Comments 1 to 5

Text edited as below to address these comments:

In this study, the Sentinel-1 A and B Level 2 OCN product produced by the European Space Agency (ESA) was validated. This product, derived from SAR observations, provides measurement of neutral surface wind speed and direction at 10 m above sea level (a.s.l.) with a spatial resolution of 1 km^2. Even though this type of analysis was previously performed in other parts of Europe (Hasager et al., 2015), it has never been conducted using both marine and coastal in situ measurements at a national scale in Ireland, which has a significant offshore wind resource (Remmers et al., 2019). Moreover, to the authors' knowledge, the Sentinel-1 level 2 OCN product has not yet been validated against in situ measurements, with the exceptions of one match-up comparison in the waters adjacent to the Korean peninsula (Jang et al., 2019). Similarly, long term statistics retrieved using this product, such as the average wind power, which is the most relevant for the wind energy industry, have never been analysed before.

The aim of this study was to validate and the Sentinel-1 A and B Level 2 OCN product against in situ measurements in Ireland and asses this data ability to describe the wind resources. First the satellite product and the study area are introduced, next the methodology is provided and finally, the results are presented and discussed.

Comment 6 to 9

Text edited as below to address these comments:

The two satellites are located on the same orbit 180° apart and at an altitude close to 700 km. In Irish coastal waters, the acquisition mode is Interferometric Wide (IW) swath using the TOPSAR technique which provide a better quality product by enhance the image homogeneity (ESA, 2019). All Sentinel-1A and B SAR images in IW acquisition mode from May 1, 2017 to May 1, 2019, in the area located around Ireland between 51°N and 56°N in latitude and 5°W and 16°W in longitude, were collected (n=5,509). The quality flag for these data ranges from 0 to 3 (0 being the best and 3 the worst) and, following visual inspection, only data with a quality flag ≤ 2 were used for the validation. The Level 2 product tiles were combined into a gridded map for the area of interest, in order to form a data cube where each pixel had a corresponding time series of measurements. The revisit rate ranges from 10 to 20 passes per month for most areas in Irish waters, which occur in the morning around 6.30 am or in the evening around 6 pm, Greenwich Mean Time (GMT) in the winter and Irish Standard Time (IST) in the summer. Figure 1 shows the number of samples for each pixel and Figure 2 shows the average daily passing time of the satellites. The impact on quality flag from landmass contamination was visible with the reduced sample size in coastal area.

Comment 10

Text edited as below to address this comment:

taken as 0.0002 m (Charnock, 1955). Table 1 gives the exact locations of these buoys and their percentage of availability

Comment 11 to 13

Text edited as below to address these comments:

The predominant wind direction on the Irish west coast is eastward, flowing from the sea to toward the land. Simulations of these type of flows have shown that for a moderate coastal slope, onshore wind speeds recorded at proximity to the shore can equate the wind speeds at sea just before reaching the coast (Bassi Marinho Pires et al., 2015). Following this principle, the wind speed derived from satellite measurement were not scaled to the weather station terrain elevation, but instead were considered as being in the same streamline and kept at the OCN product elevation of 10 m a.s.l.. The weather station data were compared with Sentinel-1 SAR Level 2 OCN wind speeds measured with the closest pixel without quality flag. Due to the complex Irish coast line and to avoid land contaminate, the OCN measurement were one or two pixels away from the shore (i.e. 1 or 2 km).

Comment 14

We will use the suggested notation.

Comment 15

We will remove these definitions as suggested.

Comment 16

We have added this text to the introduction as suggested but would also like to keep it here as it is a nice transition to the next section.

Comment 17 – 21

Text edited as below to address these comments:

3.1 Match-up comparison

The main objective of the Sentinel-1 SAR surface wind comparison with in situ data was to highlight the agreement and dissonance between the two. Sentinel-1 SAR Level 2 OCN surface wind data and in situ wind data were collocated in space and time. Since the spatial resolution of this product is very high (1 km^2) and offshore winds have a low spatial heterogeneity caused by sea surface homogeneity, the spatial resolution was slightly degraded in order to increase the number of samples. The best remotely sensed value, both in term of quality and distance, from the pixel directly adjacent to the in situ measurement (i.e. 3 km^2) was chosen for the match-up comparison.

In the time domain, each in situ measurement with the corresponding satellite measurement performed in a 30 mn time interval before or after were selected for the analysis. For all buoys, the wind speed correlation with the remotely sensed data at a one-hour time interval was around 0.99, which showed that the time difference between the satellite and in situ data does not introduce a significant source of error. Another factor in this respect is that Sentinel-1 SAR Level 2 OCN spatial averaging at the resolution of 1 km^2 may somewhat *compensate for the lack of time averaging. However, the bias due to these differences in the measurement technique, in space and time, is difficult to predict theoretically. Therefore, the bias can be caused not only by the SAR sensor intrinsic error, but also by the different scales of measurement. Another source of potential error derived from the assumption of neutral atmospheric stability when scaling the buoy data from 3 m to 10 m a.s.l using Equation (1). Hence, the overall bias needed to be evaluated empirically through a match-up comparison.*

The bias for all available data used in the match-up comparison was found to be -0.42 m s-1 and -0.39 m s-1 and the RMSE 1.41 m s-1 and 1.51 m s-1 for the buoys

Comment 22

Will use "mast" as suggested

Comment 23

Text edited as below in the introduction to address this comment:

Sentinel-1 A and B are two polar-orbiting satellites equipped with C-band SAR. This sensor which records surface roughness, has the advantage of operating at wavelengths not impeded by cloud cover or a lack of illumination and can acquire data over a site during day or night in all weather conditions. The Sentinel-1 Level 2 OCN product includes a component called Ocean Wind Fields (OWI) which is a ground range gridded estimate of the surface wind speed and direction at 10 m a.s.l, assuming a neutral atmospheric stratification, with a spatial resolution of 1 km2.

