Ocean Radar for the Planning and Operational Phase of Off-Shore Renewable Energy Systems

Thomas Helzel
Helzel Messtechnik GmbH
Kaltenkirchen, Germany
helzel@helzel.com

Oswaldo López
Innova Oceanografia Litoral
Barcelona, Spain
oswaldo@oceanografialitoral.com

Lucy Wyatt
Seaview Sensing Ltd.
and University of Sheffield, UK
lucywyatt@seaviewsensing.com

Abstract* - The WERA system (WavE RAdar) is a shore based remote sensing system to monitor ocean surface currents, waves and wind direction. This long range, high resolution monitoring system is based on short radio wave radar technology. The vertically polarized electromagnetic wave is coupled to the conductive ocean surface and follows the curvature of the earth. This over the horizon oceanographic radar can pick up back-scattered signals from the rough ocean surface (Bragg effect) from ranges of up to 200 km. Results for various installations from all over the world demonstrate the accuracy and reliability of the system. The value of the provided data for off-shore applications is described, in particular for renewable energy systems.

Keywords; remote sensing, currents, waves, wind

I. Introduction of Ocean Radar "WERA"

The WERA system is a shore based remote sensing system to monitor ocean surface currents, waves and wind direction. The measurement range of these WERA depends on the operating frequency and can reach out to more than 200 km for current mapping or up to 100 km for wave measurements. The resulting data are integrated over a well defined ocean area in range and azimuth, a grid cell. The size of the grid cells depends on the allocated radar bandwidth and is typically small for shorter range systems (250 x 250m) and may exceed 3 x 3 km for the longest ranges [1]. The resulting data of the ocean surface (current vectors and wave directional spectra) from this shore based system, see figure 1, provide valuable information for the planning or operational phase of off-shore installations.

Figure 1. WERA antenna array integrated in a boardwalk at the cost of Georgia, USA (photo provided by Dana Savidge, SKIO)

II. Accuracy and Reliability

Publications about the results from systems installed all over the world have proved the accuracy of the WERA system. The accuracy of the current mapping was tested by means of comparisons between the measured data of an ADCP and the WERA system. The results from various studies typically shows an excellent correlation factor of >0.9. The comparison for wave height measured with "Wave Rider" buoys or ADCPs and the WERA system typically also show a very good correlation of about 0.9 [2, 3].

For example tidal velocities measured at the coast of Georgia and South Carolina, USA, are extremely well reproduced by the radar estimates (Fig. 2) [4].

The temporal availability of ocean surface current data provided by these systems is very high. Some users reported a long term data availability of more than 98 % of the time [5].

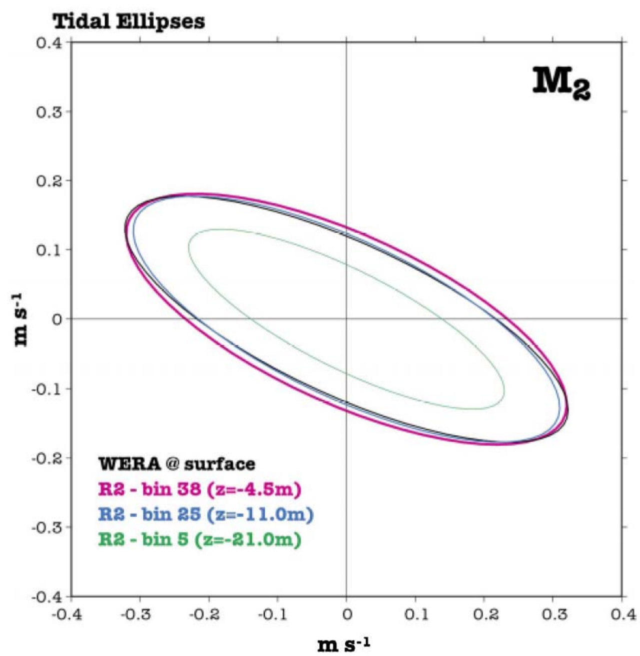

Figure 2. Estimated M2 (>12 h) tidal ellipses derived from T-Tide for radar velocities and ADCP velocities from several depths in the water column, data provided by Dana Savidge, SKIO

This outstanding accuracy and reliability makes these shore based system very attractive for operational monitoring applications.

