Documentation of MeteoSwiss Grid-Data Products

Daily Relative Sunshine Duration: SrelD

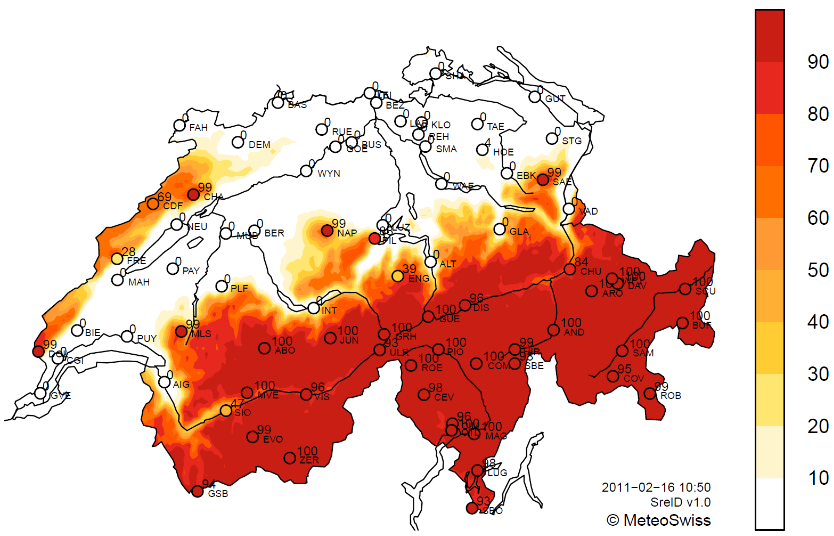

Figure 1: Daily relative sunshine duration (%) for 1. February 2011.

Variable

Daily relative sunshine duration in percent (%, midnight to midnight), i.e. the ratio between the effective sunshine duration and that maximally possible if no clouds were covering the sun. A period with sunshine is defined as a period when the direct solar irradiance exceeds 200 W/m^2.

Application

Climate monitoring and climate change downscaling. Solar energy and architecture. Tourism. Agriculture and ecology. Hydrology and glaciology, Evaluation of weather forecasts.

Overview

SrelD is a near real-time spatial analysis of daily relative sunshine duration in Switzerland. The analysis for a day becomes readily available on the following day. SrelD covers the entire territory of Switzerland and extends over a multi decadal period (1981-present). The analysis technique, developed at MeteoSwiss (Frei et al. 2015), combines station measurements (typically 70) with high-resolution satellite data and is capable to resolve the structure of low-level stratus over the Swiss Plateau and cumulus clusters over major Alpine mountain massifs. SrelD is a valuable basis for the planning of solar energy facilities and applications in architecture. Moreover, it can be useful as a proxy for short-wave radiation in soil water balance models (agriculture, hydrology) and in glacier models.

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Data base

SrelD relies on a statistical technique that combines sunshine duration measurements at stations with satellite-based retrievals of a clearness index.

As for the station measurements, all stations with a near real-time data delivery into the MeteoSwiss central data archive are integrated. This involves approximately 70 stations from SwissMetNet (MeteoSwiss 2010). The station network has an average inter-station distance of about 30 km and encompasses more flatland and valley floor stations, with high-mountain regions relatively underrepresented. The number of stations used for SrelD is almost constant in time. The measuring device is a Hänni Solar 111 B type heliometer (for details see Odebrecht and Rast, 2007). Relative sunshine duration is obtained by comparison to the maximum possible sunshine duration determined for each calendar day and station. The time series used were not explicitly corrected for temporal inhomogeneities, but maximum sunshine durations have been adjusted in case of station relocations.

The satellite data is based on Meteosat Second Generation (MSG, see Schmetz et. al 2002) cloud retrievals and the derivation of a daily HELIOSAT clearness index (Cano et al., 1986). The clearness index (%) is a measure of the actual global radiation relative to the maximum possible under clear sky conditions (Rigollier et al., 2004). The index was derived with a specific algorithm for the Alps, giving special consideration to snow (Dürr and Zelenka, 2009; Stöckli 2013). The clearness index dataset has an effective spatial resolution of approx. 1.1x1.7 km over Switzerland and was aggregated to the 2-km target grid. It was available for all days of the period 2004-2012.

Method

The analysis method adopted for SrelD combines data from in-situ measurements of relative sunshine duration (i.e. at stations) with a km-scale satellite-based clearness index dataset. The role of the satellite data is to provide high-resolution information on recurring cloudiness patterns. The combination does not need simultaneous satellite measurements and hence can be applied over climatological periods extending into the pre-satellite era. A detailed description and evaluation of the method is given in Frei et al (2015). In brief, it encompasses the following steps:

(A) All data (station and satellite clearness index) is *logit*-transformed to achieve approximate normality of data distributions.

