Ship and Wake Scattering Characteristics in S-Band Range-Doppler Maps at Low Grazing Angles

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Backscattering from ship motions plays a critical role in various applications such as navigation, security, and remote sensing. To understand the backscattering signatures, synthetic aperture radar (SAR) and range-Doppler maps have been widely used as analytical tools. However, range resolved Doppler signatures of ship motion have yet to be explored in detail at low grazing angles using ground based S-band radar systems. In this paper, we will describe the joint AFRL-NRL S-band radar data collection and analysis of range resolved Doppler signatures of vessels of opportunity in the Chesapeake Bay.

In order to measure radar signatures of ship motion, an experimental study was designed and executed by a joint AFRL-NRL team on the western shore of Chesapeake Bay to collect backscattering data with an S-band (3.2 GHz) radar system. The radar system transmitted linear frequency modulated (LFM) pulse waveforms with an 18 MHz instantaneous bandwidth, which is consistent with approximately 8.3 m down-range resolution, and a pulse repetition frequency (PRF) of 1 kHz. The maximum unambiguous Doppler velocity was approximately 23.4 m/s, which is sufficient to measure a ship travelling less than 45.5 knots. A reflector antenna with a beamwidth of 5° was used for transmitting and receiving the vertically polarized signals at grazing angles less than 1°.

The analysis of range resolved Doppler signatures using the S-band radar measurement data from vessels of opportunity is presented. The Doppler behavior of ship movements will be detailed using a time-series of range-Doppler maps. To generate the range-Doppler maps, a discrete Fourier transform (DFT) with an appropriate length of a time window was applied to each range bin in multiple range profiles.