Radiowave Oceanography Workshop 2019 Program V2.3

August 28 - 30, 2019

Hosted at

Ocean Networks Canada

University of Victoria

2474 Arbutus Rd

Victoria BC Canada

OCEAN NETWORKS CANADA

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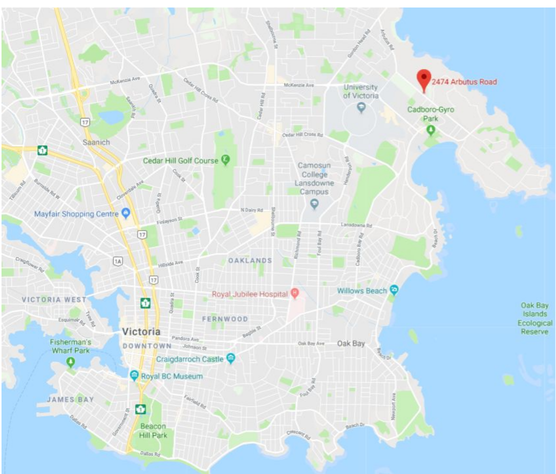
WHALE & WILDLIFE WATCHING EAGLEWING TOURS

Welcome to Victoria

Ocean Networks Canada and the University of Victoria welcome you to the 2019 Radiowave Oceanography Workshop (http://row2019.oceannetworks.ca/). Ocean Networks Canada (ONC), an initiative of the University of Victoria, maintains and operates a wide range of ocean observing systems, including the original VENUS and NEPTUNE cabled ocean observatories located in the Salish Sea and the Northeast Pacific, respectively. Since 2009, the ocean observation capabilities have expanded to include CODAR and WERA high frequency radar installations, and smaller community based observatories along the rugged BC coast and the Canadian Arctic. Starting in 2006, ONC collects live streaming data from more than 300 real-time instrument system of all varieties, including standard CTDs and ADCPs, to specialized plankton samplers in extreme environments such as the hot vents at the Endeavour Ridge and the Canadian high Arctic. The main ONC offices are located at 2474 Arbutus Rd, a ten minute walk east from the University of Victoria campus. The primary ONC engineering and ocean hardware facility is at the Marine Technology Centre at 9865 West Saanich Rd, across the street from the Institute of Ocean Sciences.



Transportation to ONC

All ROW workshop meetings will be held at the ONC offices at 2474 Arbutus Rd, NE of the main University of Victoria campus. The University has a major transit bus terminal, accessible from all over the Victoria region. https://www.bctransit.com/victoria
The number #11 will be the preferred bus for many of the delegates staying downtown. The #11 heads eastbound on Gorge Rd, along Douglas to Fort, then west on Fort and towards ONC. Returning or from UVic, the #11 leaves UVic Bay H every 15 minutes. Either way, it can stop near the ONC offices. There is a slight detour in the #11 route at the moment, so please request the stop at the corner of **Hobbs and Arbutus**. ONC will provide bus passes to all those who will be taking the bus to the ROW meeting. Individual trip tickets cost $2.50, and two tickets or $5.00 by request to the drive on the **first trip** of the day will buy you a single day, unlimited bus pass. For more information on local transportation, including maps and schedules, visit http://ROW2019.oceannetworks.ca/travel/ .

There is ample parking at the ONC Offices (2474 Arbutus Rd), but parking at ONC costs $8 a day for all vehicles. Parking permits are available from the kiosk next to the main entrance.

The ISSOR and ROW web site includes more links to local resources:
http://ROW2019.oceannetworks.ca/

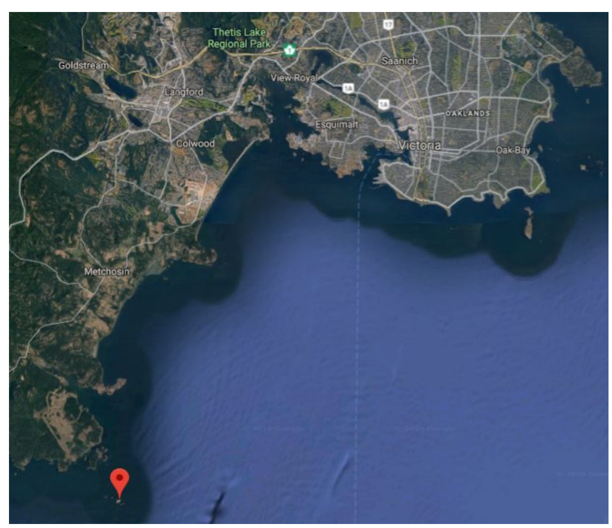
All of the ROW abstracts are included in an Appendix.

Special Events:

Sunday PM August 25 (ISSOR) Icebreaker:
There will be an informal gathering for the ISSOR participants the evening of Sunday August 25 at the Sticky Wicket Pub of the Strathcona Hotel at 919 Douglas St. in downtown Victoria, starting at 6PM. Participants can purchase dinner and drinks, and meet the other delegates and instructors. ONC will have bus passes to hand out for those taking BC Transit to the school venue (2472 Arbutus Rd.) starting Monday morning.

Wednesday PM August 28 (ISSOR/ROW) Reception and Fireside Chat:
A reception at the end of ISSOR and the beginning of ROW will take place at the ONC offices (2474 Arbutus Rd) starting at 17:30 on Wednesday August 28. Drinks and dinner will be provided, followed by an informal presentation by Dr. Rich Pawlowicz of UBC at 19:30: “Where Do Floating Objects Go?”

Thursday 16:00 PM August 29 Field Trip/Tour: (leave via bus at 16:00 from the ONC office/ROW Meeting)
A special field trip/tour has been arranged for Thursday evening, on a boat with Eagle Wing Tours to visit the Race Rocks lighthouse south of Victoria, where ONC has just installed a CODAR antenna. A boxed dinner will be provided. A dedicated bus will depart the ONC offices at 16:00 for the Victoria Fisherman’s Wharf park and marina. There will be time to eat the boxed dinner in the picnic areas, and then head down to the dock at 17:30 for boarding at 17:45. The boat will depart the dock at 18:00 and return by 20:00. All participants will need to fill out an on-line waiver form prior to departure. The destination is the Race Rocks Lighthouse and Marine Protected Area, just south of Victoria. This is the southern most island of British Columbia, with Washington State (USA) to the south, across Juan de Fuca Strait. ONC has recently installed a CODAR antenna on the Islands, and we will tour the area by boat. The ocean waters of Juan de Fuca are cold, and summer sea-breeze winds often blow down (west to east) the Strait late in the day. All participants should bring warm sweaters and/or a coat for the high-speed trip to Race Rocks and the cool/cold air temperatures on the deck of the ship.



