

Abstract

Improved Methods for Oceanographic High Frequency Radars

by

Brian Michael Emery

HF radars measure coastal ocean surface currents with a spatial and temporal resolution that remain unmatched by other approaches. Because they observe the scientifically and economically important coastal zone, these radars often form an integral part of coastal ocean observing systems. Thus, improvements to the techniques they employ and the data they produce would have far reaching impacts.

Several opportunities exist to improve HF radar data. First, idealized antenna patterns are widely used despite the fact that the most accurate observations are obtained when the radars use measured antenna patterns. Second, the radars produce maps of surface current velocities without estimates of the measurement uncertainties. Third, advances in signal processing techniques over the last few decades have not been evaluated for use with these radars.

To simplify and automate the antenna pattern measurement (APM), a method is presented for obtaining antenna pattern measurements for HF radars from ships of opportunity. Positions obtained from the Automatic Identification System (AIS) are used to identify signals backscattered from ships in ocean current radar data. The ship signal and ship position data are then combined to determine the APM. Data screening methods are developed and shown to produce APMs with low error when compared with APMs obtained with standard approaches.

To produce estimates of uncertainty in the surface current observations, a method to estimate uncertainty in the radar directional measurement [3] is identified and combined

with previous results to produce an estimate of the uncertainty in the radial component observations produced by individual HF radars. The method is evaluated with radar simulations that incorporate complex ocean current scenarios. These simulations suggest processing modifications that inform the application to observational data. Uncertainty estimates are further evaluated using archive data from two operational HF radars. Results from these radars suggest that the uncertainty estimates can be used for data quality control, and would be suitable for incorporation into numerical models.

Finally, an evaluation of alternative signal processing techniques suggests that significant improvements in spatial coverage are possible. Oceanographic HF radars typically employ Multiple Signal Classification (MUSIC) for direction of arrival (DOA) estimation. Signal processing literature suggests that several alternative DOA methods may provide advantages over MUSIC when applied to HF radars, which attempt to resolve complex and dynamic flows given poor signal conditions and constrained antenna designs. Results of radar simulations suggest that the Maximum Likelihood method produces improved spatial coverage at higher, though manageable, computational cost.

These results imply improvements in the ocean current maps produced by HF radars in terms of more accurate maps, quantified uncertainty, and improved spatial coverage. Improved observations of near shore dynamics will benefit the many practical applications employing these observations, including plume dispersal studies, oil spill response, and search and rescue.