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Inversion of X-band nautical radar data for sea-state monitoring: a new technique to estimate the surface currents

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The inversion of X-band marine images sequences allows obtaining the sea state parameter estimation and the reconstruction of the wave height evolution [1-4].
This result is possible tanks to the fact that the backscattering from the sea is “visible”, under some conditions, on the marine radar images. These radar signatures, that typically are suppressed because represent a noise (clutter) for the navigation, are the “useful signal” to be processed in order to achieve information about the sea state: peak wave length, period and direction, current speed and direction and the evolution of surface elevation.
The backscattering phenomena is due to the Bragg resonance with ocean waves of wavelengths similar to those of the transmitted electromagnetic waves. In particular, the longer waves modulate the backscattering phenomenon and thus they become visible in the “radar” images. As a consequence, the radar image is not a direct representation of the sea state and thus a processing procedure is needed in order to reconstruct the sea state. After a Fourier Transform of the data, a spectral filter is used to erase all the undesired phenomenon via a dispersion relation. The use of the Modulation Transfer Function (MTF) allows the passage from the radar spectrum to sea spectrum; finally, the resulting spectrum is Fourier transformed to return to the space-time domain.
A key step of the whole procedure is the generation of the spectral filter. To built the filter the surface currents have to be estimated, if they are not correctly determined the results of the overall inversion are quite poor. This drawback is further increased when the values of the surface current become high or the data are acquired by a moving vessel, since the problem of the determination of the current is quite complicated and particular attention needs the filtering procedure.
This work presents an innovative procedure able to estimate the free-surface current values with high accuracy compared to the ones achieved by the standard classical approach based on a least square fitting. The method is based on the maximization of the scalar product between the spectrum of the received signal and a model generated by mean of the dispersion relation considering different surface current values [4]. This allows to enlarge the applicative arena of the sea state monitoring from radar images to the radar platforms on moving ships.
The full procedure for the estimation of the sea state parameters has been applied on real data acquired by an X-band marine radar mounted onboard a vessel travelling on the strait of Messina by using this area has been selected due to its strategic location for the navigation and because it is periodically characterized by high currents values.

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