SOLAR ENERGY POTENTIAL IN COMPLEX TERRAIN (SWITZERLAND)

SUMMARY

Title
Solar energy potential in complex terrain (Switzerland)

Service
MSG SEVIRI-based Solar Energy Mapping including the radiative effects of topography and bright surface targets, by use of the Heliomont algorithm

End users
Renewable energy companies, communal and regional infrastructure planners, home owners, architects, climate research scientists, agriculture (farmers, wine growers), regional NWP and climate modellers

Intermediate users
- Solar energy professionals
- Electricity grid operators
- Government agencies
- Agricultural and hydrological modellers
- Solar cadastre builders
- Private meteorological companies

Application(s)
Climate monitoring and analysis; generation of climatology

Models used
Total column water vapour and ozone data from the operational forecast and the ERA interim reanalysis provided by the European Centre for Medium Range Weather Forecasts (ECMWF)

Climate data records used
Ground-based surface solar irradiance measurements of the SwissMetNet national meteorological observation network and the global Baseline Surface Radiation Network (BSRN), for development and validation

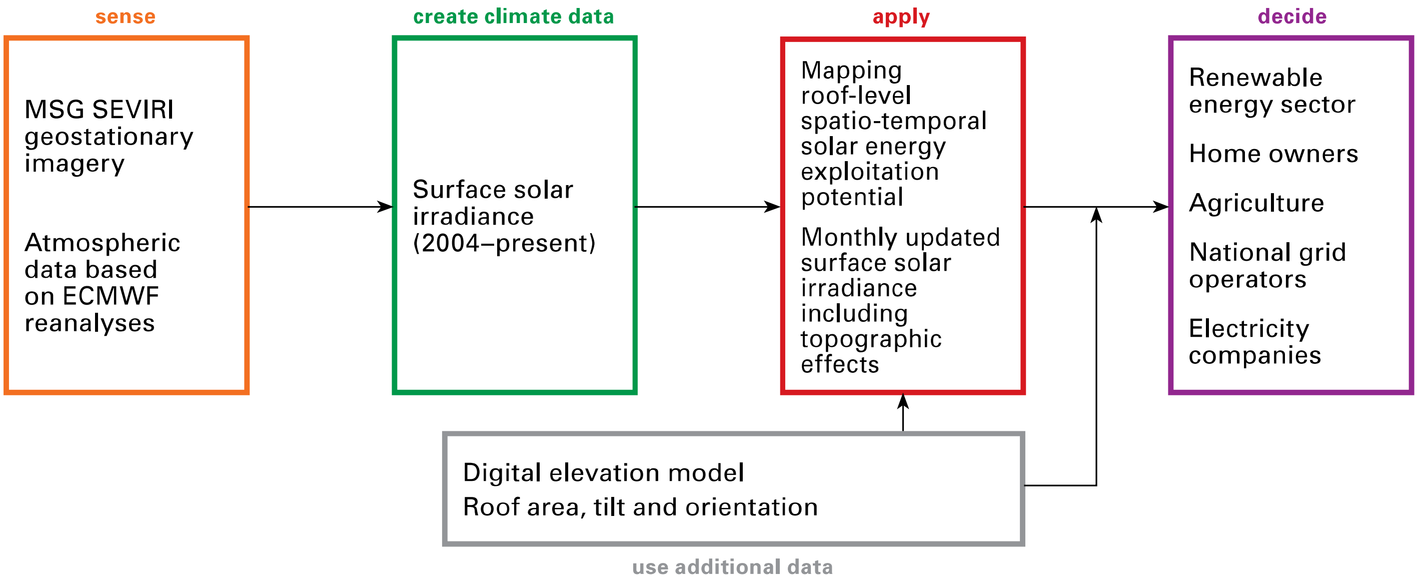
Satellite observations used
MSG SEVIRI inter-calibrated radiances from the High Resolution Visible and 0.6, 0.8, 1.6, 10.8, 12.0 μm channels, at 15-minute temporal resolution

Agencies that produce records
- EUMETSAT (MSG SEVIRI) and ECMWF (atmospheric boundary conditions)
- MeteoSwiss (climatological solar energy maps)

Sustainability of service (demonstration or ongoing)
- Operational service: monthly mean and anomaly radiation maps for Switzerland
- Demonstration service: Near real-time direct beam diffuse and direct normal irradiance for customer-defined areas in Europe and Africa

Solar panel

INFORMATION FLOW



DESCRIPTION

Description

Renewable energy sources have started to play an increasing role in the energy infrastructure of our society. However, compared to traditional energy sources, the production, transport and use of renewable energy from solar, wind and hydropower has a higher dependency on meteorological and climatological boundary conditions. Therefore, the precise knowledge of such conditions and their variability through space and time is important in order to optimize decentralized production, to synchronize it to actual usage and to secure the stability of networks which transport energy across national boundaries. Supporting the energy sector with knowledge and tailored information useful for planning and operational purposes is one of the activities of the National Centre for Climate Services (NCCS) of Switzerland, which the Centre implements according to GFCS recommendations.