Program at a Glance

All Events at Ocean Networks Canada, 2474 Arbutus Rd

Wednesday, August 28

13:00	Delegates arrive at ONC Queenswood Campus
	Join students from ISSOR after their Lunch
13:30	Session 1: HF Radar Data Quality
15:30	Health Break & Posters
16:00	Session 2: Advanced Data Processing
17:30	Reception
18:00	Light Dinner (provided)
19:30	Fireside Chat - Rich Pawlowicz (UBC)

Thursday, August 29

08:00	Coffee
08:30	Session 3: Radar Signal Transmission and Reception
10:30	Health Break & Posters
11:00	Session 4: HF Radar Applications - 1
12:30	Lunch
13:30	Session 5: HF Radar and Sea State
15:30	Break - collect boxed dinners
16:00	Board Bus for a Field Trip to Race Rocks
14:45	Arrive Fisherman's Wharf, picnic dinner
17:30	Head to dock to board Eagle Wing Whale Watching Boat
18:00	Depart for Race Rocks Light House
20:00	Return to dock

Friday, August 30

08:00	Coffee
08:30	Session 6: HF Radar Applications - 2
10:30	Health Break & Posters
11:00	Session 7: HF Radar Applications - 3
12:30	Adjourn

Detailed Program

All Events at Ocean Networks Canada, 2474 Arbutus Rd

Presentations will be 20-25 minutes, plus 5 to 10 minutes for questions.

Date/Time	Name	Title
Aug 28		
13:30	Session 1	HF Radar Data Quality
13:30	Guillaume Sicot	HF radar spectrum comparison method for current maps analysis - Study of the environmental conditions impact
14:00	Sung Yong Kim	Quality assessment techniques applied to surface radial velocity maps obtained from high frequency radars
14:30	Guillaume Sicot	Improvement of surface current maps from HF radar by comparison of Doppler spectra
15:00	Guiomar Lopez	Evaluating HF radar measurements at a highly energetic site
15:30	Health Break	& Posters
16:00	Session 2	Advanced Data Processing
16:00	Eric Gill	Time-domain processing of HF-radar data for ocean parameter extraction: a new paradigm
16:30	Brian Emery	Direction Finding and Detection for Oceanographic HF Radars
17:00	Katrin Hessner	The accuracy of WaMoS surface current estimates from moving ships
17:20	Richard Dewey	Logistics, waivers, and preparing for the Tour
17:30	Reception	Bar: Local wine and beer
18:00	Light Dinner	Provided
19:30	Fireside Chat	Invited Speaker
	Rich Pawlowicz	“Where Do Floating Objects GO?”

Aug 29		
08:00	Coffee	
08:30	Session 3	Radar Signal Transmission and Reception
8:30	Stuart De Vos	Travelling Wave Antennae for Directional Low Band HF RADAR Transmission
9:00	Leif Petersen	Measurement results with dual frequency WERA system using a single receive array of broadband active receiving antennas
9:30	Simone Cosoli	Development and Implementation of the Listen-Before-Talk mode for SeaSonde HFR systems
10:00	Thomas Cook	Investigation of Ionospheric Clutter at Low Frequency HF Radar Stations
10:30	Health Break	& Posters
11:00	Session 4	HF Radar Applications - 1
11:00	Weifeng Sun	An Algorithm for Vessel Tracking Using Compact HFSWR
11:30	Emma Reyes	Contribution of coastal HF Radar to enhance maritime safety and environmental applications
12:00	Simone Cosoli	KAPTAN – MAKING HF RADAR DATA USEFUL TO USERS
12:30	Lunch (provided)	
13:30	Session 5	HF Radar and Sea State
13:30	Weimin Huang	High Frequency Radar Cross Section for an Ocean Surface with Arbitrary Heights
14:00	Guillaume Sicot	Calibration experiment of WERA radars covering the Iroise Sea and measurement of radar wave attenuation above the sea and behind islands
14:30	Lucy Wyatt	New approaches to HF radar wave measurement
15:00	Libe Washburn	Near-shore eddies detected by HF radar and their effects on kelp forest ecosystems

15:30	Break	Collect Box Dinners, Prepare to board bus
16:00	Field Trip	Bus to Fisherman's Wharf, picnic boxed dinner
18:00	Board Boat	Boat our to Race Rocks, where ONC has just installed a new CODAR antenna. Return 20:00
20:00	Return to Dock	The bus will take everyone close to home.
Aug 30		
08:00	Coffee	
08:20	Session 6	HF Radar Applications - 2
08:20	Richard Dewey	Look at Race Rocks Radial Currents
08:30	Cedric Chavanne	Do High-Frequency Radars Measure the Wave-Induced Stokes Drift?
09:00	Abigaelle Dussol	Experimental confirmation of the wave-induced Stokes drift measurement by High Frequency radars
09:30	Anthony Kirincich	Submesoscale Dynamics over the Continental Shelf: Drivers and Implications for Across-Shelf Exchange.
10:00	Manman Wang	Implementation of data quality control of surface current data from HF radar at Ocean Networks Canada
10:30	Health Break	
11:00	Session 7	HR Radar Applications - 3
11:00	Chad Whelan	33 years of SeaSonde Development and Partnerships
11:30	Dale Trockel	Wind Turbine Interference Characterization and Mitigation
12:00	Michael Cook	On the Sea Surface Circulation of the Malta-Sicily Channel
12:30	Adjourn	
	All Abstracts	See Appendix

If you have any questions or concerns, prior to or during the ISSOR or ROW meetings, please contact the ROW 2019 Organizing committee:

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ROW 2019 Session – 1

Wednesday August 28: 13:30 – 15:30

HF Radar Data Quality

HF radar spectrum comparison method for current maps analysis - Study of the environmental conditions impact

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Oceanographic HF radar allows to describe the hydrodynamics of a coastal area by providing a synoptic surface current map at high frequency and regular time steps (10mn). Its interest lies in its wide cover, the high frequency of acquisition and the regularity of the measurements (regardless of weather conditions). Nevertheless, the estimation of surface currents is not straightforward and requires processing of the data acquired by radar in order to extract surface radial current. The methods involving a beamforming or methods known as direction finding are the most used in this scope. Unfortunately, these methods do not provide exactly unambiguous estimations. In addition, HF radar can be associate to others sensors (ADCP, satellites, etc.) or methods (numerical models) that also provide relevant information about the area of interest. Thus, the analysis of hydrodynamics behavior at various time scales (from tidal to pluriannual time scale) requires the analysis of all these sources of information in order to better catch and possibly improve the knowledge of this key area in between the bay of Biscay and the Celtic Sea.

In this presentation, a method which intends to compare a current map to HF radar data will be introduced. The surface current could come from any sensors that provides surface current map or from numerical simulations. This comparison is directly performed with the low level data acquired by the radars ; we would rather avoid the comparison to geophysical data (current themselves) in order to prevent from information loss due to the estimation process or due to geometrical configurations of the radars (geometrical dilution of precision). Indeed, this comparison is performed thanks to an analysis of the radar Doppler spectrum. Hence the comparison is done by radar and therefore only the radial component is studied at the same time. This presentation will focus on the impact of the met-oceanic (wind, waves, tides) conditions and will highlight the main differences observed from current map estimating from HF radar itself and from a high resolution numerical simulation.

The area of interest for this study is the Iroise Sea on the west of Brittany in France where data have been acquiring since 2006. This large amount of data covering a wide span of environmental conditions has been fundamental to investigate this area in a wide variety of hydrodynamical situations.

