Remote ocean sen

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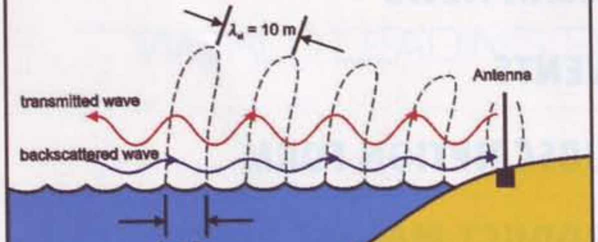
Coastal radar has become an increasingly important monitoring tool for hazard management and environmental protection


WERA transmitting array near Brest, France

During the past few years remote ocean sensing by HF (high-frequency) radar has become more and more valuable to modern coastal management. It offers an insight into the dynamics of the coastal seas for a variety of applications without ever leaving dry land. For example, search and rescue (SAR) operations can narrow down the search radius for people lost overboard, port authorities can use the data to improve vessel traffic services and, in the case of oil spills or lost containers, it can be an important tool for environmental protection. Even the marine renewable energy sector has discovered the advantages of using this reliable technology.

Diverse studies prove the benefits of using HF radar for hazard management and an increasing number of countries are relying on the technology by integrating it into their ocean observing networks. One of the leaders in the field of HF radar is Helzel Messtechnik GmbH, which provides the shore-based remote ocean sensing system WERA (WavE RAdar). This system contributes to coastal management by monitoring surface currents, wind direction and wave parameters with the highest spatial and temporal resolution.



Principle of ocean backscatter due to the Bragg effect

OCEAN RADAR

The WERA long-range, high-resolution monitoring system is based on short radio wave radar technology. The vertically polarised 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 more than 200 kilometres. The concept of the WERA system was developed at the University of Hamburg by Gurgel et al in 1995 and the hardware development was completed in 2000 at Helzel Messtechnik GmbH. Results from more than 50 installations worldwide demonstrate the features and flexibility of the system – high-resolution monitoring with a range cell size of 300 metres for short ranges or three kilometres for long-range applications, all generated with the typical high temporal resolution of 10 minutes. As it is a very flexible system, it can be adopted to the user's needs and requirements, as well as optimised to site-specific conditions.

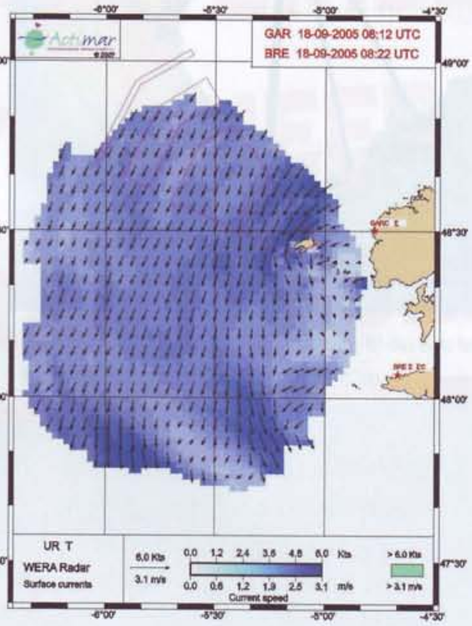
ACCURACY AND RELIABILITY

A pair of WERA ocean radar stations have been delivering data from an extremely dynamic ocean area off the French coast near Brest since 2006. The range of these systems is about 120 kilometres with a spatial resolution of 1.5 kilometres and a temporal resolution of six measurements per hour. These two shore-based stations

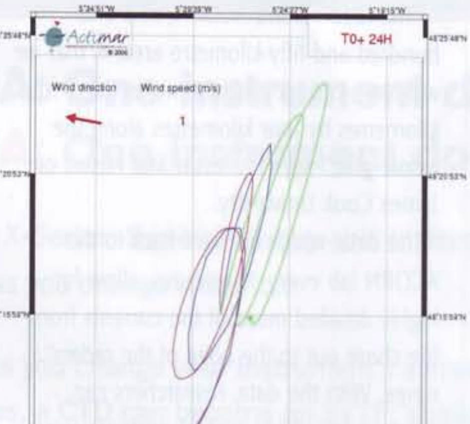
sing by HF radar

cover an ocean area of around 10,000 square kilometres. The systems provide real-time maps of ocean surface currents and significant wave height for vessel traffic services and oceanographic research.

Over a period of three months a study was carried out to validate the quality of the data provided by means of a comparison with buoy data. Furthermore, the reliability was quantified by comparing the users' requirement for data availability with the resulting data. The accuracy and reliability was studied by SHOM (Service Hydrographique et Océanographique de la Marine), France, using an ADCP and a Waverider buoy for ground truthing. Both instruments were located approximately 30 kilometres off the coast. The corresponding correlation between the ADCP and WERA data shows a correlation coefficient of 0.947. This excellent agreement proves the accuracy of the WERA system to measure ocean surface currents.



