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Using remote sensing data for integrating different renewable energy sources at coastal site in South Italy

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Abstract

Italian coastal sites have the advantage of favorable climatic conditions to use mixed renewable energy sources, such as solar and wind. Harbors are safe places to install wind turbines where wind conditions are almost offshore. Space-borne remote sensing 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 harbors.

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Keywords: Remote sensing; SAR; Wind; Solar radiation; Renewable Energies

1. Introduction

To date, the policies of reducing Greenhouse Gas emissions, energy saving and a secure and efficient supply of renewable sources, are supporting the creation of “Green Ports”: i.e. sustainable port facilities with zero emissions. The Permanent International Association of Navigation Congresses (PIANC) founded in 1895 in Brussels, including port authorities around the world, has in this regard established the Working Group "Renewable Energy for Maritime Ports" [1].

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The main objective of this work is to establish a pilot within the Italian Calabria Region (Fig. 1), using the port of Vibo Valentia at the Tyrrhenian coast (Fig. 1), as a test case, within the Italian "Green Port" project. The goal of the project was to define a model for the integrated management of energy from renewable sources and energy efficiency, to reduce the impact of the port area on the environment. The main activity concerned to establish and evaluate a methodology to estimate the environmental parameters functional to assess wind and solar energy potential i.e. wind speed and solar radiation.

In this study, we used space-borne remote sensing for retrieving time series of wind speed and direction and solar radiation [2, 3, 4].

For wind, satellite observations of the ocean surface from Synthetic Aperture Radars (SAR) [5, 6] provide information on the spatial wind variability over large areas at higher spatial resolutions but at lower time resolution than scatterometers i.e. QuikScat [2, 7].

Several studies from the North Sea have shown that SAR images are a reliable source of information for estimating offshore wind climatology [2, 6]. Studies relating to the North Sea show biases compared to on-site data from weather stations as less than 5% for the average wind speed and below 7% for the parameters A (m/s) and k of the Weibull distribution, when a sufficient number of samples is available [4, 5].

This is of special interest in the Mediterranean [2, 8, 9], where spatial wind information is only provided by sparse buoys, often with long periods of missing data. In a previous study [9], a good agreement was found between the climatology from SAR and from a time series collected at the town of Crotone at the Ionian east coast of Calabria. Therefore, a possible option is to use offshore measurements to predict the climatology at a coastal site.

For solar radiation, the Down-welling Surface Short-wave-Flux radiation (DSSF) is a product available from Meteosat Second Generation Spinning Enhanced Visible and Infrared (MSG-SEVIRI). The estimated DSSF product derived from the Land Surface Analysis Satellite Application Facility (LSA-SAF) covers Europe [10] and it has been validated with in situ data stations [11, 12]. In a previous paper [13], the results showed a difference of about 55W/m^2 and 87W/m^2, for clear and cloudy sky conditions between instantaneous satellite estimates and ground measurements, respectively.

In this study, we present a comparison between the measured power production of a photovoltaic, PV, plant and the estimated power production using DSSF as input to the power curve of the PV plant. Furthermore, we use SAR data to predict the wind climatology at the harbor of Vibo Valentia. Since in-situ measurements were not available, we considered data from a site located 30 km away. Since the Calabria Region is a long and narrow mountainous peninsula with significant wind variability from one coast to the other, we discuss the influence of the orography on the offshore wind spatial variability.

2. Datasets and methodology

2.1. 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) [7].

The software uses an algorithm that employs the CMOD-5n algorithm [14]. 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° lat./long. Grid and the wind vectors at around 10 m height.

Here, we used SAR to produce maps of average wind speed U (ms^{-1}), Weibull parameters A (ms^{-1}) and k and wind power density E (Wm^{-2}), to 10 m asl with a resolution of 0.02 ° grid lat/long and over the South Italy domain in Fig. 1 below.