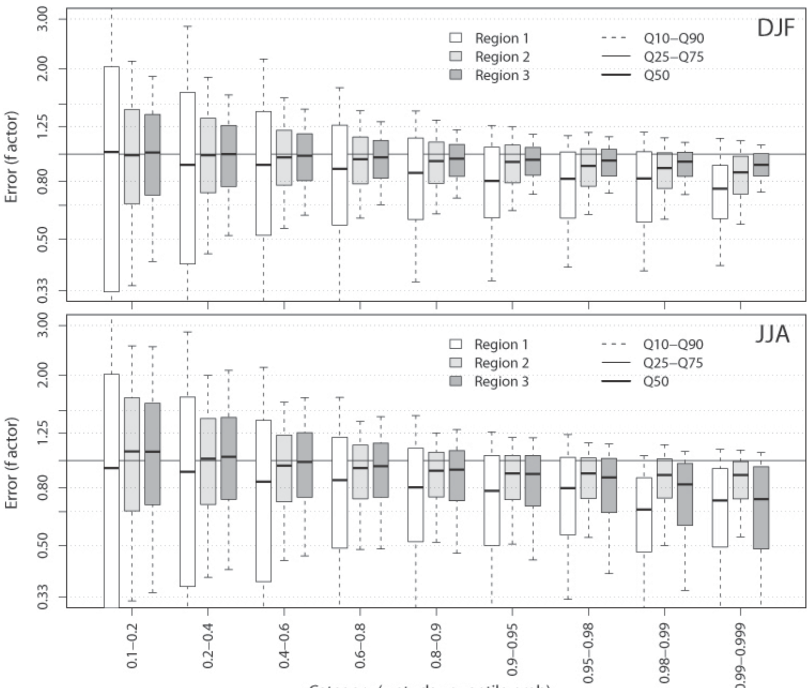

Figure 5. Boxplot of interpolation errors determined from a systematic leave-one-out crossvalidation in three characteristic regions. Region 1: area with a coarse station network, Region 2: mountainous area with a dense network, Region 3: flatland area with a dense network. Errors are expressed as the ratio between the interpolation (at the location of the station) and the observation at the station. The errors are stratified into bins of precipitation intensity defined in terms of quantiles (wet days only) with low (high) intensities on the left (right). The upper plot is for winter (DJF), the lower for summer (JJA). The boxplots represent the median (bold line), the interquartile range (box) and the 10-90% quantile range (whisker) of the error distribution. From Isotta et al. (2014).

- Grid spacing vs. effective resolution: The substantial interpolation errors for point estimates (Fig. 5) pinpoint to the limited effective resolution of the dataset (in fact of any gridding from station data only). The km-scale gridpoint spacing does not imply that dataset resolves these scales. The effective resolution of the Alpine Precipitation Grid Dataset is in the order of or coarser than the typical inter-station distance, i.e. around 10–20 km depending on the region. The user should be very careful in relying on estimates at single or very few gridpoints.

- Temporal homogeneity: Temporal variations in the station network invoke climatological inhomogeneities in the dataset. These can affect long-term variations, especially in high-frequency statistics (e.g. frequency of wet days, exceedence of thresholds). (See Isotta et al. 2014 for details.)

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