Surface current map with averaging time of 12 min and 1.5km range cell size at the French coast near Brest (image kindly provided by www.actimar.fr)



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

SEARCH AND RESCUE

To test the technique for SAR applications, surface drifters were launched and tracked. The drift prediction for this simulated "man-over-board" situation was carried out by means of a 2D tidal model typically used for the SAR operations and by a drift prediction based on the ocean currents measured by the WERA systems. Currently, search and rescue tools are based on hydro-dynamic and atmospheric models to provide hindcast and forecast situations. Even if these oceanic numerical models are efficient in the production of instantaneous maps of currents, the accuracy of derived Lagrangian trajectories has limitations for search and rescue purposes. Results of the SAR-DRIFT project show the significant improvement of the drift simulation when using real-time current data provided by radar systems instead of using results from numerical models. This improved quality in the drift prediction can be very useful for search and rescue applications.

This drift prediction can also be used to forecast the drifting of oil spills or lost containers to make the management of the pollution more effective. Furthermore, in the case of oil pollution the tool can be used to trace back the course of any detected pollution so as to identify the origin and time of the spill.

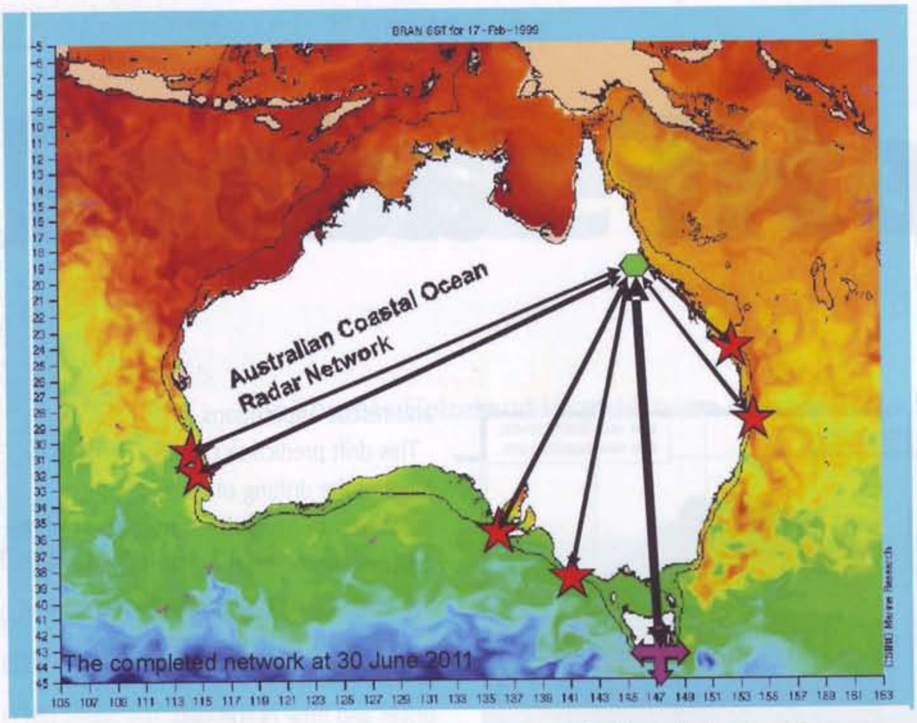
In connection with the SAR-Drift project [Røang, 2009], two in-situ experiments were carried out in Norway and France with drifting objects. With the help of the Navy in both cases, models of containers and a real container were left to drift in the area of coverage by HF radars. The current-induced drifts of the objects were first predicted using forecast models, and then re-computed using currents from the radar measurements. All the results show a very good agreement between the observed trajectories and the radar-computed ones, while the predicted drifts without radar data rapidly diverge from the real trajectories.

This emphasises the importance of HF radars for search and rescue operations, especially in dynamic ocean areas. After an accident, an accurate estimation of the location of an object or body can be obtained using HF radar.

HF RADAR AS PART OF NATIONAL OCEAN OBSERVING SYSTEMS

Another trend can be seen in the integration of HF radar into national ocean observing systems. Examples of this are the German ocean monitoring system (OMS) on the North Sea coast and, on a larger scale, the Australian Coastal Ocean Radar Network (ACORN).

As part of the Integrated Marine Observing System (IMOS), Australia is establishing a unique coastal ocean radar



The Australian Coastal Ocean Radar Network (ACORN). Red stars are HF radar sites (pairs of stations), the green hexagon is the ACORN laboratory in Townsville, the purple cross is the IMOS headquarters and the location of the staff running the IMOS data archive

network. Formally called the Australian Coastal Ocean Radar Network, it is a system with exciting implications and a potential to help many aspects of coastal ocean research and management, from coral reef restoration and tsunami warning to pollution control and SAR efforts.

In April 2007 the first WERA radar was installed on the beach of Tannum Sands, Queensland. This was followed by the installation of a second set at Lady Elliot Island, off the Queensland coast. Radars have also since been set up in Western Australia and South Australia. Over the next few years, more coastal radars will be installed at sites across Australia with more than A$5 million (GB£2.8 million) in funding allocated through IMOS.