Quality assessment techniques applied to surface radial velocity maps obtained from high-frequency radars

Sung Yong Kim

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This paper presents examples of the data quality assessment of surface radial velocity maps obtained from shore-based single and multiple high-frequency radars (HFRs) using statistical and dynamical approaches in a hindcast mode. Since a single radial velocity map contains partial information regarding a true current field, archived radial velocity data embed geophysical signals, such as tides, wind stress, and near-inertial and low-frequency variance. The spatial consistency of the geophysical signals and their dynamic relationships with driving forces are used to conduct the quality assurance and quality control of radial velocity data. For instance, spatial coherence, tidal amplitudes and phases, and wind-radial transfer functions are used to identify a spurious range and azimuthal bin. The uncertainty and signal-to-noise ratio of radial data are estimated with the standard deviation and cross correlation of paired radials sampled at nearby grid points that belong to two different radars. This review paper can benefit HFR users and operators and those who are interested in analyzing HFR-derived surface radial velocity data.

Improvement of surface current maps from HF radar by comparison of Doppler spectra

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The HF oceanographic radar is a sensor that produces surface current maps on a regular basis, regardless of weather conditions with a wide cover. Surface current maps are produced by analyzing the signals received and especially by measuring the Doppler shift of Bragg waves. Thanks to a simple direct model (based on Walsh *et al.* 2011), simulated Doppler spectra can be compared to Doppler spectra built using data acquired by radar. This method allows in particular to study surface current maps in relation to radar measurements and thus to identify areas where the current map (geophysical data) do not properly reflect the full content of the electromagnetic data acquired by the radar.

This study presents a way to use this method of comparison to produce surface current maps that improve the similarity between the simulated Doppler Spectra and the one straightly derived from radar measurements. This method has been applied with data acquired by two WERA radars which have been operating since 2006 over the Iroise Sea. This area is hydrodynamically complex with turbulent fluxes due to strong tidal flows ; they induce wide and highly sheared boundary layers along the Islands (such as Ushant and the ones of the Molène Archipelago) that contribute to large inputs of vorticity. In order to quantify and highlight the impact of the method, the surface current maps thus produced were used to estimate the trajectory of virtual surface (first meter) drifting buoys and compared to real ones (20 of them deployed during the **drift4skim** experiment funded by the European Space Agency).

Evaluating HF radar measurements at a highly energetic site

G. Lopez, A-C. Bennis, Y. Barbin, L. Benoit, R. Cambra, D. Conley, L. Marié, A. Sentchev, L. Wyatt

A pair of HF radars has been installed on the north-west coast of France to characterize the temporal and spatial variability of surface dynamics at a highly energetic site known as Alderney Race, where peak spring tide currents can reach 5 ms^{-1}. Radar measurements collected at two different transmitting frequencies (13.5 MHz and 24.5 MHz), which are alternated two times per hour, are evaluated by comparison against data collected by a bottom-mounted ADCP deployed in the area, and numerical results obtained with MARS3D. Agreement between the radar and in situ measurements, quantified by a Pearson correlation of 0.96, and 21 cms^{-1} RMSE is deemed satisfactory. When compared to the modeled data, the agreement varies depending both on the radar transmitting frequency, and the location within the measuring grid. The highest differences are found in the area of strongest currents, where the radar-measured current magnitudes are generally lower, specially those acquired at 13.5 MHz. The latter is represented by a bias that can reach 0.8 m s^{-1}. On the same area, the radar measurements show a positive flow asymmetry, with higher velocities measured at the peak of the flood, while the analysis of the modeled data resulted in the opposite outcome. Given the high topographic complexity of the area, the relatively coarse resolution of the radar measurements collected at 13.5 MHz is thought to be the main driver of the differences between model and HF radar. Hence, the raw data were reprocessed using a direction finding technique, which provides results at a higher resolution. When compared to the model results, the latter resulted in minimal differences at the same area where the beamforming technique presented the highest discrepancies. However, the results elsewhere are slightly noisier. The reasons of the discrepancies between radar processing techniques and modelled results are discussed, and the driving mechanisms of the differences examined.

ROW 2019 Session – 2

Wednesday August 28: 16:00 – 17:30

Advanced Data Processing

Time-domain processing of HF-radar data for ocean parameter extraction: a new paradigm

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For over sixty years [1], the first step in the procedure to extract ocean wave parameters from and to process HF-radar data has been almost invariably to first form the Doppler spectrum from the received radar data, and then process the result to extract important ocean wave parameters, such as the significant wave height, primary wave period, principal wave direction, or even the full directional ocean wave spectrum. In the full presentation,through two examples, we will show how processing the incoming received time-domain signal directly leads to more effective and efficient algorithms than those found in the literature.

In the full presentation, we will show through these two important examples that the formation of the Doppler spectrum is unnecessary, and we describe algorithms for both significant wave height extraction and motion compensation of HF-radar data on a moving platform, which skip the formation of the Doppler spectrum, and instead operate directly on the incoming time-domain signal.

In the case of significant wave height extraction, the proposed algorithm is extremely efficient and we show that although higher-order returns are neglected, the solution is still accurate.

Additionally, although calibration is required, it is only necessary for a single ocean patch, after which the same calibration may be used for all ocean patches in the field-of-view of the radar.

In the case of motion compensation, the time-domain algorithm is shown to be capable of compensating platform motion exactly up to numerical error. This is in contrast to the commonly-used frequency-domain method which requires the evaluation of an infinite sum of Bessel functions, which can only be performed approximately due to truncation effects, and which has been shown in the past to be ill-posed. The proposed method is shown to be able to perform well even in very high sea-states, where the frequency-domain method encounters many difficulties.

I. Acknowledgements

The authors would like to acknowledge the support of NSERC through a Discovery Accelerator Supplement associated with Discovery Grant RGPIN-2015-05289 to Eric W. Gill.

References

[1] D. D. Crombie, "Doppler spectrum of sea echo at 13.56 mc./s." *Nature*, 1955.

Direction Finding and Detection for Oceanographic HF Radars

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Many alternative methods exist for obtaining direction to signal source locations. With respect to oceanographic radars, these methods may improve the maps of ocean currents obtained by existing radars, and inform the design of future radars. Our recent work has identified a possible improvement in coverage when using Maximum Likelihood Estimation (MLE) for direction finding (DF). The use of any DF method also requires a method for determining the number of emitters -- here defined as spatially distinct patches of the ocean surface. The commonly used DF method known as Multiple Signal Classification (MUSIC) involves an eigen decomposition and typically parameters computed from the eigenvalues and MUSIC results are used for detection. To realized any improvements through the use of MLE, a separate detection method must be used, and here we describe and evaluate the use of the Generalized Likelihood Ratio Test (GLRT). The combined detection-estimation methods MLE and GLRT are compared with MUSIC and MUSIC parameters for SeaSonde HF radars, along with an extension of this method for 8-channels and 16-channel systems. We also compare against a recently developed method using only the characteristics of the MUSIC direction of arrival function.

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ROW 2019 Session – 3

Thursday August 29: 08:30 – 10:30

Radar Transmission and Reception

Travelling Wave Antennae for Directional Low Band HF RADAR Transmission.