Geostationary satellite data has complemented sparse station-based Surface Solar Irradiance (SSI) measurements since the early 1980s, particularly for mapping spatio-temporal solar energy potential. Compared to monthly mean station-based SSI measurements, the Heliosat method (Cano et al. 1986) can achieve uncertainty levels of below 5%.

The availability of a scientific method does not, however, guarantee consistent and continuous multi-decadal climate data records. Very few SSI climate data records exist that provide a climatologically homogeneous time series between heritage satellite systems (such as Meteosat First Generation (MFG) Meteosat Visible and InfraRed Imager (MVIRI)) and more recent systems (such as Meteosat Second Generation (MSG) Spinning Enhanced Visible and Infrared Imager (SEVIRI)). Heliosat, like other satellite-based retrieval algorithms, makes the simplified assumption of a plane-parallel dark surface target which offers visual contrast to bright clouds. These basic requirements are not met in complex, snow-covered terrain, such as the Swiss Alps and other high-altitude and high-latitude areas. MeteoSwiss thus engages as a partner of the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) to further develop algorithms and climate data records that satisfy climatological homogeneity criteria and can be used in all terrain. A 28-year SSI climate data record (1983-2010) covering the entire Meteosat disc has been produced (Posselt et al., 2012). MeteoSwiss has also developed the Heliomont method (Stöckli, 2013).

Heliomont derives SSI maps from MSG SEVIRI data, model data of total column water vapour and ozone data from the operational ECMWF forecast and the ERA interim reanalysis. SEVIRI data are used at 15-minute, hourly, daily, monthly and yearly intervals. Special care is taken over snow-cloud separation using infrared channels and topography shading effects at the sub-kilometre spatial scale (Figure 1). Monthly updated visualizations of SSI mean and anomaly data across Switzerland are publicly available (MeteoSwiss, 2015). Monthly updated SSI mean and anomaly data at 2-km resolution for Switzerland are available through the MeteoSwiss data subscription service. Near real-time direct and diffuse normal irradiance at 15-minute intervals, downscaled to 25-m spatial resolution for a customer-defined geographic region within Europe and Africa is currently in demonstration mode and can be provided on request.

The Heliomont climate data records are available for the MSG period since 2004. It features realistic SSI estimates for mountainous regions with the highest SSI levels occurring over snow-covered mountain peaks (Figure 1). The real socioeconomic value of such a satellite-based SSI dataset was demonstrated for two Alpine regions during the EU Interreg project PV ALPS. This project created solar potential maps for regional decisionmakers by merging the Heliomont climate data records with land-use planning and photovoltaic power production estimates. As a consequence, the Heliomont climate data records are now applied in a country-wide solar cadastre showing the roof-level photovoltaic and solar heating potential for the whole of Switzerland (Figure 2). They also support national climate monitoring activities (Figure 3), are used for deriving agricultural suitability maps, and enable the evaluation of the COSMO NWP model.

References

Cano, D., J.M. Monget, M. Albuisson, H. Guillard, N. Regas and L. Wald, 1986: A method for the determination of the global solar-radiation from meteorological satellite data. *Solar Energy*, 37:31–39.

MeteoSwiss, 2015: http://www.meteoswiss.admin.ch/home/climate/present-day/monthly-and-annual-maps.html.

Posselt, R., R.W. Müller, R. Stöckli and J. Trentmann, 2012: Remote sensing of solar surface radiation for climate monitoring – the CM-SAF retrieval in international comparison. *Remote Sens. Environ.*, 118:186–198.

Stöckli, R., 2013: *The HelioMont Surface Solar Radiation Processing*. Scientific Report 93, MeteoSwiss.