There is potential to apply the data to the management of coastal marine resources, and to marine safety fields. Real-time maps of surface currents and the prospect of short-term forecasting have the potential to reduce search areas in coastal waters and to make pollution/spill mitigation more effective. The near real-time provision of surface currents and wave height data in a graphic format on a freely accessed website has the potential to improve the level of awareness of the maritime conditions within the community (e.g. for recreation applications). With the establishment of HF radar monitoring stations like those in ACORN, there is growing opportunity for researchers around the world to access data from well-curated archives so as to carry out basic research on physical oceanography or applications research without having direct access to the measuring facility.

"The idea behind ACORN, in a one hundred and fifty-kilometre area, is that we will have current measurements every four kilometres by four kilometres along the whole grid," says Professor Mal Heron of James Cook University.

The data, which are sent back to the ACORN lab every 10 minutes, allow for highly detailed maps of the currents from the shore out to the edge of the radars' range. With the data, researchers can create maps of sea-surface currents, wave features and ocean swells generated by the coastal ocean's intricate dynamics – factors which interact to affect everything from coral bleaching and fish migrations to pollution drift and deep ocean water movements. Describing and understanding these relatively undeciphered yet highly important shifting dynamics will help link the study of deep ocean patterns with nearshore processes.

"We have the BLUElink model, and moorings", says Heron in reference to a new national ocean forecasting programme that was recently developed by Australia's Commonwealth Science and Industrial Research Organisation (CSIRO) and other ocean observation tools. "What we haven't observed so well are the changes – upwellings from the deep ocean, or eddies (small-scale eddies that are difficult to model). We know the large-scale currents around Australia, but we don't know the interactions and the small-scale details ... what we're doing is putting in a very important basic research layer."

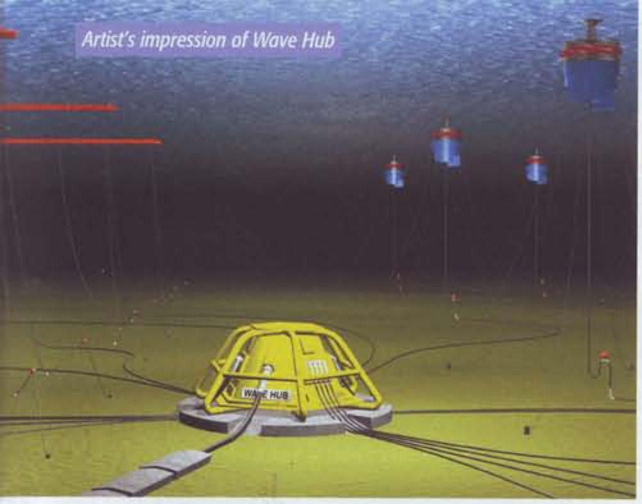
Eventually, there are plans for a public website where surface current images would be freely available. The maps will potentially benefit many sectors of the community, from marine researchers to fishermen to tourist operators and the general public, who may simply want to know what's happening in local waters. "We want to encourage community use," Heron says. "We want to be able to demonstrate at the end of IMOS that there is a community following."

BENEFITS OF HF RADAR FOR MARINE RENEWABLES

Finally, the renewable energy sector has discovered the usefulness of HF radar for measuring wave energy resource potential and to judge the influence marine renewable infrastructure has on the ocean environment.

The Wave Hub project, for example, is a groundbreaking wave power research project to create the UK's first offshore facility to demonstrate the operation of arrays of wave energy generation devices. Many different devices are being developed in the UK and elsewhere to generate electricity from the power of waves. After the devices have been tested as prototypes elsewhere, the Wave Hub will provide an area of sea with grid connection and planning consent where arrays of devices can be operated over several years.

The project will be developed approximately 10 miles (16 kilometres) off Hayle, on the north coast of Cornwall. The hub is a 'socket' located on the seabed which wave energy converters (WEC) can be plugged into. From Hayle, a cable will


Artist's impression of Wave Hub

be taken through a duct beneath the sand dunes and then across the seabed to an eight-kilometre square area within which the devices will be moored. This area will be indicated with navigational markers. A cable from the hub to mainland will take electrical power from the devices to the electric grid.

To monitor the influence of these devices on the ocean environment, the Peninsula Research Institute for Marine Renewable Energy, a joint venture of the University of Plymouth and the University of Exeter, will install two WERA systems on the north Cornwall coast to receive current and wave data on the sea area leased to the device developers. The land-based radar systems will be able to deliver valuable real-time data on ocean currents for 110 kilometres and wave data for up to 50 kilometres.

The extraction of energy by the devices will by definition change the physical environment at the Wave Hub site. The radar systems will be used to determine the magnitude of this change and to assess the nature and magnitude of far-field changes present in the shadow area in the lee of Wave Hub. In addition, they will provide the offshore wave boundary conditions for numerical simulations of nearshore and shoreline change in the Wave Hub shadow, particularly high-resolution directional wave spectra. It is also expected that Wave Hub, with its large collection of in-situ sensors, will provide an optimal site for proving the reliability of high-frequency radar systems for wave measurements.

In conclusion, it can be seen that HF radar technology has widespread potential to help many aspects of coastal ocean research and management.

ACKNOWLEDGEMENTS

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