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*†‡The Integrated Marine Observing System (IMOS) is supported under the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS)

***Abstract*— As a result of interference with primary and pre-existing secondary terrestrial users and in order to comply with the requirements of using the ITU radiodetermination bands pursuant to Australian conditions and ITU recommendations, we have been required to implement directional transmit antennae at two of our CODAR SeaSonde sites operating in the ITU band (5.250–5.275MHz). When attempting to create a directional antenna for this band one encounters a tyranny of scale. With one wavelength, λ, at the centre frequency of 5.2625MHz, being 56.96m and typical antenna dimensions being on the order of $\frac{1}{4}$ or $\frac{1}{2}\lambda$. This can require hundreds of square meters of relatively flat area for installation of a phased array; a luxury not available at the sites in question. Fortunately, delving back in to the history of radio transmission, another class of directional antenna exists. Unlike a conventional antenna where untransmitted energy reflects back and forth in the form of a standing wave; travelling wave antennae are characterised by unidirectional flow of energy on their radiating elements with the result that one direction of radiation may predominate in favor of another. In this paper we detail our development of travelling wave delta loop antennae for low band High Frequency (HF) RADAR installations in response to the challenges outlined above. In addition to antenna design details and matching arrangements we present the results of simulations, drone antenna pattern measurements and operational results from our field trials and deployments via modification of the existing transmit antennae at our New South Wales sites. Our results demonstrate that travelling wave principals allow the design of a compact and directional antenna with straight forward transmission line matching arrangements which can be easily deployed by minimal modifications to an existing transmission antenna. They exhibit flat wideband frequency and phase response over bandwidths which will easily encompass and exceed HF radiodetermination bands. The only significant difficulty with these antennae is their quite low radiation efficiency which has the potential to limit their application under some circumstances but which has actually proved helpful since our ability to reduce interference by reducing radiated energy have been limited by the poor stability of the power amplifier and attenuation modules at output power levels far below their design capacity and a level of external attenuation is one means to address this issue. Travelling wave antenna designs have a potential benefit for reception in phased array RADAR system where a desirably flat frequency and phase response is combined with an inherent front to back ratio which will undoubtedly assist in the reduction of terrestrial interference. It is planned to further investigate this and other aspects of travelling wave antennae at our deployments around Australia.**

Presentation for the ROW 19

Abstract:

Measurement results with dual frequency WERA system using a single receive array of broadband active receive antennas

Authors: Leif Petersen[1], Thomas Helzel[1], Matthias Kniephoff[1], Jan Widera[1]

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Since 2014 the WERA systems are available for dual frequency application. To get the full performance at each frequency two antenna arrays need to be installed. Even if there are various options how to merge the antenna arrays one into the other such a solution is challenging and costly.

This presentation will show the setup and results of a dual frequency system using only one single receive array composed of broadband active receive antennas. The system is measuring alternatingly (time multiplex) at two different operating frequencies. As this receive array is setup with a fixed antenna spacing, this spacing needs to be optimized for the higher operating frequency. The impact of this spacing for the lower operating frequency will be discussed.

The alternating operation at two different radar frequencies will result in different ranges, different resolution and different penetration depths. These effects are shown and discussed as well.

Keywords—ocean current monitoring, dual frequency, hf-radar, broadband active antenna

Development and Implementation of the Listen-Before-Talk mode for SeaSonde HFR systems

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High-Frequency Radar (HFR) systems in Australia operate within the ITU frequency bands with secondary-type licenses on a basis of non-interference to primary services. As a consequence of several interference claims and consequent notices of breach of the Communication Act, the Australian Communications and Media Authority (ACMA) is now enforcing the full implementation of ITU Resolution 6.12 conditions 2, 3, 4, 5. The Australian HFR systems already transmit low-to-extremely low-power (even below 1W) signals, with no significant performance losses, operate in interrupted, alternate short-burst mode (512-1024 s), and deploy either conventional or customised directional antennas for both phased-array and direction-finding HFRs. Resolution 6.12 requires reducing the use of spectral band, either through the application of existing band-sharing capabilities, the reduction of the spectral leakage to neighbouring frequency bands, or the development and implementation of listen-before-talk (LBT) capabilities. While LBT mode is operational and commonly used at several phased-array HFR installations, the implementation to commercial direction-finding systems does not appear to be available yet. In this presentation, we share details on the actual implementation of the LBT mode for commercial SeaSonde HFRs deployed in Australia and discuss potential critical aspects for systems operated under this configuration. First, we show that no additional hardware is needed for the purpose, but instead the available commercial software can be used to acquire spectrum scans at user-configurable time intervals through any of the receive channels. We then propose a method to adapt the operating frequency to the cleanest band within the allocated frequency region. Finally, we show that the 5MHz frequency band in Australia is particularly impacted by major interference sources. We also point out some of the critical aspects of this operation mode, particularly for direction-finding HFRs where long-term averaging is beneficial to data quality. A first example relates to a dynamical adaptation of the operating bandwidth for direction-finding HFRs; although feasible, it results in non-homogeneous spatial resolution and reduction of the quality of the data. The second is related to the assumption that a single calibration (antenna pattern measurement) is valid over the entire frequency band; while this is potentially true for the low-frequency band, where the ITU allocations give 25KHz (50KHz) channels at 5MHz (4MHz), it may be a questionable assumption for other ITU bands where allocated bandwidths can range between 100kHz to 300KHz.

Submitted for consideration as Oral presentation

Investigation of Ionospheric Clutter at Low Frequency HF Radar Stations

Thomas M. Cook[1], Eric Terrill[1], Carlos Garcia-Moreno[1], Ian Robbins[2]

1- Coastal Observing Research & Development Center, Scripps Institution of Oceanography, University of California, San Diego. 2- Center for Coastal Marine Studies, California Polytechnic State University.

Interest in the interaction between HF and the ionosphere spans multiple disciplines. Knowledge of the location of the ionosphere influences long range communications as well as ship tracking from over the horizon radars. Clutter from the ionosphere is also a common source of error in the measurement of surface current from HF Surface Wave Radar. This clutter is typically seen in two forms, specular and spread, which exhibit different behaviors. Specular type clutter is due to direct reflection of the radar signal from the ionospheric layers, most often the E layer, and is often contained in a small portion of the doppler spectrum typically found in range cells around 100 km. Spread type clutter can occupy most to all doppler and range bins, and is commonly explained as skywave clutter. Spread clutter exhibits more directivity than specular reflections, and can often be suppressed by spatial adaptive techniques. The intensity and duration of ionospheric clutter varies daily with the movements of the ionosphere. A global network of ionospheric soundings (Global Ionosphere Radio Observatory), provides real-time and archived ionospheric sounding database available to the public. Additionally, maps of Total Electron Concentration (TEC) and ionospheric fluctuations derived from perturbations measured with global navigation satellites are compiled hourly.

In this work, spectral noise is evaluated at selected low frequency (4-5MHz) HFR stations. Spectral noise varies diurnally and is associated with decreased radial current coverage. Spectral noise is evaluated alongside ionospheric soundings to further understanding radar interactions with distinct movements of specific ionospheric layers. Finally, the time series of spectral noise is shown to correlate with time series of TEC.

ROW 2019 Session – 4

Thursday August 29: 11:00 – 12:30

HF Radar Applications 1

An Algorithm for Vessel Tracking Using Compact HFSWR

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[2] Memorial University of Newfoundland; [3] First Institute of Oceanography, MNR

I. Introduction

Compact high-frequency surface wave radar (HFSWR) suffers from low azimuth accuracy for target detection due to its wide beam width. Multi-target tracking (MTT) algorithms, when applied to the raw target detection data of HFSWR, fail to effectively filter the target azimuths thus resulting in inaccurate target tracks and courses. To address this problem, based on the knowledge that the information accumulated by long-time integration in a track better reflects the target motion characteristics, a vessel azimuth correction method is developed by exploring Doppler velocity and the accumulated information characterized in target tracks.