III. Data for the Off-Shore Industry

The main data output, the ocean surface currents, can be used for various applications in the field of coastal engineering. The option to provide very reliable current drift predictions based on these data are very important in case of accidents for search and rescue and pollution management. The results of a drifter experiment ("man-over-board" simulation) shows the potential to safe lives with this technology, see fig. 3.

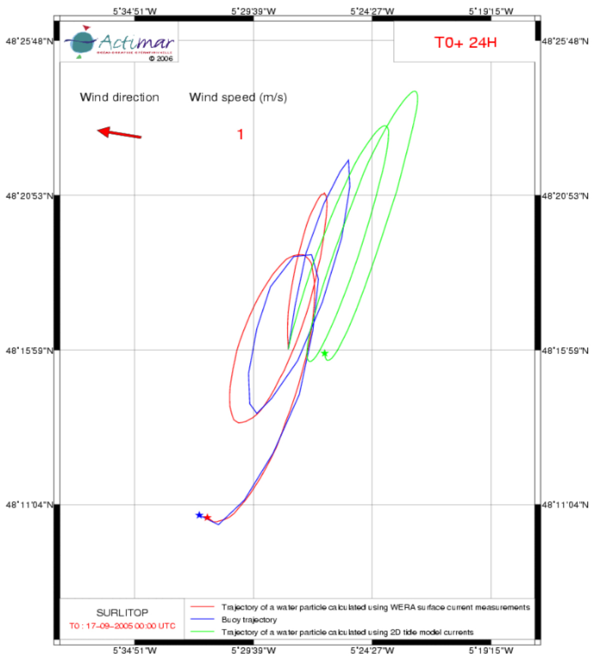

Figure 3. Drifting "person", real 24 hour trajectory in blue, prediction based on 2D tidal model in green and prediction based on measured data in red

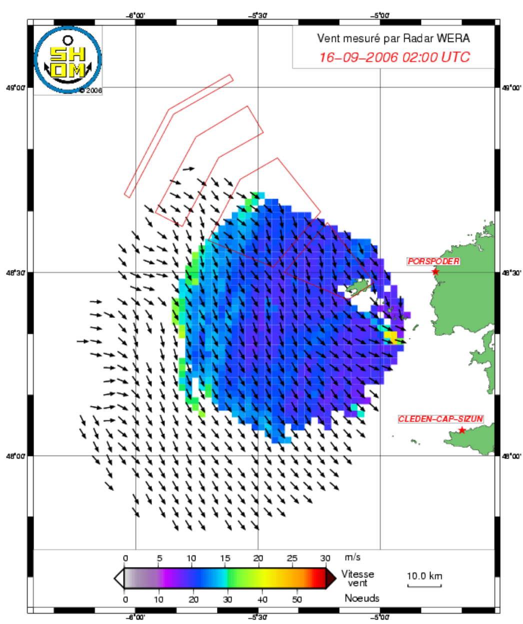

Figure 4. Map of wind speed and direction from a pair of 100 km range WERA system near Brest, France, data provided by Actimar

The excellent spatial resolution of these ocean radar systems allows for the monitoring of the spatial variability of the surface currents and thus can aid in identifying best locations for tidal stream power devices.

For other players in the marine renewable energy industry additional specific data can be provided. Information about wind fields off the coast are valuable for off shore wind farm operators. Wind directions can be measured over wide areas as shown in figure 4. Wind speed is, at present, a less robust product and under further development, but provides reasonable estimates in high winds although over a reduced range compared to wind direction These data are of course valuable for the operators of off-shore wind farms, and can also be used to provide more reliable forecasts for other users.

For wave power applications the radar can measure wave directional spectra from which maps of the wave power and direction in the monitored area can be provided.

In particular in coastal areas the wave characteristics can change within a quite short distance. That means it might be not sufficient to measure the wave data just at one point. Figure 5 shows an impressive example of this wave variability from the west coast of France near Brest. The directional wave spectra from two grid cells in a distance of 10 km show a clear difference in main wave direction and period.

