

SATELLITE DATA SET FOR SOLAR AND WIND RESOURCE ASSESSMENT A CASE STUDY: PORT OF CROTONE IN SOUTH OF ITALY

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Abstract: In this work we define a methodology within the context of the Calabria Region, in the port of Crotona (Figure 1), and we define for it a model for the integrated management of energy from renewable energy sources, such as solar and wind. Satellite data can provide information to determine solar and wind energy production potential cheaper than usual observational activity to identify and assess suitable areas. Here, we present a case study for both energy resources assessment from satellite in harbours.

Keywords: solar energy, wind energy, coastal site, remote sensing

1. INTRODUCTION

Coastal sites in Italy have the advantage of favorable climatic conditions to use mix of renewable energy sources, such as solar and wind. For wind energy, harbors have some advantages: they are safe places where to install wind turbines, wind conditions are almost offshore, and wind and wave energy can be integrated, by estimating the environmental parameters of the weather character identified in the port area in order to determine the potential in terms of wind and solar energy. Generally, in the Mediterranean area, there is a lack of available data because the buoys are sparsely spread and with a large amount of missing data, therefore the mapping of the wind and solar radiation has need of alternative data sources including remote sensing sensors.

In this study we computed potential solar energy using as input DSSF (Down-welling-Surface Short-wave-Flux) data products from MSG-SEVIRI (Meteosat Second Generation Spinning Enhanced Visible and Infrared) instrument. In a previous paper [1], the estimated DSSF product derived from the Land Surface Analysis Satellite Application Facility (LSA-SAF) has been validated with in situ data stations and the results showed a difference of about 55W/m² and 87W/m², for clear and cloudy sky conditions between instantaneous satellite estimates and ground measurements, respectively.

We show the maps at the Crotona port of the electrical reproducibility using a theoretical PV Plant. Wind speed in the Mediterranean area was retrieved from March 2002 to April 2012 using ENVISAT ASAR scenes acquired in Wide

Swath Model [2], [3]. The ANSWRS 2.0 software produces per default wind speed fields initialized using wind directions determined by the Navy Operational Global Atmospheric Prediction System (NOGAPS) models interpolated in time and space to match the satellite data [4], [5]. Results are compared with hourly measurements of 10m mast, located at the coastline and, belonging to the marine network of sensors of ISPRA (Institute for Environmental Protection and Research) [6].

Space-borne remote sensing, can provide information to determine energy production potential of both solar and wind reducing the financial resources currently required for the observational activity needed to identify and assess suitable areas [6]. Here, we present a case study for wind and solar resource assessment from satellite in harbors.



Figure 1. The site is located at 600 m from the coastline in open position into one of three main planes of the region. The area is flat but influenced by both Valley/mountain (anthropic pressure) and Land/sea breeze.

2. DATA AND METHODOLOGY

2.1 SOLAR RADIATION, MSG SEVIRI

We retrieved the DSSF from the MSG-SEVIRI instrument developed by LSA-SAF, over the Calabria Region for a period from October 2013 to June 2014. A

standard day consists of 48 files in HDF5 format, one image every 30min [7].

Analyses were carried out in the original projection and spatial resolution of the DSSF products in order to reduce the impact of data re-sampling caused by re-projection, and data were extracted at Crotona area.

The DSSF products are estimated by three short-wave SEVIRI channels (centred at 0.6, 0.8, 1.6 μm) at a spatial resolution of 3km [7]. Different parametrization procedures for clear and cloudy sky conditions were developed for this algorithm because DSSF is strongly depended on solar elevation and cloud coverage. In previous study, we are evaluated the solar radiation retrieval methodology in port area of ViboValentia [8] and we estimated the power production over the area. Here, we estimated the power production in Crotona harbour area using DSSF products as input and a theoretical panel with 1kWp and efficiency of 84%, with a theoretical PV power curve "SOLAR" used in the MATLAB community (power output time 10 minute).

2.2 WIND SPEED, ENVISAT

SAR images from March 2002 to April 2012 from the ENVISAT mission of the European Space Agency (ESA) Wide-Swath-Mode (WSM) were acquired over the Mediterranean area around Italy. The ASAR is a C-band VV and HH instrument with a 405 km swath with 150 m and 1 km resolution in wide-swath mode. Wind speed was retrieved using the Johns Hopkins University, Applied Physics Laboratory (JHU/APL) software APL/NOAA SAR Wind Retrieval System (ANSWRS version 2.0) [5].

The software uses an algorithm that employs the CMOD-5n algorithm. The algorithm creates a wind field image by passing information about polarization, ascending/descending pass, incidence angle and wind direction from the wind model data, to the CMOD-5n algorithm, and applies a land mask. The algorithm is initialized using wind directions determined by the Navy Operational Global Atmospheric Prediction System (NOGAPS) models interpolated in time and space to match the satellite data. NOGAPS data are available at 6-hour intervals mapped to a 1° latitude/longitude Grid and the wind vectors at around 10 m height. Here, we used SAR to produce maps of average wind speed $U(\text{ms}^{-1})$, Weibull parameters $A(\text{ms}^{-1})$ and k and wind power density $E(\text{Wm}^{-2})$, to 10m a.s.l. with a resolution of 0.02° grid latitude/longitude and over the South Italy domain in Figure 1.

