Extensions to the COSRAD HF Ocean Surface Radar: Extraction of Swell Wave Parameters

Thesis submitted by

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The innovative development of the automated swell extraction algorithm relies on the frequency modulation of the radar echo by swell waves (Chapter 5 and 6). This technique is unique to this thesis and publications arising from this thesis.

Publications arising from this thesis:

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Abstract

Routine extraction of ocean surface information from HF radar spectra has, to this point, been predominantly limited to surface currents and wind parameters which rely on the analysis of the first-order spectral lines. Recently, wind wave parameters are also being supplied in a routine manner. Their calculation involves the ratio of first and second-order spectral energies to produce significant wave heights and direction. Parameter extraction from portions of the long ocean wave spectrum has proven difficult. The derivation of the second-order cross-section by Barrick (1972b) led to solutions for the extraction of swell wave information (Lipa and Barrick, 1980). However, this still did not lead to a reliable supply of long wave information. Only recently has there been some success with full directional spectrum analysis under certain conditions, (Wyatt, 1999). The solutions provided by Lipa and Barrick (1980) are evaluated in this thesis on data collected by the coastal ocean surface radar (COSRAD). The results proved unsatisfactory due to the high sensitivity required by the solutions.

To develop an original method of extraction for swell wave information, two sets of data were acquired using a pair of COSRAD systems overlooking Tweed Heads and Bass Strait in 2001. At Bass Strait the radar was configured to cover a sweep (approximately 60 degrees) every 60 minutes with spatial resolution of the order of 3km. Spectral pre-processing procedures included frequency and power level normalization prior to incoherent averaging. We average 8 adjacent pixels over a 2-hour period to improve the signal to noise ratio and aid in the identification and manipulation of the second-order swell peaks that lie about the strong first-order Bragg lines in the spectrum.

A new method for the extraction of swell wave parameters from HF radar spectra is presented along with results and comparisons to a directional wave buoy which lies in the coverage zone. The method of extraction of the parameters, period, direction and height, relies on a frequency modulation approach that describes the hydrodynamic interaction of

the swell waves with the resonant, shorter, Bragg waves. The analysis process minimises the electromagnetic second-order interaction and a simulation model was used to validate the approach. This simplified method provides a fast means of examining swell conditions over large areas of the ocean surface. The automated algorithm returned results that compared favourably with the wave buoy at both deployment locations. The best results were achieved during periods of swell activity that exceeded 0.3 m in height, below this value the second-order sidebands became noisy and unreliable. During these periods the swell height was measured to within ±0.1 m of the wave buoy. The swell direction was measured to accuracies of ±10 degrees and the swell period to ±1 second. The results support the use of the COSRAD HF ocean surface radar for mapping swell in the near-shore zone and shows potential for the routine extraction of parameters in near real-time.

A routine for the extraction of wind direction was also developed and tested on data collected during the deployment at Tweed Heads. A comparison of pairs methodology for the resolution of the inherent ambiguity in wind direction about the radar beam is presented. The determination of an appropriate spreading parameter is demonstrated, as carried out previously by Heron and Prytz (2002), to refine the directional results in comparison with wind wave data from the wave buoy.

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