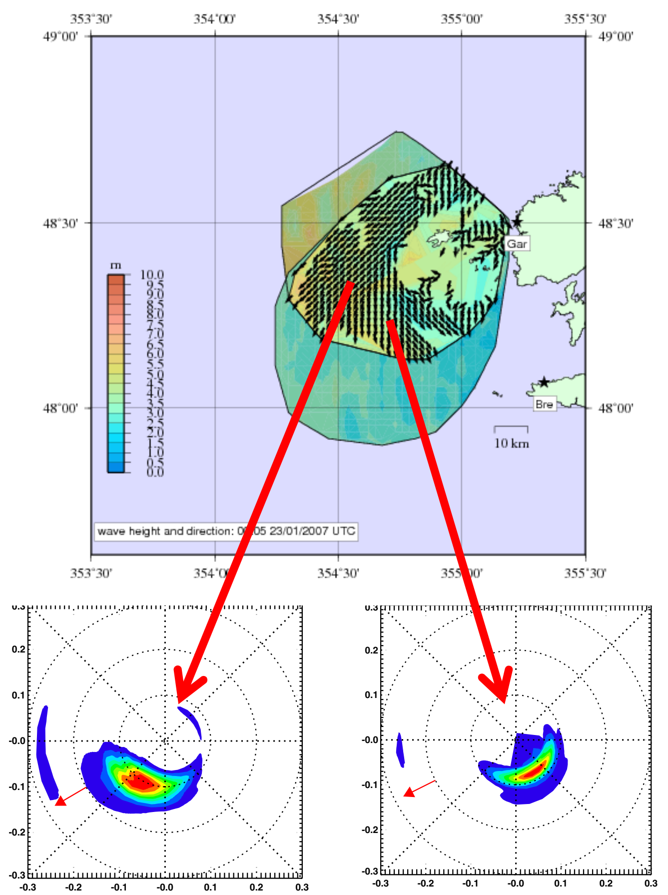

Figure 5. Map of waveheight and direction from a pair of 100 km range WERA system near Brest, France. Directional spectra are available for each arrow on the map, two examples shown.

An example of the derived wave power and direction is given in figure 6 using WERA data from the west coast of Norway [6].

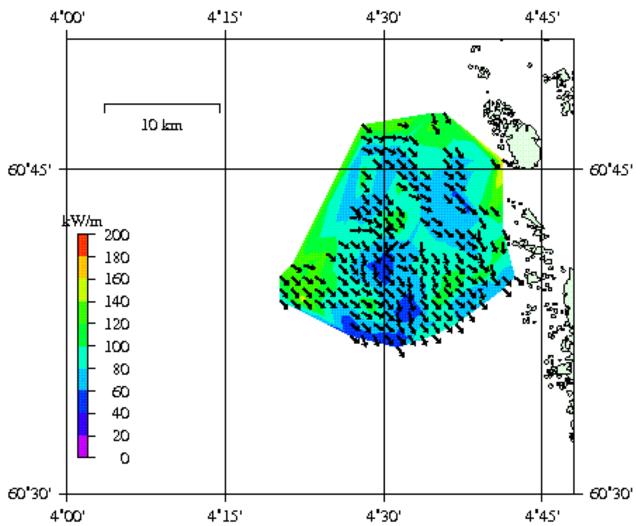

Figure 6. Map of wave power from 50 km range WERA systems near Bergen, Norway

These measurements enable monitoring of the long term behavior of the wave power and energy period, as displayed in figure 7. This figure compares the radar data (in black) with co-located buoy data (in red) showing good agreement.

IV. Conclusions

The examples presented here demonstrate the value of these data for the planning and operational phase of off-shore marine renewable installations. These data can help to optimise the installation phase and can reduce costs. It is very valuable in case of accidents and can save lives and can help to protect the environment. During the operation of the off-shore installations the improved forecasts of the ocean conditions will help to optimize the service and reduce maintenance costs. The ocean radar enables coastal engineers to use the convenience of shore based instruments for offshore projects.

