Documentation of MeteoSwiss Grid-Data Products

Monthly and Yearly Relative Sunshine Duration: SrelM and SrelY

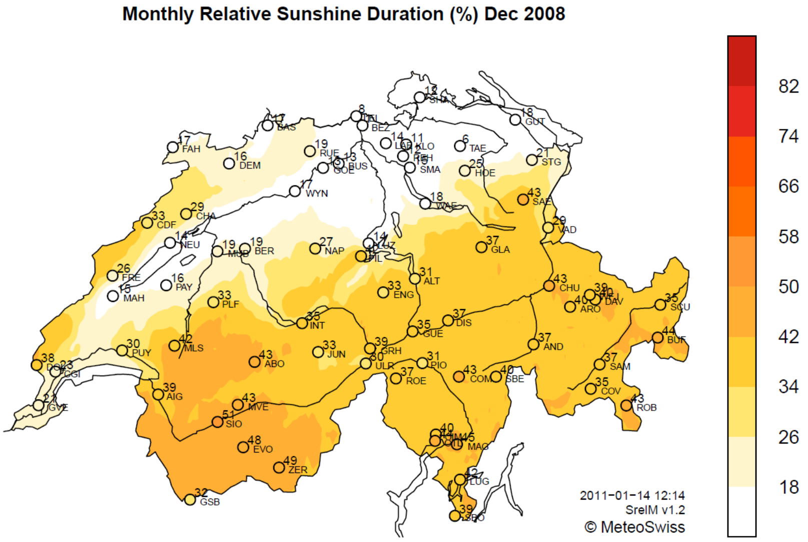

Figure 1: Monthly relative sunshine duration (%) for December 2008.

Variable

Monthly (yearly) relative sunshine duration during calendar months (years) in percent (%). *Sunshine* is occurring when the direct solar irradiance exceeds 200 W/m^2. Relative sunshine duration is the ratio between the effective sunshine duration and that maximally possible.

Application

Climate monitoring, solar energy and architecture, tourism, agriculture and glaciology, climate change downscaling.

Overview

SrelM and SrelY are spatial analyses of monthly and yearly relative sunshine duration in Switzerland for a multi decadal period (1971-present). The analyses integrate in-situ heliometer measurements (about 70 stations) and high-resolution satellite data to provide an effective spatial resolution near the km-scale. The datasets are intended primarily for climate monitoring purposes, but they can also be valuable for quantitative applications on solar energy production, agriculture and glaciology.

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Data base

SrelM and SrelY rely on a statistical technique that combines sunshine duration measurements at stations with satellite-based retrievals of a clearness index.

The in-situ component encompasses approximately 70 stations from SwissMetNet (MeteoSwiss 2010). This yields an average inter-station distance of about 30 km. Flatland and valley floor sites are overrepresented compared to high-mountain regions. The number of stations used for the analyses is almost constant between 1981-2010. The measuring device is a Hänni Solar 111 B type heliometer (for details see Odebrecht and Rast, 2007). Relative sunshine duration is obtained by dividing the total monthly (yearly) time with sunshine by the maximum possible time for each calendar month (year). For the present data product, homogenous measurements have been used, i.e. data where variations due to station relocations and instrument changes have been corrected.

The satellite component 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 (Stöckli, 2013; Dürr and Zelenka, 2009). The clearness index dataset has a monthly resolution, spans over a 5-year period (2004-2012) and covers the territory of Switzerland with a spatial resolution of approx. 1.1x1.7 km^2.

Method

The method of spatial analysis adopted for SrelM and SrelY is described in detail in Frei et al. (2015). It is very similar to that used for SrelD (see Willi 2010). In brief, it encompasses the following steps:

(A) 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.