II. PROPOSED METHOD

The proposed method includes an initial track estimation module, an azimuth smoothing module, a speed and course estimation module, and an azimuth refinement module, as illustrated in Fig.1.

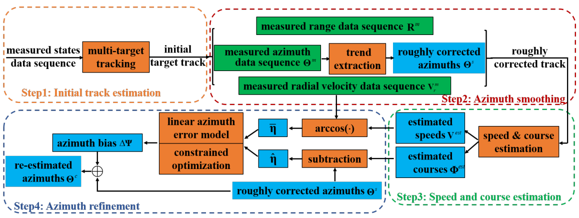

Fig. 1. The framework of the proposed method.

It begins with applying an MTT algorithm to a measured target states data sequence acquired by HFSWR to produce initial target tracks, from which the measured range, azimuth, and radial velocity data sequences are obtained. Then, the azimuth trend is extracted from the obtained azimuth data sequence as roughly corrected azimuth estimates, with which the target locations can be roughly corrected. Subsequently, target speeds and initial courses are estimated based on the roughly corrected location data sequence, followed by a data selection procedure based on proposed control parameter rules to select the qualified data for calculating the projected angles in terms of speed and direction, separately. Eventually, the target azimuth data sequence is further refined using a linear azimuth error model, whose parameters are obtained by minimizing the difference between the projected angles using a constrained optimization method.

III. EXPERIMENTAL RESULTS

Tests using field data from the East China Sea were conducted and the azimuth correction result for one target is shown in Fig.2.

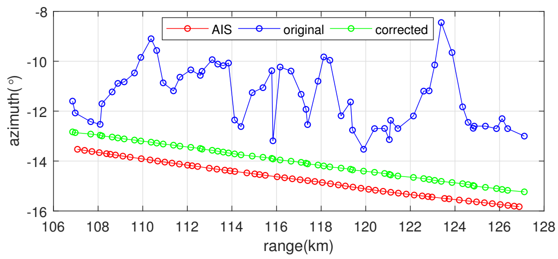

Fig. 2. Azimuth comparisons before and after correction.

The results demonstrate that the proposed method can estimate the target azimuths with significantly improved accuracy. Consequently, the deviations of the corrected target locations are considerably reduced and the accuracy of course estimation is enhanced.

IV. Conclusion

A simple yet efficient target azimuth correction method for small-aperture compact HFSWR is presented. It demonstrates good performance in correcting inaccurate target azimuths and is able to act as a follow-up method for multi-target tracking algorithms to enhance the tracking accuracy.

Contribution of coastal HF Radar to enhance maritime safety and environmental applications

Emma Reyes[1], Adèle Revelard[1], Baptiste Mourre[1], Paz Rotllán[1] and Joaquín Tintoré [1,2]

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Maritime safety and environmental applications, mostly based on Lagrangian trajectory models, require timely and accurate surface current data for determining a search area, particularly in coastal risk-prone regions. In order to cover diverse spatio-temporal scales and to guarantee near-real time availability, their catalogues combine multi-platform observations with multiple ocean models. However, when different models result in disparate trajectories, the major concern of users is to select the most accurate prediction. This has led to the development of automated skill assessment services, where satellite-tracked drifters are often used to evaluate the performance of each model. However, the current lack of drifter availability in coastal areas restrict the potential of these services. Therefore, the use of coastal HF Radar -HFR- derived simulated trajectories as benchmark offers a valuable asset for model assessment. Moreover, HFR derived surface currents can also be used as alternatives of the models for backtracking purposes.

In this study, we first assess the skill of HFR derived data compared with hindcast simulations of different ocean models from SOCIB and Copernicus Marine Service and then we evaluate its role as benchmark in model assessment, in substitution of drifters. The trajectories retrieved from 22 drifters between September 2014 and December 2018 in the Ibiza Channel (Western Mediterranean) and 5 different ocean models overlapping in the region are used. The evaluation is based on the Normalized Cumulative Lagrangian Separation distances between simulated-real trajectories, resulting in a dimensionless index ranging from 0 to 1 (value= 1 implies perfect fit). To be able to compute HFR-derived Lagrangian trajectories, the Open-boundary Modal Analysis has been applied to the radial current fields in order to obtain gap-filled surface currents.

HFR data show much better performance on average than any of the models in reproducing the drifter trajectories, except for an event when drifter motions were dominated by inertial oscillations embedded in a meridional flow. However, in areas with higher HFR observational errors (two-station baseline and at the outer edges of the domain), the performance decreases. Models present varying skill levels predicting the drifter trajectories, depending on the region and on the analyzed period. This is mainly related to their different capacities to reproduce coastal and shelf processes at short timescales and due to the misrepresentation of diverse flow regimes at larger scales. When HFR simulated trajectories are used as benchmark, the evaluation of the models provides similar results than when compared with the real trajectories from drifters. This analysis suggests that HFR could indeed be used as benchmark for near-real time model assessment in maritime safety and environmental applications.

KAPTAN – MAKING HF RADAR DATA USEFUL TO USERS

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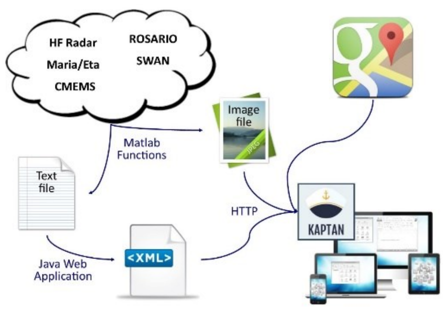
[6]Oceans Graduate School & The UWA Oceans Institute The University of Western Australia

As the CALYPSO Follow On project came to completion in December 2015 with the addition of a fourth HF radar station in Ragusa Harbour, another major milestone was being accomplished with the launching of KAPTAN, an integrated service of met-ocean information, delivered online and on smartphone to aid sea farers navigating in the proximity of the Maltese Islands and south of Sicily for planning their journeys and ensuring safer trips. The initiative follows the trail of efforts by the CALYPSO series of projects to merge HF radar observations to other data layers including numerical models to deliver services deriving from operational oceanography and meteorology to users, not only at the level of national stakeholders that require data and information for their routine operations, but also to the general public by making use of popular media and affordable smart technologies.

The data for this integrated service to mariners is mainly derived from the CALYPSO HF radar observing system, consisting of a network of CODAR SeaSonde installations on the northern Maltese and southern Sicilian shores at four selected sites. High resolution weather and marine numerical models running at the University of Malta specifically for the Malta-Sicily Channel, together with satellite observations of the area, provide a full suite of very local reporting, and complement other weather forecasts derived from GFS/WRF models and local weather stations.

The services are delivered on KAPTAN using Google Maps API, and are composed of six components: sea surface currents on 2D Eulerian maps; sea surface currents along transects; sea current drift; atmospheric forecasts – wind vector, air temperature, precipitation, mean sea level pressure; sea surface temperature - observed and forecast; and sea wave conditions – significant wave height, wave direction, peak period and mean period.

