Wind mapping offshore in coastal Mediterranean area using SAR images

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WIND MAPPING OFFSHORE IN COASTAL MEDITERRANEAN AREA USING SAR IMAGES

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Abstract
Satellite observations of the ocean surface from Synthetic Aperture Radars (SAR) provide information about the spatial wind variability over large areas. This is of special interest in the Mediterranean, where spatial wind information is only provided by sparse buoys, often with long periods of missing data.

Here, we focus on evaluating the use of SAR for offshore wind mapping. Preliminary results from the analysis of SAR-based ocean winds in Mediterranean areas show interesting large scale wind flow features consistent with results from previous studies using numerical models and space borne wind data i.e. scatterometers with lower resolution.

In the first phase of planning prospective offshore wind farms, it is of fundamental importance to choose suitable areas worth to be explored in detail.

To find such areas, suitable information on the long-term wind characteristics i.e. average wind speed, wind speed and direction frequency distributions and spatial variability are needed, especially in the coastal zone where offshore wind has the highest spatial and temporal variability.

SAR wind field maps have the advantage of providing higher spatial information (100m) with respect to space borne wind data from scatterometers such as QuikSCAT (~ 25 km).

Motivations
We use data from ENVISAT satellite by the European Space Agency (ESA).

In ScanSAR mode, the ASAR sensor is capable of scanning in a 400 km wide swath with a spatial resolution of 100 m.

Wind speed in the Mediterranean from March 2002 to April 2012 is retrieved at high resolution using the Johns Hopkins University, Applied Physics Laboratory (JHU/APL) software APL/NOAA SAR Wind Retrieval System (ANSWRS version 2.0).

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 from the lowest model level around 10 m above the arc used.

The statistical analysis of SAR wind map, for a total of 3269 scenes, is performed with the Satellite —Wind Atlas Analysis and Application Program (SWASAp) tool developed by Risø DTU. SWASAp is a software for wind resource estimation based on SAR data.

Methodology

We presented preliminary results from the analysis of SAR-based ocean winds in Mediterranean area at a spatial resolution of 500m, suitable for estimating the coastal wind climatology. Here, we showed the wind climatology for the Mediterranean obtained using wind data retrieved for the whole ENVISAT mission.

The resulting wind maps show reliable flow patterns induced by the orography i.e. flow channeling i.e. in the Sardinia channel and in connection to the only in Valley in Italy that put in communication the Ionian and the Tyrrhenian Sea. The SAR methodology is certainly useful as a guide to indicate prospective coastal areas where to carry on detailed measurements.

Work in progress to study the accuracy of the ANSWRS 2.0 - SAR wind retrieval system, using as input the RAMS mesoscale model at 10 km resolution instead of the NOGAPS model, since NOGAPS is not able to catch i.e. the different sea breeze direction development at either sides of a peninsula narrower than its spatial resolution.

Conclusions

Wind climatology and a case study

The wind climatology of the region is characterized by a predominant easterly wind regime, which is stronger in the southern Mediterranean Sea. The wind field is dominated by the influence of the large-scale circulation, which is characterized by a general easterly flow over the Mediterranean Sea.

The wind direction frequency distribution is shown in the figure below. The wind direction data are represented in a玫瑰图, which is a circular histogram that shows the relative frequency of wind directions.

The玫瑰图 shows that the predominant wind direction is from the east, with a peak at 90°. The wind directions are also influenced by the orography of the area, with local maxima at 330° and 210°, which correspond to the Sardinia and Sicily channels, respectively.

In the case study of Crotone, the wind direction data are compared with the wind roses from SAR and observations at Lampedusa and Ustica Islands. The comparison shows a high correlation between the SAR and observation wind directions, with a coefficient of determination R² = 0.99 depending on the distance. The high correlation confirms the limit of the NOGAPS horizontal resolution in presence of opposite sides of peninsulas, is R² = 0.85.

Another example is on the NOGAPS wind direction correlations at either side of the Calabria region at two points at 45 km offshore. The coefficient of correlation between NOGAPS data wind direction of opposite sides of peninsulas, is R² = 0.85.

Also in this case, the high correlation confirms the limit of the NOGAPS horizontal resolution. Opposite winds during sea breeze days are not caught.

Preliminary results from the analysis of SAR-based ocean winds in Mediterranean areas show interesting large scale wind flow features consistent with results from previous studies using numerical models and space borne wind data i.e. scatterometers with lower resolution.

Observations. Three hourly wind data were available for the Lampedusa and Ustica Islands from the Italian Meteorological Service; hourly measurements at a 10m mast, located at the coastline, in the coastal town of Crotone were provided by the marine network of sensors of ISPRA (Institute for Environmental Protection and Research).

Figure 1 displays the wind roses from SAR and observations at Lampedusa (top) and Ustica (middle) islands, with respect to the distance. The high correlation confirms the limit of the NOGAPS horizontal resolution in presence of opposite sides of peninsulas, is R² = 0.99 depending on the distance. The high correlation confirms the limit of the NOGAPS horizontal resolution in presence of opposite sides of peninsulas.

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