Remote Sensing of Ocean Surface using Digital Communication Signals

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Accurate measurements of key ocean parameters such as wind speed, wind direction, and sea surface height are critical for accurate atmospheric and weather modeling. One promising method of measuring these parameters uses ocean-reflected signals of opportunity: navigation and communication signals transmitted by satellites. Until recently, Global Navigation Satellite System (GNSS) signals (navigation signals) were the primary signals used for measuring ocean parameters in bistatic parameters. However, GNSS-derived resolution and sensitivity are limited due to relatively low power of transmitted signals, a time-varying geometry of the navigation satellites due to their location in middle-Earth orbits, and the confinement of signal transmission to the L-frequency band. In contrast, communication signals are able to provide more accurate measurements due to the nature of the system, including high-power broadcast signals, wide transmission bandwidth, and geostationary orbit of transmitters.

This study presents the results of wind speed retrieval from ocean-reflected XM Radio signal data recorded by an aircraft flying over Chesapeake Bay, on the eastern seaboard of the US. In this experiment, raw data from both directly-received and ocean-reflected signals of XM satellites was recorded using a Universal Software Radio Peripheral carried by an aircraft flying at altitudes between 8,000-11,400ft. Recorded direct and reflected signals were cross-correlated to generate waveforms that were compared to theoretical models. A non-linear least-square fit was applied to data using scattering models to retrieve wind speed. The estimated wind speed was 6m/s for signals transmitted by the “Rhythm” satellite, and 7.2m/s for signals from “Blues.” Buoy#44014, anchored near the location of these measurements, recorded a wind speed of 7.5m/s during the test flight. This result indicates that theories developed for bistatic radar using GPS signals can be extended to communication signals; therefore communication signals can be used for ocean remote sensing.