



Tomographic Methods for Mapping Coastal Ocean Surface Winds from High Frequency Radar

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BACKGROUND

Ocean surface wind observations are critically needed for both research and operational uses. Spatially dependent wind fields are required to constrain numerical weather prediction models and supply search and rescue, pollutant, and algal bloom drift models with high resolution forcing fields. However, obtaining wind and current observations at relevant spatial and temporal scales represents a technical challenge. A gap currently exists in our ability to observe the coastal zone at sufficient resolution: buoy-based observation systems cannot provide high spatial resolution observations, and satellites cannot provide high temporal resolution observations. Land-based High Frequency Radars (HFRs) offer a possible solution to achieving continuous coastal ocean surface winds from HFRs over a wide-area.

DESCRIPTION

Researchers at the University of California, Santa Barbara and Woods Hole Oceanographic Institution have created a novel technique to extract spatially detailed surface wind fields over coastal waters by analyzing backscattered radio waves from land-based HFRs. The method identifies wind-driven surface roughness effects on the first-order Bragg-scattered radar signal power, including the effect of path attenuation, then applies tomographic inversion methods using data from multiple HFR sites to generate continuous maps of ocean surface winds. The approach leverages existing HFR networks to provide simultaneous and nearly independent observations of winds and currents with spatial scales of 1-5 km and temporal resolution at sub-hourly intervals, enabling improved coastal ocean monitoring and forecasting of coastal winds with an accuracy comparable to satellite sensors. This method is likely applicable to all coastal HFR types and frequencies, making it possible to generate both surface current and wind maps from existing HFR observing systems and facilitating real-time monitoring of coastal conditions for search and rescue, pollutant tracking, or algal bloom drift models.

ADVANTAGES

- ▶ Potentially provides real-time, continuous, all-weather wind observations alongside ocean surface currents
- ▶ Likely applicable to all HFR systems using groundwave propagation, allowing broad adoption and integration
- ▶ Utilizes existing operational HFR infrastructure without additional hardware deployment
- ▶ Observations could improve coastal ocean models and weather forecasting for various environmental and safety applications
- ▶ Generates high spatial (1-5 km) and temporal (sub-hourly) resolution of coastal wind fields

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OTHER INFORMATION

KEYWORDS

tomographic, ocean surface winds, surface wind fields, backscattered radio waves, environmental monitoring, monitoring, weather, weather forecasting, coastal ocean models, navigation enhancement, land-based high frequency radars, radar, mapping, high frequency radar

CATEGORIZED AS

- ▶ **Environment**
- ▶ Other
- ▶ Sensing

RELATED CASES

2026-795-0

- ▶ Enables generation of long-term wind data archives for research and operational use
- ▶ Tomographic inversion enhances accuracy and reduces noise in wind estimates
- ▶ Functionally independent wind and current measurements derived from different radar signal components

APPLICATIONS

- ▶ Environmental monitoring and forecasting for coastal weather and ocean conditions
- ▶ Search and rescue operation support by providing precise coastal wind maps
- ▶ Pollutant dispersion and algal bloom drift modeling for marine ecosystem management
- ▶ Offshore wind energy site assessment and operational planning
- ▶ Maritime safety and navigation enhancement via improved local wind data
- ▶ Integration into National Weather Service and NOAA coastal observation systems
- ▶ Support for governmental and commercial oceanographic research initiatives

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