When users open KAPTAN, the smartphone device sends requests for data, over an Internet connection, to a Simple Object Access Protocol (SOAP) web-based service. The extraction from the available data sources (observations, models, local and third party) is performed through text files and maps that are generated by dedicated Matlab © functions; they contain data belonging to one time-frame or a group of related time-frames. All services are implemented as a Java web application. Requests to consume the service are transmitted in EXtensible Markup Language (XML) format using HTTP, and include strings carrying the required input parameters.



The new CALYPSO South project is extending the HF radar network to seven units, doubling the coverage to 16,000 km^2 and including the coastal sea areas south of the Maltese Islands. KAPTAN will be enhanced to cover operational integrated data products in the form of environmental indices generated by merging HF radar to EO-derived parameters.

The phone app can be downloaded for free for both Android and iOS devices (Google Play and App Store on iTunes respectively). The same services are also available online on www.capemalta.net/calypso/kaptan. A video guide is available at:
http://oceania.research.um.edu.mt/cms/calypsoweb/images/videos/KAPTAN_app.mp4

CALYPSO South (www.capemalta.net/calypso-south) is partially funded by the Interreg V A Italia-Malta Programme, 2014-2020

ROW 2019 Session – 5

Thursday August 29: 13:30 – 15:30

HF Radar and Sea State

High Frequency Radar Cross Section for an Ocean Surface with Arbitrary Heights

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In his theory of HF propagation over the ocean surface, Barrick [1] imposed two limitations to the electric field over the ocean surface using perturbation theory: 1) the significant wave height of the ocean surface is small compared to the radar wavelength ($k_0 H_s << 1$), and 2) the slope of the ocean surface should be smaller than 1. While these restrictions can be applied to most sea states at different radar frequencies, this introduces a limitation on the applicability of cross-sections to a range of significant wave heights for each frequency [2]. In this work we propose the use of a different perturbation parameter, which combined with the generalized functions approach introduced by Walsh and Gill [3], allows for the removal of the small heights assumption in the scattering analysis from the ocean surface.

By removing the small-heights limitation from the analysis appearing in [3] and choosing the wave slope as the perturbation parameter, the previously derived forms for first- and second-order electric fields are conserved, with a correction term being added to the second-order. This term (σ_{12c}) is shown in Figure 1, for a transmitting frequency of 13.385 MHz and wind speed of 20 m/s. At this wind speed, Barrick's perturbation parameter $k_o H_s$ is equal to 2.1, indicating that the expressions derived using that theory are insufficient to describe the behaviour of the scatter from the ocean surface.

It is intended that the present work will allow for a more accurate analysis of the ocean surface in high sea states using HF-radar.

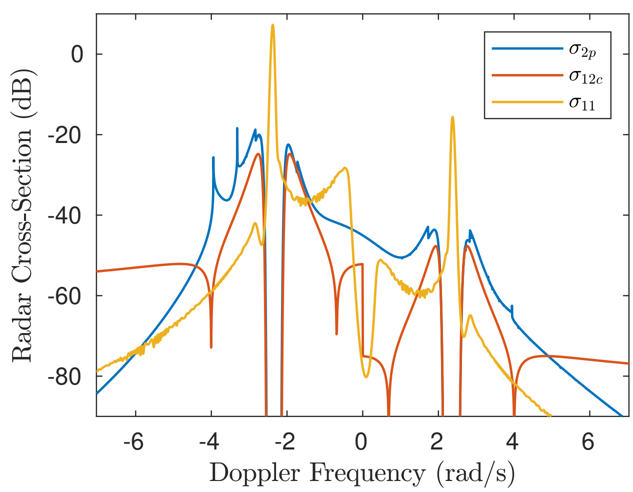

Figure 1: Comparison between scattering orders for arbitrary heights

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[2] L. R. Wyatt, J. J. Green, and A. Middleditch, "HF radar data quality requirements for wave measurement," *Coastal Engineering*, vol. 58, no. 4, pp. 327–336, Apr. 2011.

[3] J. Walsh and E. W. Gill, "An analysis of the scattering of high-frequency electromagnetic radiation from rough surfaces with application to pulse radar operating in backscatter mode," *Radio Science*, vol. 35, no. 6, pp. 1337–1359, Nov. 2000.

Calibration experiment of WERA radars covering the Iroise Sea and measurement of radar wave attenuation above the sea and behind islands

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[2] Ifremer, Plouzané, FRANCE

[3] ENSTA-Bretagne, 2 Rue François Verny, 29 200 Brest, FRANCE

Since 2006, the Shom has been operating two High Frequency (HF) radars to estimate surface currents, sea states and wind direction on the Iroise Sea. The HF radar appears as an efficient tool to produce periodically surface current maps over a wide area with a relative high resolution. This equipment demonstrates its ability to estimate accurately the surface currents speed, used to validate hydrodynamic models and improve our knowledge of ocean circulation and tide in the Iroise Sea. The HF radars sites are composed of 4 emitting antennas arranged in a square and 16 equally spaced and aligned receiving antennas at a working frequency of 12.3 MHz with a 100-kHz bandwidth.

In September 2018, a calibration campaign in Iroise Sea is carried out at 12.3 MHz in order to evaluate the receiving antenna pattern. The second objective was to measure the attenuation of the ground wave with the distance, along a 60 km path, and behind the islands present in the area: Ushant Island, Molène Archipelago, Sein Island... The idea of this experiment is to emit a pure wave from a boat at sea and to use the receiving antennas of the two radar sites Garchine and Brézellec. During the experimentation the radar emission was switched off. The 16-antenna linear array is used for signal reception. So receiving antennas are located on the coast, and transmitting HF antenna is installed on the boat. The boat followed eastward and westward radials and circle arcs at different distances from radars.

The propagation of radio waves has been a subject of scientific interest since the end of the nineteenth century and the theory is well known. The conducted experiment gave reliable data compare with the theory.

New approaches to HF radar wave measurement

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M.D. Moorhead, Neptune Radar Ltd, UK, I.A. Fairley, University of Swansea, UK, R.L. Hardman, University of Sheffield, UK, C.C. Engleback, University of Sheffield, UK.

This paper will present a number of new developments in phased array HF radar wave measurement. The aim is to increase the availability of these measurements and include more flexibility in radar system configurations. To date our work has focussed on an integral inversion method applied to data from two radars observing the same area at the same (or near same) time providing the directional spectrum and parameters, e.g. significant waveheight, peak period and direction, derived therefrom. We used two radars to constrain the inversion to deal with amplitude and direction ambiguities inherent in the scattering process. We have obtained good results when radar data quality is good. However many radar systems deployed around the world have been configured for surface current measurement and signal to noise is not always sufficient for wave measurement in the region of overlap. We have therefore revisited the inversion problem for single radars and have explored two options to see whether sufficient inversion constraint can be achieved. The first uses neighbouring measurement cells assuming spatial homogeneity over larger scales and some results will be presented. The second uses different radar operating frequencies which of course can also be combined with neighbouring cells. We are exploring this using data from the Pisces radar collected on different frequencies sequentially. A new version of Pisces has been developed that provided data on two frequencies simultaneously and we will also present results from that system. We anticipate that this technology will also provide some benefit for a dual radar system making it more resilient to interference and environmental conditions and we are seeking funding to test this.