(B) A set of "typical" patterns of the cloudiness distribution in Switzerland is derived from a nine-year satellite dataset (clearness index) by means of a Principal Component Analysis (PCA). The patterns were calculated individually for the seasons and they show characteristic features of the cloudiness distribution such as low-level stratus over the Swiss Plateau, Foehn and topographically induced cumulus clusters.

(C) A linear combination of the satellite-based patterns from step B is fitted to the station measurements individually for each day. Hence, the station data determine together the prominence of each pattern on a particular day. Formally, this is accomplished in a kriging model with external drift (see Cressie 1990, Ribeiro and Diggle 2007), using Principal Component loadings from step B (and some additional topo-geographic fields) as predictors. An exponential variogram model is adopted with shape parameters depending only on the calendar month. Cross-validation experiments suggested that 9 leading PCA patterns provided a decent compromise between model flexibility and risk of overfitting.

(D) The resulting field is back transformed and truncated where necessary.

A detailed evaluation of the method demonstrates that the inclusion of satellite data leads to more realistic distributions and clearly improves interpolation accuracy. Even with the rather limited number of predictor patterns, situations with low-level stratus at different altitudes could be reasonably distinguished. See Frei et al. (2015) and Willi (2010) for more detail.

Target users

The 30 year coverage makes SrelD suitable for the monitoring of decadal cloudiness variations and the calibration / evaluation of climate change downscaling methods. Moreover, SrelD provides a valuable basis for the planning of solar energy facilities and for applications in architecture and in tourism. Sunshine duration can also serve as a proxy for short-wave radiation in soil water balance models used in agricultural research, ecology and hydrology, and in glacier models for glaciology. The near real-time availability allows for a quick access to recent cloudiness and sunshine conditions and immediate evaluation of weather forecasts.

Accuracy and interpretation

The accuracy of SrelD depends on several factors: (1) the accuracy of the heliometer measurements, (2) the representativity of the satellite-based patterns for sunshine variations in Switzerland and (3) the representativeness of the station network for estimating the linear combination of patterns accurately. Factor 1 is of secondary significance. An optimal performance of the interpolation had to be found with a compromise between factors 2 and 3.

To assess the quality of SrelD a systematic cross-validation was undertaken over a 10-year period that was independent from the satellite calibration period (Willi 2010, Frei et al. 2015). The median of the mean absolute error (averaged over all stations of a day) is 10% relative sunshine duration for winter days with an interquartile range (75% of all days) of 6-14%. For summer days the median of the mean absolute error is smaller (7.5%) and its interquartile range is 6-9%. SrelD explains 50-80% of the spatial variations on winter days and 40-70% on summer days. Days with a small explained spatial variance are days with a comparatively small station-to-station variance. Hence, the seemingly poor performance on some days is rarely associated with significant absolute errors.

An additional evaluation for a selection of challenging test cases has shown that complex spatial structures are realistically reproduced. Low-level stratus cases show realistic valley-mountain contrasts (see the example in Fig. 1) and variations in the stratus layer height can be reasonably reproduced. However, difficulties can occur on days when the sunshine distribution has unusual small-scale features.

The spatial detail introduced by the satellite patterns is plausible and effective in improving interpolation skill. Nevertheless, the effective resolution of SrelD must be expected to be coarser than the grid spacing. The coarse resolution of the original MSG data and the truncation of Principal Components are contributing to this. Users are cautioned about relying applications on single (or few) grid points in SrelD. See Willi (2010) and Frei et al. (2015) for further information.

Related products

SrelM and SrelY: Monthly and yearly relative sunshine duration, produced with the same method as for SrelD, but applied to monthly and yearly station and satellite data. Averaging the daily analyses of SrelD does not reproduce SrelM and SrelY, because of non-linearities in the analysis procedure and because maximum sunshine duration varies in the course of a month/year. Users interested in monthly/yearly resolution only are encouraged to use these alternative datasets rather than aggregating daily data.

SanomM8110 and SanomY8110: Anomalies of monthly and yearly sunshine duration, relative to the mean of 1981-2010.

Daily global radiation: This data product represents surface incoming shortwave radiation (in Watts per m^2) on a km-scale grid over Switzerland. It is derived from Meteosat Second Generation satellite measurements by means of a Heliosat algorithm, a snow detection scheme and a bias adjustment using station data.

Grid structures SrelD is available in the following grid structure:

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

Versions Current version: SrelD v1.0

Previous versions: none

Update cycle SrelD is updated daily. The analysis for day *D* is typically available at 09:00 of day *D+1*.

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