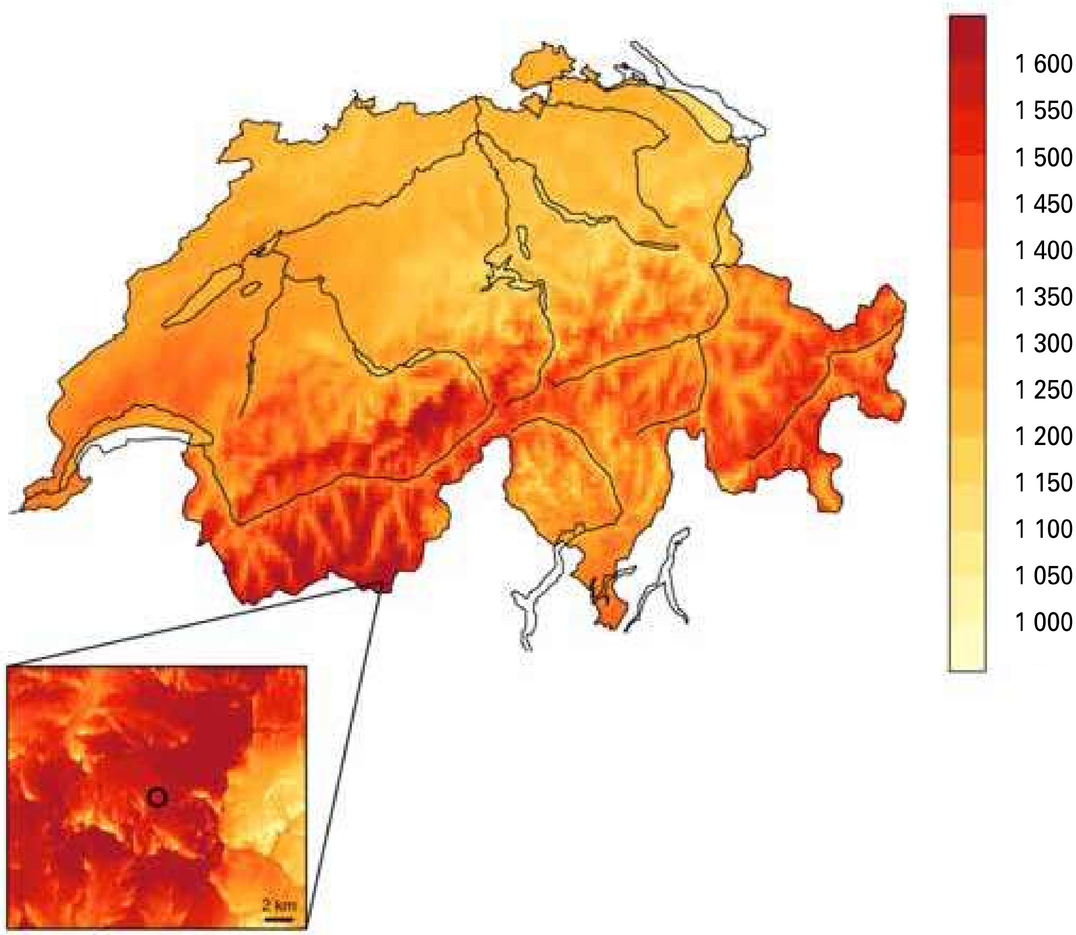


Figure 1. Annual mean surface solar irradiance (kWh m^{-2}) for Switzerland calculated from MSG SEVIRI data using the Heliomont method; cropped area: 25-m resolution downscaled data including the local-scale radiative effects of topography surrounding the Monte Rosa alpine hut (circle)