Other developments include wave inversion for bistatic radar configurations. This has been tested mainly on simulated dual radar data and this work will be reported. We do have a small amount of single radar bistatic data which we hope to invert and report on in this paper. New inversion methods using neural networks are also being explored with a particular focus on improving accuracy in noisy conditions or in the presence of high receive antenna sidelobes which can introduce spurious high amplitude low frequency wave components into the spectrum. A comparison of this approach with the standard Seaview Sensing integral inversion method will be presented.

Near-shore eddies detected by HF radar and their effects on kelp forest ecosystems

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Brian Emery, Marine Science Institute, University of California, Santa Barbara, CA, USA. (brian.emery @ucsb.edu)

Anthony Kirincich, Woods Hole Oceanographic Institution, Woods Hole, MA, USA. (akirincich@whoi.edu)

Chris Gotschalk, Marine Science Institute, University of California, Santa Barbara, CA, USA. (gots@ucsb.edu)

Kelp forest ecosystems in the Southern California Bight, USA acquire important subsidies such as nutrients, larvae, and phytoplankton from cross-shore and alongshore transport processes. For example, previous studies as part of the Santa Barbara Long Term Ecological Research project (SBC LTER) have revealed that internal waves traveling across the shelf are important mechanisms for supplying nutrients (e.g. nitrate + nitrite) to giant kelp on the inner shelf. However, other SBC LTER studies show that internal waves alone are insufficient to supply all of the nutrients required to sustain the kelp forests. This suggests that other mechanisms contribute to the supply of required nutrients and other subsidies. As an alternate mechanism, we hypothesize that eddies occur intermittently on the mid-shelf and that the cross-shelf flows they produce exchange waterborne materials between the kelp forests and offshore waters. To examine this hypothesis we are using the vector geometry method of Nencioli et al. (2010) to detect eddies from a 7-year record during 2011-2018 of surface currents obtained from the US HF radar network operated as part of the NOAA Integrated Ocean Observing System. Preliminary results indicate that (1) cyclonic eddies occur more frequently than anti-cyclonic eddies; (2) cyclonic eddies are more frequent offshore and anti-cyclonic eddies are more frequent closer to shore on the slope and shelf; and (3) pseudo-drifter trajectories computed from the HF radar observations suggest eddies can transport waterborne materials from the 100 m isobath shoreward past the 50 m isobath. Ongoing work focuses on the structure of the eddies, what conditions might produce them, their strength as quantified by their relative vorticity, and their possible delivery of phytoplankton to the inner shelf based on moored chlorophyll fluorescence time series. Future work will examine another possible mechanism, along-shore current pathways connecting offshore waters to the kelp forests.

ROW 2019 Session – 6

Friday August 30: 08:20 – 10:30

HF Radar Applications 2

Do High-Frequency Radars Measure the Wave-Induced Stokes Drift?

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High-frequency (HF) radars remotely measure ocean near-surface currents based on the Doppler shift of electromagnetic waves backscattered by surface gravity waves with half the electromagnetic wavelength, called Bragg waves. Since their phase velocity is affected not only by wave–current interactions with vertically sheared mean Eulerian currents but also by wave–wave interactions with all the other waves present at the sea surface, HF radars should measure a quantity related to the Stokes drift in addition to mean Eulerian currents. However, the literature is inconsistent—both theoretically and experimentally—on the specific expression and even on the existence of the Stokes drift contribution to the HF radar measurements. Three different expressions that have been proposed in the literature are reviewed: 1) the weighted depth-averaged Stokes drift, 2) the filtered surface Stokes drift, and 3) half of the surface Stokes drift. Effective measurement depths for these three expressions are derived for the Phillips wave spectrum, and compared with the effective measurement depths for classical vertical profiles of Eulerian currents.

Experimental confirmation of the wave-induced Stokes drift measurement by High Frequency radars.

Abïgaëlle Dussol*, Cédric Chavanne* and Dany Dumont*
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High-frequency (HF) radars remotely measure ocean surface currents based on the Doppler shift of electromagnetic waves backscattered by surface gravity waves with half the electromagnetic wavelength, called Bragg waves. Since their phase velocity is affected not only by their interaction with the mean Eulerian currents (wave-current interaction), but also by interactions with all the other waves present at the sea surface (wave-wave interaction), the question arises as to whether HF radars measure a quantity related to the wave-induced Stokes drift in addition to mean Eulerian currents. However, the literature is inconsistent—both theoretically and experimentally—on the expression and even on the existence of the contribution of the wave-induced Stokes drift to the HF radar measurements. Three different expressions have been proposed in the literature: (1) the filtered surface Stokes drift, (2) half of the surface Stokes drift, and (3) the weighted depth-averaged Stokes drift. Here, we evaluate these expressions for directional wave spectra measured by three bottom-mounted Acoustic Wave and Current (AWAC) profilers in the Lower St-Lawrence Estuary, Canada. We then compare the Eulerian surface currents measured by the AWACs with the radial currents measured by four HF radars: two WEllen RAdars (WERA) and two Coastal Ocean Dynamics Applications Radars (CODAR). The AWAC and HF-radar currents are surprisingly not correlated, but when subtracting the wave-induced Stokes drift contributions from the radar measurements, moderate but significant correlations are obtained. The highest correlations are obtained when subtracting the filtered surface Stokes drift, suggesting that HF radars measure the latter in addition to mean Eulerian currents.

Submesoscale Dynamics over the Continental Shelf: Drivers and Implications for Across-Shelf Exchange.

Anthony Kirincich, Woods Hole Oceanographic Institution, (akirincich@whoi.edu)
Pierre Flament, University of Hawaii, and
Victoria Futch, United States Coast Guard Academy

Recent advancements in remote sensing of oceanic surface currents have observed dramatic examples of both persistent and transient small-scale O(1-10km) circulation features in proximity to the coast. With horizontal length scales similar to the internal deformation radius, and Rossby numbers O(1), coherent vortices and frontal features represent a class of lateral exchange processes that are not well characterized within the coastal ocean. Though mesoscale and submesoscale dynamics have been studied in the open ocean for some time, the potential influence of bottom stress, topography, winds, and tides on the genesis and life of coastal submesoscale features render them distinct from both open ocean submesoscale dynamics and purely bathymetrically forced features such as headland, and are poorly understood.

Similarly, their role in driving the exchange of water and materials across the shelf remains unknown. Despite efforts examining the heat, salt, and momentum budgets over continental shelves, budgets of broad shelves such as the Middle Atlantic Bight (MAB) have uncertainties that suggest unresolved across-shelf eddy heat fluxes. Additionally, the temporal and spatial scales of eddy diffusivity, a primary indicator of mixing and exchange are not well constrained in coastal environments. Efforts focused on the inner part of the shelf, i.e. water depths less than 30 m have suggested that coastal mesoscale and submesoscale dynamics can have a significant impact on exchange budgets between the nearshore and the rest of the shelf. However, these features are difficult to resolve in existing coastal observing systems, particularly along broad and shallow shelves.

This work seeks to observe and diagnose the coastal mesoscale and submesoscale dynamics over the middle part of the New England Shelf (NES), identifying their role in driving exchange across the shelf. Utilizing a novel implementation of HF radar to resolve horizontal scales of 2 km up to 90 km offshore, combined with in situ sampling of these features by both fixed, moored, and mobile platforms, the ongoing effort is collecting observations over multiple seasons to explore the seasonally varying effects of small scale features on exchange across the shelf. Initial results from the project effort are presented here.

