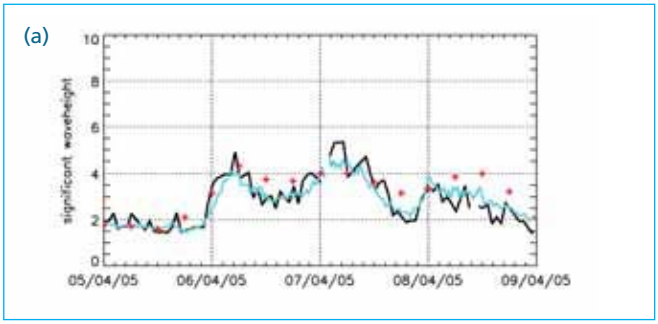
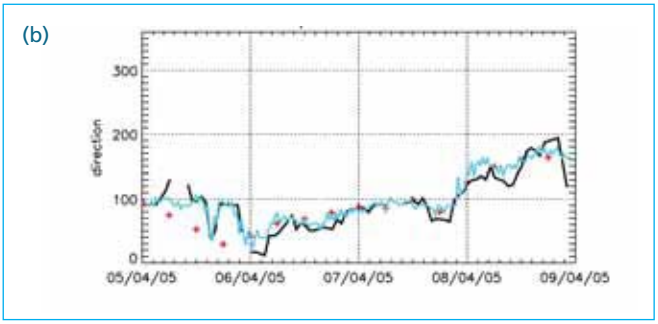
Coast to coast

Monitoring the coastal ocean surface - The potential use of HF radar for the design and operational management of coastal engineering projects

Figure 1. Waveheight (a) and peak direction (b) measurements during early April 2005. Pisces radar in black, buoy in cyan and Met Office model in red.





If you are designing a coastal flood protection system or a new marina you need to take into account the likely storm wave heights and directions and tidal elevations over the region of your proposed construction. Similar information is needed when deciding where to locate and how to estimate the efficiency of a wave or tidal stream power device. Offshore wind farms need information on wind fields both for their design and in the subsequent operations. Offshore oil and gas operators need to know current and predicted metocean conditions to make decisions about shutting down operations or allowing helicopter landings for example.

In most cases these needs are being met by single point in situ measurement systems for example wave buoys, anemometers or acoustic Doppler systems. These provide useful and usually accurate data but trouble shooting in harsh environments is not always easy or quick. Where the need for spatial information is recognised models are often used to provide this. Again these often provide useful and accurate data but they have their limitations either in terms of spatial or temporal resolution or in terms of limited physics. The need for wave, current and wind data with good temporal and spatial resolution can be met by HF radar systems. These are located on the coast and thus the delays in recovery or repair associated with offshore systems can be avoided. The measurement of waves to ranges of up to 150 km and of currents up to 200km have been demonstrated providing useful coverage for many coastal applications.

Coastal observing systems

In the United States HF radars are considered to be an essential part of coastal observing systems providing, primarily, surface current measurements over ranges of up to 150km or so from the coast. In the UK, at the time of writing, there is only one system in operation – the WERA HF radar (available from the German company Helzel GMbH) included in the Proudman Oceanographic Laboratory Liverpool Bay Coastal Observatory measuring surface currents, waves and winds using software developed at the University of Sheffield and available from Seaview Sensing Ltd. The wave measurement capability of HF radar systems has led DEFRA and EA to consider using them in their wave monitoring network, WAVENET.

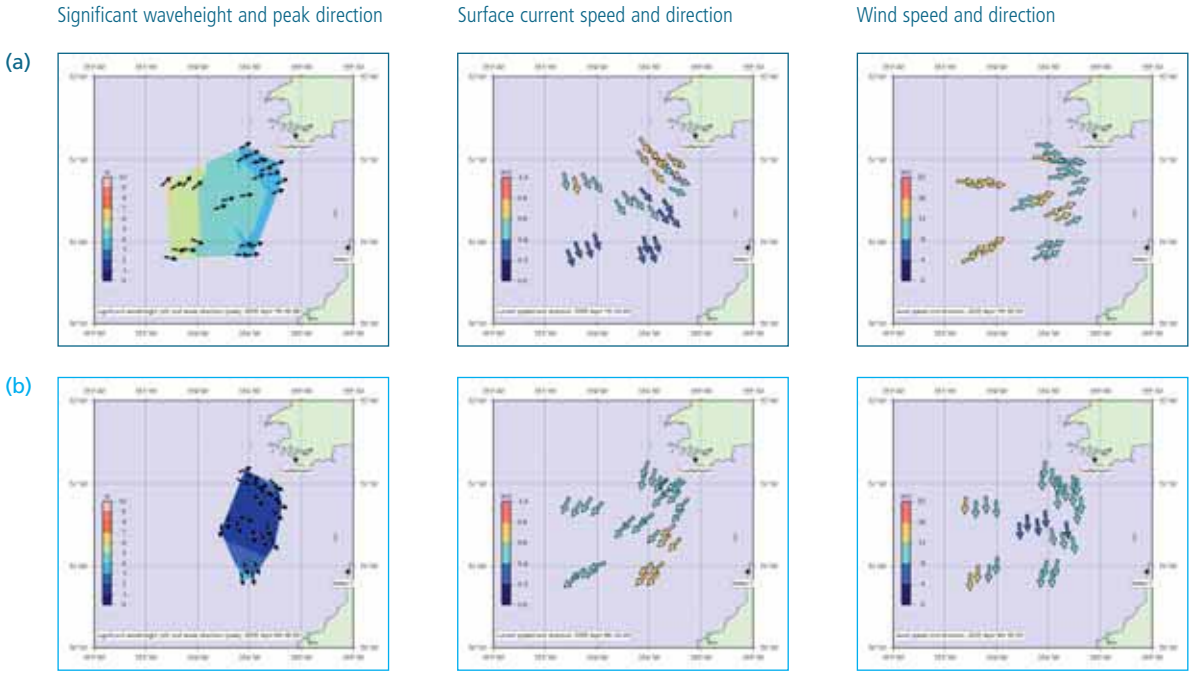
On their behalf, the UK Met Office organised a trial using the Pisces HF radar (available from Neptune Radar Ltd) with Seaview Sensing software. This continued from December 2003 to June 2005 providing 18 months of hourly measurements continuously throughout the period. These data have been validated with a Datawell directional waverider and with the Met Office wave model products including winds and currents.