In this study we use hourly data of wind speed and direction from a 10m ISPRA mast located in Crotona area during a two-year period 2007-2008 and we produce maps of wind speed and Energy density in the area of interest of Crotona, the two Weibull parameter A and k were estimated by fitting the SAR retrieved data providing the spatial distribution offshore the Calabria region.

3. RESULTS

3.1 SOLAR RESOURCE ASSESSMENT

After evaluating the solar radiation retrieval methodology[7],[8],[9],[10],[11], in figure 2 and in figure 3 we show the solar radiation in Calabria region and power production in Crotona port area using DSSF as input and a theoretical panel with 1kWp and efficiency of 84%.

We computed the maps in two different sky conditions: clear and cloudy.

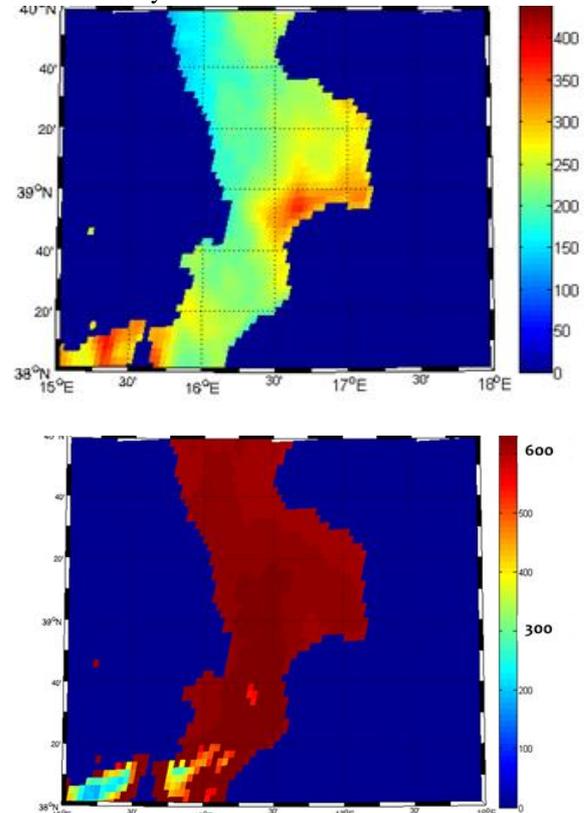


Figure 2. Map of average of the DSSF in W/m^2 of the 17 October 2015 at 12 UTC, in cloud sky conditions (top) and clear 05 October 2015 (bottom) sky conditions.

For the date and time of figure 2, MSG-SEVIRI shows an extended cloudiness over the northern part of the peninsula.

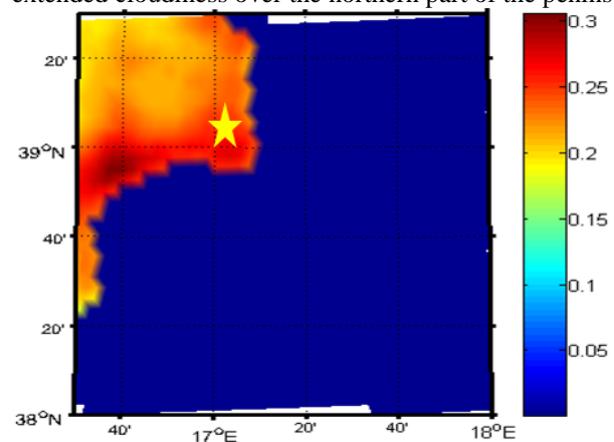


Figure 3a. Power production ($\text{kWh}/\text{kWp}\cdot\text{day}^{-1}$) in clear sky conditions during October at 12 UTC over Crotona harbour area.

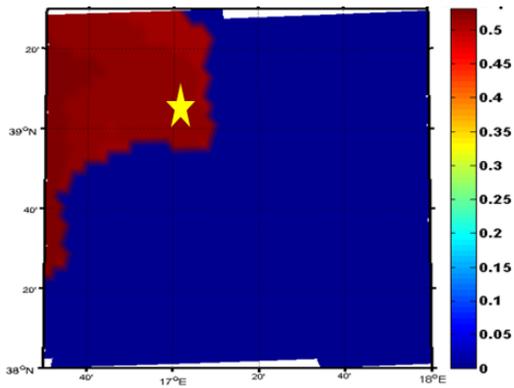


Figure 3b. Power production (kWh/kWp*day-1) in cloud sky conditions during October at 12 UTC over Crotona harbor area.