ROW CODAR QC Abstract

Title: Implementation of data quality control of surface current data from HF radar at Ocean Networks Canada

Manman Wang, Alice Bui, Mike Morley, Richard Dewey, Steve Mihaly
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Ocean Networks Canada (ONC), an initiative of the University of Victoria, operates HF radar systems along the west coast of Canada. Four CODAR HF radar sites cover the southern Strait of Georgia in the Salish Sea, two CODAR HF radar sites cover Chatham Sound near Prince Rupert, and a WERA radar array at Tofino, off the west coast of Vancouver Island. ONC CODAR sites covering the shipping lanes in the eastern Strait of Juan de Fuca have been installed and will soon be on line, and ONC will be taking over operation of the Department of Fisheries and Oceans CODAR sites in Hecate Strait on the North Coast of BC, for a total of eleven installations. The near-coastal waters within the footprint of these radar systems are difficult environments for estimating accurate surface current data from HF radar due to input of fresh water from major river systems such as the Fraser and Skeena rivers, and complex wave interactions. ONC is implementing quality-control testing based on the recommendations of the QARTOD Manual for Real-Time Quality Control of High Frequency Radar Surface Current Data. Once completed, a selection of data products in interoperable data formats will be available through ONC's Oceans 2.0 data portal to deliver high-quality surface current data to users. Ocean currents are one of the essential ocean variables (EOV) to be delivered in the first phase of the Canadian Integrated Ocean Observing System (CIOOS). This presentation reviews the efforts and methods for implementing quality control on HF radar data at ONC.

ROW 2019 Session – 7

Friday August 30: 11:00 – 12:30

HF Radar Applications 3

33 years of SeaSonde Development and Partnerships

Chad W. Whelan
Chief Technology Officer
CODAR Ocean Sensors, Ltd.

The state of oceanographic HF Radar today is a testament to the power of development partnerships among government, academic and commercial organizations. Following initial development of the CODAR concept of the compact HF Radar at the NOAA Wave Propagation Laboratory in the 1970's and 80's, the principle scientists formed CODAR Ocean Sensors to commercialize the technology and today have sold over 600 systems. This milestone would not have been possible, however, without the academic and government partnerships that drove key developments and capabilities along the way. Critical applications and technology advancements, past and future, will be discussed.

Wind Turbine Interference Characterization and Mitigation

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H. Roarty
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Observations in the U.K and the U.S.A. indicate that the spinning blades of offshore wind turbines cause interference in costal oceanographic High Frequency (HF) radar. With the accelerated rate of development of offshore wind farms, there is a pressing need to understand impacts of wind turbine interference and for the development of mitigation tools. In September 2016, we began an investigation funded by BOEM (Contract M16PC00017) utilizing both radar measurements and simulations to understand the potential impact of wind turbine interference on HF sea surface radars. HF radar data was collected from six HF radar sites near the five turbines installed off the Southern coast of Block Island, RI over a two-year period. Simulations were done using NEC (Numerical Electromagnetic Code®) combined with CODAR's FMCW current processing algorithms. Using analytical methods, we also characterized the wind turbine interference and obtained a functional relationship between a turbine's rotation rate and the range-Doppler cells that may contain interference. Using the function relation, along with its inverse, we developed a successful mitigation method. In addition to the forward-inverse method, several other mitigation techniques were identified and tested using both simulated radar data and data collected from Block Island. Preliminary results show the mitigation methods may be sufficient for the small number of offshore wind turbines at Block Island, but more work is needed in order to reduce the computational cost for larger wind farms.

On the Sea Surface Circulation of the Malta-Sicily Channel

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Abstract

The Malta-Sicily Channel is part of the larger Sicily Channel system where exchange of water properties between the Eastern and Western Mediterranean basins occurs. The Malta-Sicily Channel and its surface circulation structures have been studied using high frequency radar derived surface currents along with satellite derived measurements of SST, and wind and geostrophic velocities. We identified high frequency motions as well as mesoscale structures fundamental for the understanding of the Malta-Sicily Channel circulation dynamics. At time scales greater than a week two mesoscales structures dominate the circulation in the channel: The Atlantic Ionian Stream (AIS, Summer-Autumn) and the Malta-Sicily Gyre (MSG, Winter-Spring). The MSG is an anticyclonic structure trapped between the Sicilian and Maltese coasts, which has been poorly studied in the literature and often confused with the Malta Channel Crest and the Ionian Shelf Break Vortex. In order to characterize this gyre, we calculated its kinetic properties, taking advantage of the fine-scale temporal and spatial resolution of the high frequency radar data, thus confirming its presence and improving the understanding of the surface circulation patterns in the channel.

Reference

Reyes Suarez, N.C., Cook, M., Gačić, M., Paduan, J.D., Drago, A. and Cardin, V., 2019. Sea Surface Circulation Structures in the Malta-Sicily Channel from Remote Sensing Data. Water, 11(8), p.1589.

Contact: cook@nps.edu

ROW 2019 Poster Session

Wednesday August 28: 15:30

Thursday August 29: 10:30

Friday August 30: 10:30

Degreane Horizon RADAR activities

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DEGREANE HORIZON has developed since more than 30 years a wide range of products and services dedicated to meteorological observations (Airport Weather Observation System AWOS, Synoptic Automatic Weather Station, RADAR wind profiler, ceilometer…). The company has references in more than 100 countries and many partnerships with National Met services.

DEGREANE HORIZON is specialized in hardware and software development. In particular, it has developed a wide range of skills in RADAR activities for target detection or environment sounding together with hardware and software designs. Frequencies ranging from 1 MHz to 35 GHz and transmitted power ranging from 100 W to 3.5 kW are addressed with application in altitude wind sounding, cloud and rain detection or space surveillance.

Degreane Horizon has developed since the 1990's pulsed doppler radar wind profilers (50 MHz and 1290 MHz) designed to measure winds aloft for operational and research applications. It is based on robust technologies providing accurate and reliable measurement. The state-of-the-art system is based on advanced signal processing technics and allows the spreading of operational product, e.g. wind speed and direction, wind shear…, in NetCDF format. Main applications are for instance flight safety (wind shear detection), coupling with atmospheric circulation models for weather forecast improvement, and also for research projects dedicated to atmospheric dynamic studies, aerosols and so on.

On going development are dedicated to signal processing improvement to identify and filter out intermittent clutters and short time scale processes. These problematics can be addressed in a common framework for atmosphere (wind) and ocean (current) monitoring and lead DEGREANE HORIZON and the University of Toulon (UTLN) to collaborate in order to develop innovative methodologies.

In parallel, UTLN has entrusted DEGREANE HORIZON, in partnership with Helzel Messtechnik, for the refreshing and the maintenance of 3 WERA radars used to monitor Liguro-Provençal Current flowing off Toulon, South of France. The refreshing consists in hardware replacement and new antenna network design to insure long term operational functioning. Monthly preventive maintenance and remote monitoring are performed to provide high quality monitoring and reliable sea surface parameters.

Thanks to its know-how, DEGREANE HORIZON provides assistance for commercializing new WERA radars with a technical added value via site survey for antenna type and site selection.

DEGREANE HORIZON is thus the ideal partner for radar development, maintenance and sales.