(B) A linear combination of the satellite-based patterns from step A is fitted to the station measurements individually for each month. Hence, the station data determine together the prominence of each pattern in a particular month. Formally, this is accomplished by kriging with external drift (see Cressie 1990, Ribeiro and Diggle 2007), using Principal Component loadings from step A (and some additional topo-geographic fields) as covariates. An exponential variogram model is adopted with shape parameters depending only on the calendar month. Cross-validation experiments suggested that 4 leading PCA patterns provided a decent compromise between model flexibility and risk of overfitting. For details see Frei et al. (2015).

Target users

SrelM and SrelY are developed primarily for monitoring sunshine and cloudiness variations on the monthly to inter-decadal time scale. The length of the period (more than 30 years) allows for the evaluation of climate models and the development of climate change downscaling methods. SrelM and SrelY can also be used as input into environmental process models (e.g. in agriculture and ecology) and as a basis for socio-economic planning (e.g. solar energy production and tourism) in applications where monthly resolution is sufficient.

Accuracy and interpretation

The accuracy of SrelM was evaluated in a systematic cross-validation for a twenty-year period (1981 – 2000) that is independent from the calibration of the clearness index patterns.

Mean absolute errors were calculated for each month (see Frei et al. 2015). The median value was less than 5% relative sunshine duration for winter/autumn months with an interquartile range (50% of all months) of 3.5 – 5.5%. For summer months the error has a median of about 3% and varies little between months (interquartile range is +/–0.25%). The smaller absolute error in summer is associated with the smaller spatial variability compared to winter. SrelM explains 80–90% of the spatial variability in winter/autumn and 60–75% during spring/summer. Strictly, these accuracy measures refer to the evaluation at available stations. It is possible that errors are larger in regions under-represented in the station sample, such as at high altitudes.

The interpolation accuracy has substantially profited from the integration of satellite data. This was quantitatively verified in measures of the interpolation skill and it is evident in the plausible fine scale structure of the analysis (see Fig. 1). Nevertheless, users should be aware that cloud detection from satellite data is complicated by snow, and that this may lead to artifacts of the analysis at high elevation. Moreover, the effective resolution of the original satellite retrievals may be slightly coarser than the grid spacing, and the user is cautioned that features at the km-scale may be too smooth. Direct use of time series at single grid points is possible but systematic errors may be considerable.

Even though, the use of homogenous station data reduces spurious variations from changes in measurement conditions, the grid dataset itself cannot be regarded as fully homogenous. Firstly, there are variations in the station network over time. These are relatively small overall between 1981 and 2010, but they may become evident in regions where stations have been put in place or were closed down. Secondly, the station series may contain inhomogeneities from more recent station changes because a correction can only be effected after sufficiently long measurements under new conditions. These latter problems are confined to the analysis of the most recent years.

Related products

SrelD: Daily relative sunshine duration using the same method (yet with different configurations) like for SrelM / SrelY. Note that averaging the daily analyses of SrelD does not reproduce SrelM and SrelY, because the maximum sunshine duration varies through the months / year and because there are non-linearities in the analysis procedure.

SanomM9120 and SanomY9120: Anomalies of monthly and yearly sunshine duration, relative to the mean of 1991-2020. These datasets are derived with the same method (yet with a slightly different configuration) and with homogeneous station time series. For users requiring long-term climate consistency, these anomaly products are preferred over SrelM/SrelY.

Monthly and yearly 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

SrelM and SrelY are available in the following grid structure:

ch02.lonlat, ch01r.swiss.lv95, ch.cosmo1.rotpol, ch.cosmo2.rotpol, ch.cosmo7.rotpol (analyses on cosmo grids are provided upon special request only)

Versions

Current versions: SrelM v1.2, SrelY v1.2

Previous versions:

SrelM v1.1, SrelY v1.1: These versions use a previous compilation of the MSG clearness index and predictor sets (Principal Components) from a shorter time period. (This version was not distributed outside MeteoSwiss)

Update cycle

SrelM is updated every month. The analysis for a month is usually available at the beginning of the following month. SrelY is updated every year and is available in early January.

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