Acknowledgement

We wish to thank Actimar for providing some of the data and maps. The Norwegian data were obtained during the EU-funded EuroROSE project and we thank Klaus-Werner Gurgel and all of the EuroROSE team for their contributions.

References

[1] Gurgel, et al., "Wellen Radar(WERA), a new ground-wave based HF radar for ocean remote sensing", Coastal Engineering Vol. 37, NOS. 3-4, ISSN 0378-3839, pp. 219...234, August 1999

[2] Cochin, Thomas, Mariette, and Gurgel. SURLITOP experiment in West Brittany (France): Results and validation. 6th intern. Radiowave Oceanography Workshop (ROW-6), Hamburg, Germany, May 2006

[3] Wyatt L.R. et al., "HF radar data quality requirements for wave measurement", Coastal Engineering, 58, 327-336, 2011

[4] D. Savidge, et al., "Assessment of WERA Long-Range HF-radar Performance from the User's Perspective", Proceedings of IEEE/OES/CWTM 2011

[5] Helzel, Kniephoff, " Software Beam Forming for Ocean Radar WERA Features and Accuracy", IEEE Oceans Conference Proceedings, Seattle, 2010

[6] Wyatt L R , J J Green, K-W Gurgel , J C Nieto Borge , K Reichert, K Hessner, H Günther, W Rosenthal, Ø Saetra and M Reistad,."Validation and intercomparisons of wave measurements and models during the EuroROSE experiments", Coastal Engineering, 48, 1-28, 2003.

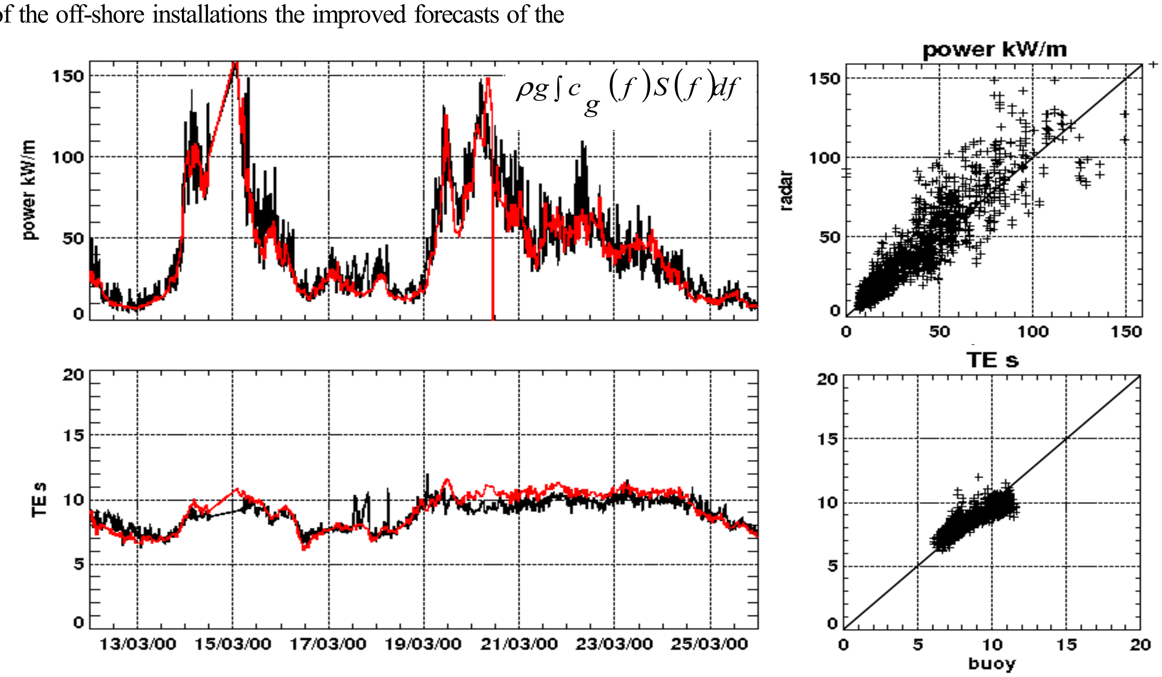

Figure 7. Time series of wave power and energy period of the same system as above