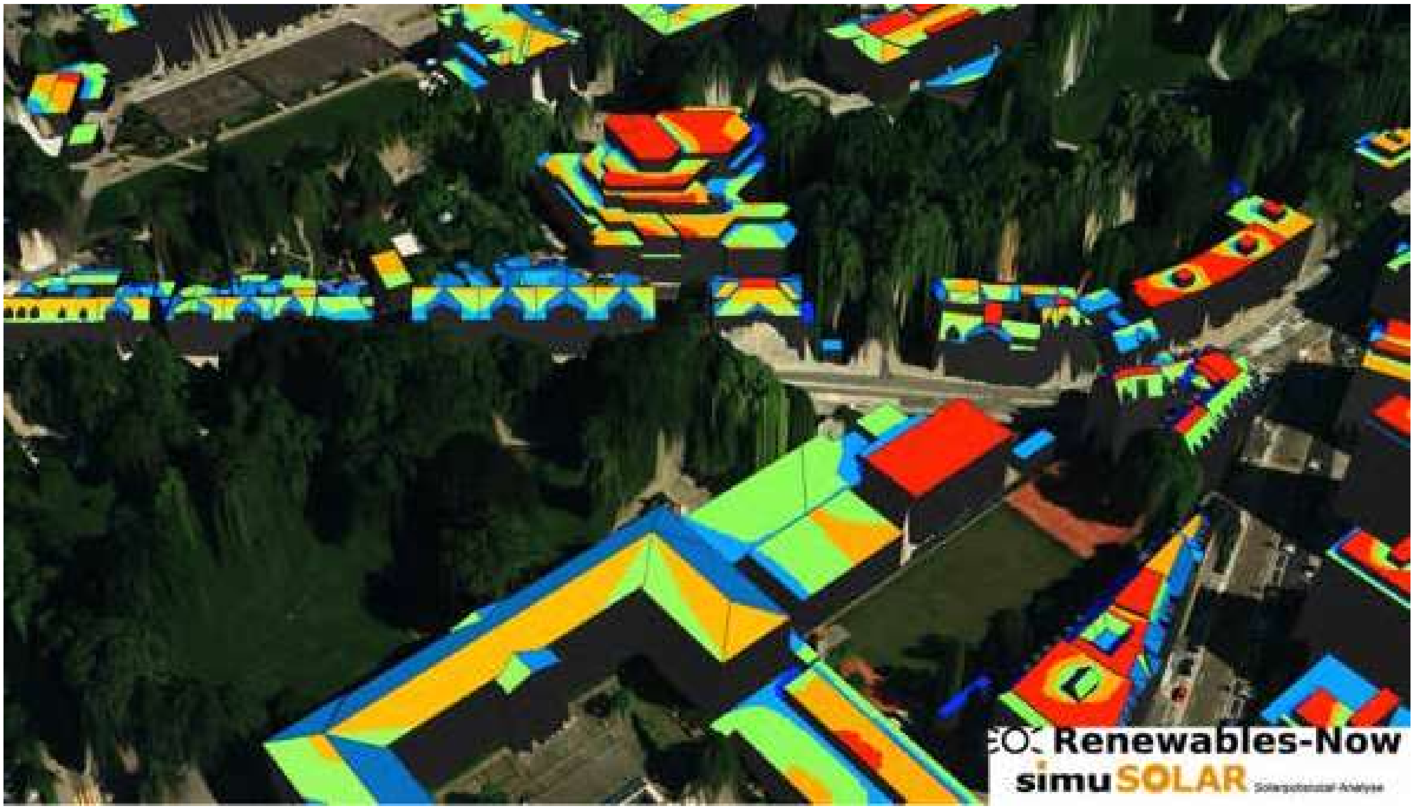


Figure 2. Roof-level suitability map for photovoltaic power production in the city of St Gallen, Switzerland, calculated from MSG SEVIRI data using the Heliomont method (red = highly suitable, orange/yellow = suitable, green = marginally suitable, blue/grey = unsuitable) (Visualization: © simuPlan)

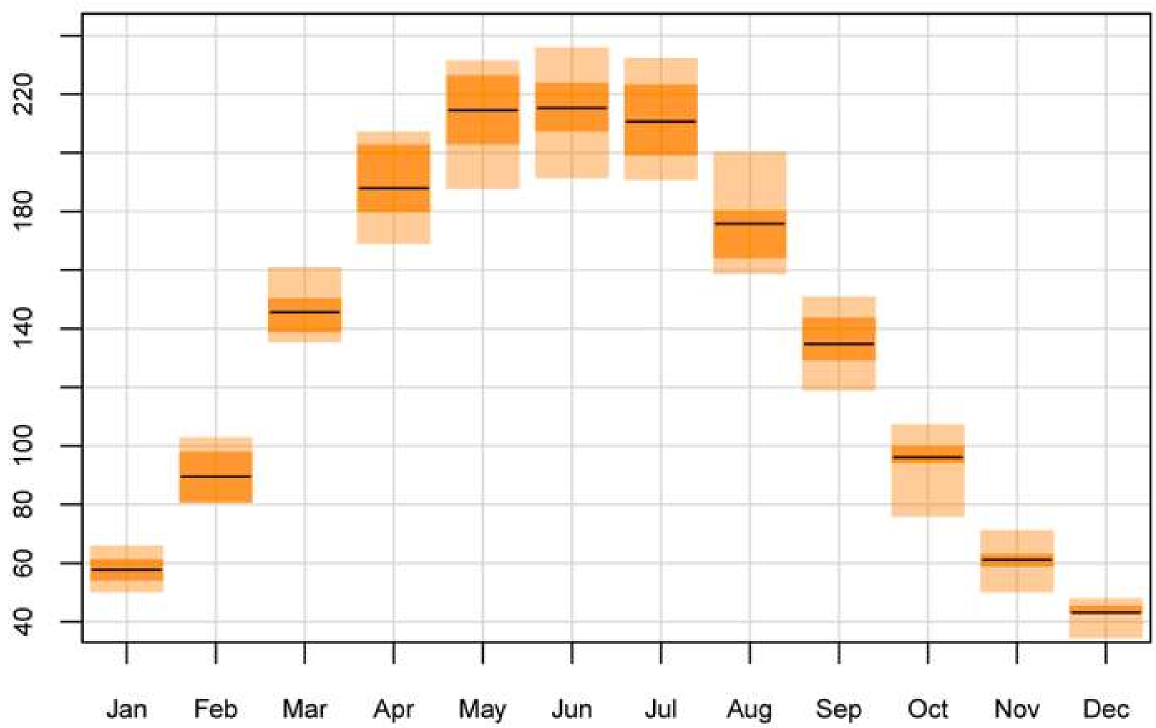


Figure 3. Seasonal course (black lines) and interannual variability (yellow shading) of the monthly surface solar irradiance (kWh m^{-2}) at the Monte Rosa alpine hut (hut location shown in Figure 1)