Figure 1 shows data from this trial for 5-9th April 2005 measured at the location of the buoy. This was the last major storm (a low pressure system moving eastwards to the north of Scotland) before the waverider was removed in late April. There is good agreement in both waveheight and peak direction particularly between the radar and the buoy. Some differences in model waveheight prediction can be seen on the 6th and the 8th April and differences in direction on the 5th.

Mapping metocean data

The wave, surface current and wind fields near the height of and at the end of the storm are shown in figure 2. For this trial the system was configured with three fixed beams for each radar to minimise costs hence the coverage may seem sparser than is often seen with HF radar systems (see below for an example). However it is clear that the system is measuring spatial variations in the parameters shown here. The maximum range shown here for wave measurements is 120km although, as can be seen in figure 2, there is variation in range from time to time. This is due to radio interference, a factor that is important at the operating frequencies needed to get to longer ranges. The impact was minimised for these trials by using different radio frequencies at different times of the day.

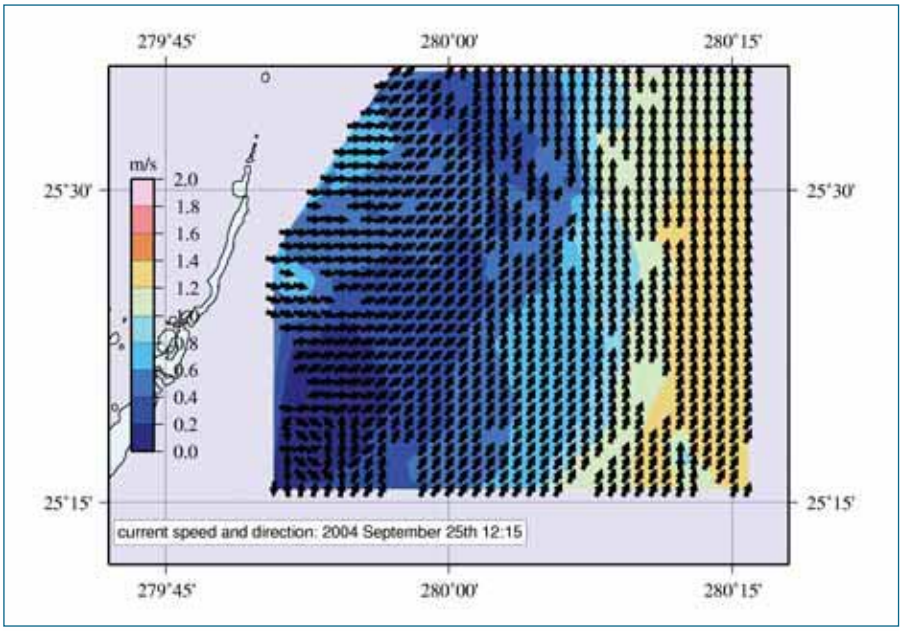
Figure 2. Pisces HF radar measurements at (a) 00:00 7th April and (b) 00:00 9th April.



The measurements above were available hourly to allow time to scan across the fixed beams. More frequent measurements are possible by increasing the number of receiver channels often combined with digital beam forming. The WERA system adopts this approach. Higher resolution in range can also be achieved although care has to be taken to avoid interference, which increases in impact with higher resolution since this requires wider radio bandwidth.

Figure 3 shows an example of surface current measurement with a WERA system using Seaview Sensing software deployed by the University of Miami on the Eastern Florida Keys in support of the Southeast Atlantic Coastal Observing System. Such measurements can be made available every 10 minutes if required thus capturing detailed spatial and temporal variability in currents, waves and wind.

Figure 3. WERA surface current measurements to the east of Miami.



Conclusions

The capabilities of HF radar systems for measuring and mapping surface currents, waves and winds have been illustrated here. Their exploitation for surface current monitoring is now well developed particularly in the United States. The wave measurement capability is beginning to be recognised in operational systems in the UK. Long-term measurements are needed to provide the statistical information required for site planning. Real time data streams are needed for operational decision-making procedures. The WAVENET trial and other operational installations have demonstrated that these requirements can be met by HF radar.

Acknowledgements

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