Satellite data and ground-based instruments for the estimation of solar irradiance at roof level in the Alpine region.

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Introduction and context

The estimation of solar radiation at ground surface plays a primary role in planning solar energy systems in urban environment. The atmospheric composition strongly influences the amount of surface incoming shortwave radiation (SIS) through absorption, reflection and scattering from trace-gases, clouds and aerosols.

Several methods have been developed for retrieving surface global irradiance using satellite observations. At the best of our knowledge, none of them has a spatial resolution capable of describing the PV potential at roof level. Moreover the evaluation of SIS in the Alpine region is still an open issue because in mountainous areas it is necessary to include snow cover detection, special treatment of clouds above snow, image georeferencing and correction of terrain effect.

Objectives

1. Estimation of the **surface incoming shortwave solar radiation in an Alpine town** considering sun position and terrain effect.
1. Evaluation of the atmospheric **extinction** of solar radiation as accurately as possible, by radiative transfer models, ground based instruments and satellite data. Both polar orbiting and geostationary satellites will be exploited.

Results

1. A **WebGIS** for the Alpine town of Bressanone (Italy) showing the classification of the buildings according to the amount of yearly solar radiation.
2. Innovative formulation of existing methods for the evaluation of solar radiation in mountainous areas. The monthly climatological values of atmospheric turbidity will be replaced with daily measurements of atmospheric parameters.

Method

We describe atmospheric influence on SIS at three detail levels:

1. We calculate clear sky irradiance through GIS (Geographic Information Systems) instruments by considering **topographical and geometrical effects**, afterwards we correct it on monthly basis with the broad-band solar irradiance measured by a pyranometer at ground level;

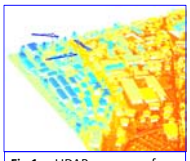

Fig.1: LIDAR survey from which the digital surface model (DSM) was obtained. A 3D model of the town is required to account for terrain effect on solar irradiance.

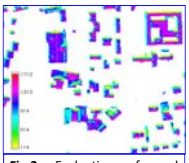

Fig.2: Evaluation ofannual amount of solar radiation (photovoltaic potential) over buildings. The cadastral map was used to identify the buildings.

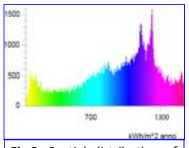

Fig.3: Spatial distribution of photovoltaic potential over buildings. It was used to fix the thresholds used in the classification of the buildings.

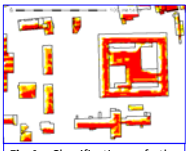

Fig.4: Classification of the buildings of Bressanone in 4 classes according to the total yearly amount of solar radiation (kWh/m² year).

2. We describe the role of atmospheric composition in SIS. We use a **radiative transfer model** (RTM) to compute the spectral components. The RTM receives inputs from both ground based instruments and from satellite data. For this purpose we installed a new sun-photometer in Bolzano;

Fig.5: Sun-photometer installed by the Institute for Applied Remote Sensing of EURAC in July 2011 in the airport area of Bolzano (Italy). It is the first AERONET site at low altitude in the Alpine region.

A **sun-photometer model CIMEL CE 318** was installed in Bolzano. It is part of **AERONET**, which is an international network of ground instruments for the measurement of microphysical, optical and radiative properties of atmospheric aerosol. The AERONET data processing and the dissemination of the products is performed by NASA. It is also possible to analyze the rough data collected by the instrument for more specific applications.

3. We analyze and validate over Alps solar radiation products developed in the framework of CM SAF (Satellite Application Facility for Climate Monitoring). According to the validation results we use a more extended data-set from METEOSAT Second Generation satellites and integrate it by using high-spatial resolution MODIS data to describe atmospheric composition.

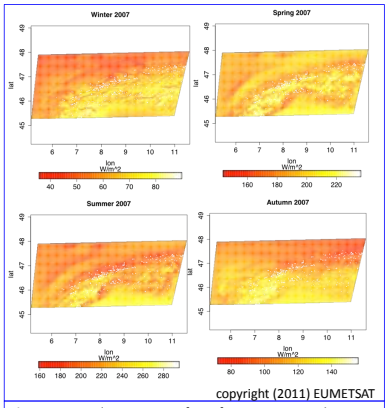

Fig.6: Seasonal averages of surface incoming shortwave radiation (SIS) in the Alpine region in 2007 (different scales are used to highlight the SIS distribution).

The validation of this product of CM SAF will be performed by exploiting the existing network of pyranometers in the Alpine region. When a proper calibration procedure was not followed for several years, the reliability of the measurements will be tested by reference tools.

Conclusions

An high accuracy solar radiation product is in development specifically for complex topography areas.

Scientific results will be accessible for exploitation into new products. Mountainous areas will take advantage of new systems for **planning and monitoring solar energy systems**.

The model developed for an Alpine town will be generalized for any mountainous site. Furthermore it will be applied to **meteorological scenarios** to evaluate the impact of climate change on photovoltaic industry.

This model could significantly facilitate a first assessment for possible future installations and it could help different actors in the PV environment, like developers, installers, financing institutions, as well as decision makers and customers.

An easily accessible WebGIS is used for the dissemination of results. The first data published on this easy to access and interactive tool is the classification of the buildings of Bressanone according to yearly clear sky irradiance corrected with ground pyranometric measurements. New information will be available together with new scientific results.

WebGIS for Bressanone

Fig.7: Screenshot from the solar WebGIS for Bressanone. The active layer shows in red the buildings whose area belongs for more than 50% to the first class of solar potential. The technical implementation of the WebGIS was completely done with Open Source GIS Software.

Main components of the WebGIS:

- Openlayers
- Ext JS
- GeoExt
- Geoserver
- GeoWebCache
- PostgreSQL
- Google Maps API

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