Comment 24

Values below 2 m/s can be filtered for the final document.

Comment 25

We will use "mast"

Comment 26

Here we took an average of the % of error in wind power across the 7 sites. Text changed to:

The bias and the error on the wind power assessment were increased on average by 9.14% across the 7 sites as shown in Table 7.

Comment 27

Captions updated as below:

Figure 5: Wind speed histograms of Sentinel-1 SAR Level 2 OCN (right) and in situ (left) data in m s-1 with corresponding Weibull fits for the weather buoy data compared with those produced from the SAR data at the same locations.

Figure 6. Wind speed histograms of Sentinel-1 SAR Level 2 OCN (right) and in situ (left) data in m s-1 with corresponding Weibull fits for the coastal weather station data compared with those produced from the SAR data at the same locations.

Comment 28 - 29

Text updated as below:

The results show that the percentage error on the average wind power was lowest for the coastal weather stations. This may indicate that they could be more reliable than weather buoys, perhaps due to the presence of waves and the relatively low altitude of the buoys. In that case, the error in offshore locations could be overestimated due to inaccuracies with the weather buoy data, although there is no possibility of proving this with certitude. The validation of the Level 2 OCN product should be further investigated in coastal area since land contamination and coastal topography can introduce bias. Another interesting feature is that the bias observed in the match-up comparison seemed to disappear in this climatological analysis. The main difference between the match-up comparison and the analysis performed here arises from including in situ data even when satellite data were not available. In this study, satellite data can be unavailable for two reasons: no data were recorded as a consequence of the relatively low revisit time of the satellite, or the data recorded were discarded if it was flagged as 'bad quality'. The former should not have any effect on the long-term statistics since an increase in sample size will result in a better Weibull distribution. However, the latter might actually introduce an artificial bias in the match-up comparison by limiting it to a specific type of situation in which satellite measurements are easier to perform.

Comment 30 - 31

Text updated as below:

In this section, the use of the Sentinel-1 Level 2 OCN product to assess wind resources around Ireland at 10 m a.s.l. with a 1 km^2 spatial resolution is presented. A clear separation of the mean wind speed into two different areas was clearly visible (Figure 7).

In terms of wind power, the results logically revealed a similar pattern with an increased heterogeneity, due to the fact that the wind power is connected to the cube of the wind speed (Figure 8). The northwest area had an average wind power of 700 W m-2 in comparison with 500 W m-2 for the rest of the map, resulting in an overall difference of 20% between the two areas. It is interesting to note that the central area of the Irish sea also has a significant potential in terms of wind power, although lower than that of the northwest area. Regarding coastal areas, a steep horizontal gradient was observed from the shore up to 15-20 km offshore, with the exception of the remote peninsulas on the west coast where the gradient *was much shorter or non-existent. In both analyses, the apparent swats can be attributed to the low sample size of satellite data which correlates with Figure 1. The better spatial resolution of SAR data inevitably reduces the revisiting time and therefore the sample size. With time, these artefacts will diminish as the satellite will acquires additional data.*

Comment 32

We have removed this comment re: turbulence and directional variance.

Comment 33

Comment added to captions 7 to 10 highlighting the visibility of the satellite tracks.

Comment 34

Text edited:

The results also highlighted the necessity for additional in situ validation points for satellite products and showed that there is a need to improve the Sentinel-1 level 2 OCN product algorithm at the edges of the swaths, perhaps through the application of machine learning techniques.

Comment 35

Min, max and number of samples per season will be added to Figure 9

Comment 36

We will split this section this into 'Discussion' and 'Conclusions' as suggested.

Comment 37

Text edited:

In any case, it was concluded that the Sentinel-1 Level 2 OCN product can be used to estimate the long-term wind speed distribution and the average wind power. This result could be obtained by using the method of the moments and assuming a Weibull law in order to compensate for the low temporal coverage of the satellites. Even though more investigation is needed to assess the OCN product in coastal area, this study showed that this remotely sensed data can be used to assess the wind resources in coastal areas as close as 1 km to the shore.

Comment 38

Test added:

Users should exercise caution when working with Sentinel-1 SAR data since a location-dependent error was found at the swath edges. The cause of this discrepancy could not be identified, but perhaps a machine learning technique based on a learning dataset of in situ data could be used to mitigate this effect.

Added References:

Charnock H (1955) Wind stress on a water surface. Q J R Meteorol Soc 81:639–640

ESA, 2019. *TOPSAR Processing.* [Online] Available at: https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-1-sar/products-algorithms/level-1-algorithms/topsar-processing
[Accessed 09 12 2019].