The maps of power production date and time of MSG-SEVIRI of Figure 3(a, b) shows an extended cloudiness over the northern part of the peninsula

3.2. WIND RESOURCE ASSESSMENT

The maps of mean wind speed and wind energy density from SAR scenes are produced using the Satellite-Wind Atlas Analysis and Application Program (S-WAsP) tool developed by the Technical University of Denmark (DTU) for wind resource assessment (figure 4)

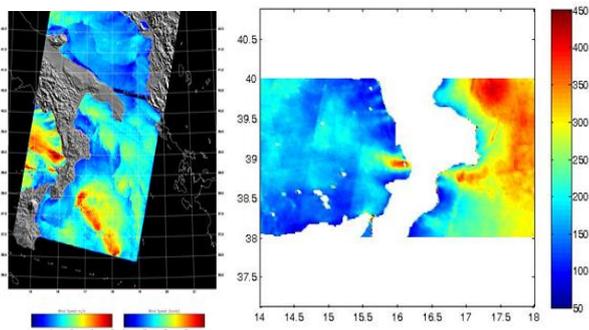


Figure 4. Wind field over Calabrian region from Envisat ASAR scenes (left). Wind power density E (Wm-2) from SAR (right), offshore the central area of the Calabria region. Period: 2002-2012.

We note in figure 4 that offshore the northern end of the Santa Eufemia Gulf the wind speed is higher than offshore at the southern end of the peninsula due to the channelling effect of the East-west oriented valley of the Marcellinara Gap[12].

Parameters	SAR	Mast
Mean wind speed (m s ⁻¹)	5.49	5.45
Mean power density[W/m ²]	228	219
K	1.69	1.74

Table 2. Comparison of the mean wind speed U and Weibull coefficients A and k from the meteorological mast at Lamezia Terme (2007-2008) and SAR (2002-2012).

Figure 5 shows the comparison of the wind climatology from SAR, offshore Crotona (see also Figure 1) where a time series was available during the period 2006-2012 at a 10 m meteorological mast. For mast data we applied a threshold 2ms-1, due to SAR tends to overestimate the mean wind speed, in fact we observed that requiring a threshold of 2m / s the sector centred on 300 ° is reduced more than the other.

The better agreement between the wind climatology between SAR offshore Crotona and the observed climatology at the harbour of Crotona is likely due to missing orographic features in the Ionian sea north of the valley.

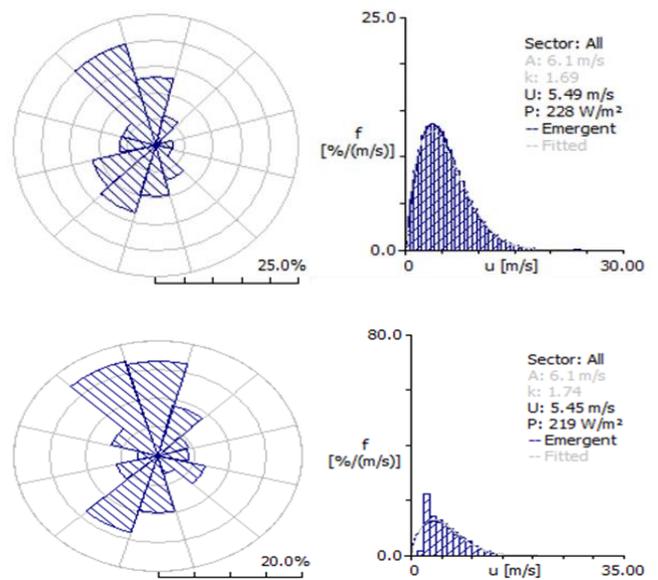


Figure 5. SAR (top) and Observed Wind Climate (bottom) from ISPRA Mast (threshold 2 ms-1). Wind roses (left) and frequency distributions (right) of wind speed and directions.

4. CONCLUSIONS

The objective of the presented study mainly concerned to evaluate the use of space-borne remote sensing to retrieve wind speed and radiation to assess energy potential of renewable sources in the harbour area of Crotona. Given the lack of in-situ measurements, we used SAR images from the ENVISAT mission of the European Space Agency ESA for wind retrieval and the DSSF products from MSG-SEVIRI for retrieval of solar radiation. For solar radiation, the DSSF product gave estimate of power production of a theoretical PV plant where measured potential electrical reproducibility. For wind speed, we found that the local orography features can impact on wind on the offshore wind spatial variability. Therefore, one should carefully choose the location offshore where to retrieve wind time series. Furthermore, low winds during inland night-time stable conditions are not represented offshore.

Acknowledgments

METEOSAT II MSG SEVIRI Principal Investigator T. Lo Feudo data are provided by LSA-SAF. SAR satellite data are provided by the European Space Agency (ESA Project n° ID 11849 – Principal Investigator: R. Calaudi. This work was partially supported by the POR Calabria 2007-2013 Asse I project “Green Ports” and “I-AMICA Infrastructure” PONa3_0363.

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