HF radar technology, applications and accuracy

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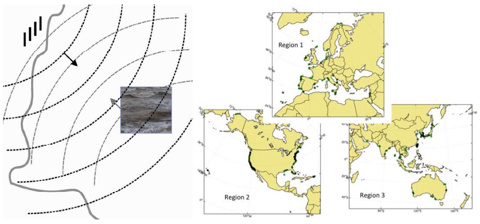
1 HF Radar

Oceanographic HF radars are normally located on the coast from where they transmit radio waves out to sea and receive signals backscattered from moving waves on the sea surface. The power spectrum of the received signal is related to the ocean wave directional spectrum through a non-linear integral equation.

They measure:

- surface current [1].
- the ocean wave directional spectrum [2] and derived [3], [4], [5] wave parameters.
- wind direction [6], [7], wind speed [8] is work in progress.



Left: radar schematic. Right: GEO-HF radar maps of installations around the globe, provided by Hugh Roarty, chair global-hfradar.org

2 Examples of HF radar systems

WERA is a German phased array radar, i.e. it has an array of receive antennas that are each phased to generate beams in required directions. Radars of this type can provide current, wave and wind maps with good temporal and spatial resolution. In the UK, the University of Plymouth operated a radar of this type. Available from www.helzel.com.

WERA Rx

G-HFDR is a newer phased array radar developed by the University of Hawaii, USA, using hardware components subcontracted to an international consortium of companies. Seaview have installed metocean software for two of these systems in Taiwan.

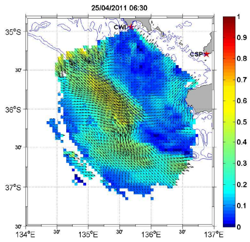
Left: Tx, Rx box Rx array Taiwan
Right: power box

Pisces was a Neptune Radar (UK) phased array radar with a waveform and antennas designed specifically for long range and wave measurement. Used in some Seaview wave validation work. Sadly no longer available.

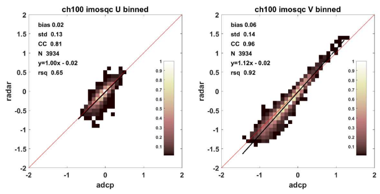
SeaSonde is a US system with a compact receive antenna which means it is easier to install and also has a wider field of view. It can measure hourly-averaged currents and provide limited wind and wave information within the first few kilometres of the radar sites. No systems currently deployed in the UK. Available from www.codar.com

SeaSonde Rx

3 Surface Currents



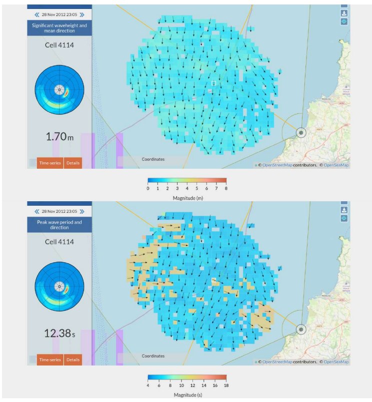
WERA surface current map from South Australia. Speed in m/s.



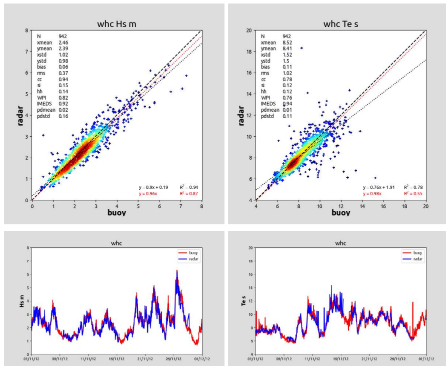
U (left) and V (right) current component comparisons between WERA and ADCP at Coffs Harbour, NSW, Australia.

Radar and ADCP data were sourced from Australia's Integrated Marine Observing System (IMOS) - IMOS is enabled by the National Collaborative Reserach Infrastructure Strategy (NCRIS).

4 Waves



Seaview data viewer maps of bimodal wave event using a WERA radar at the Wave Hub site in North Cornwall 26/11/2012 @ 13:05 Upper map is Hs and mean direction; lower shows peak period and direction; all derived from directional spectra. Example on the left (same in both panels) is from the position indicated with a small white square in the middle of the map.



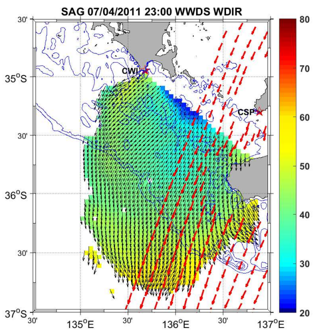
Above: Scatter plots, showing data density, of WERA radar and co-located directional waverider buoy at the Wave Hub site, significant waveheight Hs (left) and energy period T_E (right) for data in April and November 2012.

Below: Time series of Hs (left) and T_E (right), during Nov 2012.

Radar data supplied by Daniel Conley, University of Plymouth.

5 Winds

Direction and short-wave spreading

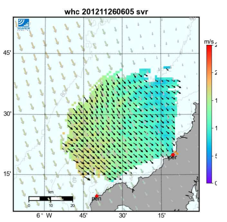


Map showing HF radar wind direction (black arrows) and short wave directional spreading (colour-coded) with scatterometer winds (red arrows) for a fetch-limited case in South Australia. WERA HF radar sites are marked with ⋆. Blue lines are depth contours. [6].

Radar data from IMOS, scatterometer data from JPL PODAAC (podaac.jpl.nasa.gov).

Speed and Direction

Seaview demonstrated the feasibility of using machine learning (ML) to obtain wind speed at the location of a wind measurement [8]. This work is now being extended with funding from the West of Orkney Windfarm, through EMEC's Offshore Wind R&I Programme, to provide wind speed mapping using data from three radar deployments, at different locations and operating frequencies, and CERRA reanalysis wind model data from Copernicus to train, test and evaluate the ML method. This work is in progress, an early result is shown here. The funding is also supporting work to increase wave measurement accuracy particularly in high seas.



ML wind map with University of Plymouth WERA radar showing spatial variability in speed (colour-coding and black arrow length). CERRA wind speed and direction arrows (outlined in grey) are scaled in length and colour-coding same as radar.

Radar data supplied by Daniel Conley, University of Plymouth.

6 Impacts on accuracy

Accuracy and availability depend on the following all of which need to be considered when setting up a radar system [1, 8, 9, 11].

- power spectrum frequency resolution
- averaging time [9]
- temporal and spatial variability in the measurement cell
- angle between two radar look directions
- inverse methods used [5]
- antenna sidelobe levels [10]
- waveheight [11]
- noise and interference levels [11]

7 References

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