June 14-16, 2022
Zhuhai, China

The 5th Ocean Radar Conference for Asia-Pacific

Program Information

About the Conference

In consideration of the importance of HF Radar system, which can be applied to many situations, such as navigation, oil spill prediction, search and rescue, harmful algal bloom forecasting, and tsunami detection and warning. At the same time, the number of HF Radar sites among Asia-Pacific increased rapidly. However, the lack of cooperation and communication among these countries impeded the progress of entire Asian Region. The first Ocean Radar Conference for Asia-Pacific (1st ORCA) was initiated by Prof. Sang-Ho Lee to promote international communication and has been successfully held on May 17-18, 2012, in Korea. Then, the second Ocean Radar Conference for Asia-Pacific (2st ORCA) was hosted by Taiwan Ocean Research Institute (TORI) on April 2-4, 2014, in Kaohsiung, Taiwan, China. The third ORCA was held on April 14-16, 2016, in Wuhan, China, hosted by Wuhan University. And the fourth ORCA was hosted by the University of the Ryukyus in June 2018 in Okinawa, Japan.

Under the impact of the global pandemic, it is difficult and challenging to host the fifth ORCA. The fifth Ocean Radar Conference for Asia-Pacific (ORCA2022) will be held on June 14-16, 2022 in Zhuhai, China, organized by Sun Yat-sen University. The Ocean Radar Conference for Asia-Pacific intends to share experiences on HF radar network planning, operation, maintenance, and data management and analysis. To exchange ideas about applications and research results. To discuss issues that are common to all operators and end-users in Asia-Pacific. To build relationships across national boundaries to foster the development and growth of HF radar observation networks along the Asian seas and Pacific Ocean.

会议简介

目前，高频地波雷达系统的应用越来越广泛，如船舶导航、溢油预测、海上目标搜索和救援、赤潮预报、海啸探测和预警等。由于高频雷达拥有如此众多的应用优势，亚太地区的高频雷达网也再迅速扩展。而由于某些原因，各个国家之间在高频雷达方面的合作和交流还是较少，进而阻碍了整个亚太地区高频雷达的发展。2012 年 5 月 17-18 日，韩国 Sang Ho Lee 教授为了促进亚太地区各个国家高频雷达技术的交流号召并且举办了亚太地区第一届海洋雷达会议。随后，台湾海洋研究所于 2014 年 4 月 2-4 日在高雄举办了第二届海洋雷达会议。

第三届海洋雷达会议于2016年4月14-16日召开，由武汉大学承办。第四届会议于2018年6月在日本冲绳举办，由琉球大学承办。

受全球疫情影响，举办本次会议充满了困难与挑战。第五届亚太海洋雷达会议(ORCA2022)将于2022年6月14-16日在中国广东省珠海市举办，由中山大学承办。亚太海洋雷达会议的主旨是分享亚太地区各个国家高频地波雷达网的设计、操作、维护以及数据管理等相关技术。而此次中山大学亚太海洋雷达会议的目的是对亚洲和泛太平洋国家和地区之间高频雷达系统的网络规划、运行、维护以及数据管理与分析的经验进行交流，交换应用和研究意见，构建亚太地区所有海洋雷达用户共同体，强化国家与地区之间的技术合作以促进亚太地区高频雷达观测网的发展。

Committee Members

<table>
<tr><th></th><th>Name</th><th>Organization</th></tr>
<tr><td>Chair</td><td>Dongxiao Wang</td><td>Sun Yat-Sen University, China</td></tr>
<tr><td rowspan="11">Advisory Committee Member</td><td>Pierre Flament</td><td>University of Hawaii, USA</td></tr>
<tr><td>Daehyun Kim</td><td>Oceantech Co., Ltd., South Korea</td></tr>
<tr><td>Sang Ho Lee</td><td>Kunsan National University, South Korea</td></tr>
<tr><td>Satoshi Fujii</td><td>University of the Ryukyus, Japan</td></tr>
<tr><td>Weimin Huang</td><td>Memorial University, Canada</td></tr>
<tr><td>Xiongbin Wu</td><td>Wuhan University, China</td></tr>
<tr><td>Hui Wang</td><td>Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), China</td></tr>
<tr><td>Lin Mu</td><td>Shenzhen University, China</td></tr>
<tr><td>Jianzhong Ge</td><td>East China Normal University, China</td></tr>
<tr><td>Yonggang Ji</td><td>China University of Petroleum (East China), China</td></tr>
<tr><td>Dongxiao Wang</td><td>Sun Yat-Sen University, China</td></tr>
<tr><td rowspan="2">Organizing Committee</td><td>Xiongbin Wu</td><td>Wuhan University, China</td></tr>
<tr><td>Xianchang Yue</td><td>Wuhan University, China</td></tr>
</table>

Member	Lin Mu	Shenzhen University, China
	Dongxiao Wang	Sun Yat-Sen University, China
	Shuo Chen	Sun Yat-Sen University, China
	Ying Zeng	Sun Yat-Sen University, China
	Zheng Meng	Sun Yat-Sen University, China
	Qiqi Lin	Sun Yat-Sen University, China
	Zhezheng Chen	Sun Yat-Sen University, China
	Yaozu Chen	Sun Yat-Sen University, China
	Yuwei Zhang	Sun Yat-Sen University, China
	Zhihui Chen	China Precise Ocean Detection Technology Co.Ltd, China

	姓名	**机构**
主席	王东晓	中山大学，中国
咨询委员会成员	Pierre Flament	夏威夷大学，美国
	Daehyun Kim	Oceantech Co., Ltd., South Korea
	Sang Ho Lee	国立群山大学，韩国
	Satoshi Fujii	琉球大学，日本
	Weimin Huang	纽芬兰纪念大学，加拿大
	吴雄斌	武汉大学，中国
	王辉	南方海洋科学与工程广东省实验室（珠海），中国
	牟林	深圳大学，中国
	葛建忠	华东师范大学，中国
	纪永刚	中国石油大学（华东），中国
	王东晓	中山大学，中国
组织委员会成员	吴雄斌	武汉大学，中国
	岳显昌	武汉大学，中国

	牟林	深圳大学，中国
	王东晓	中山大学，中国
	陈硕	中山大学，中国
	曾瑛	中山大学，中国
	孟峥	中山大学，中国
	林奇琦	中山大学，中国
	陈哲正	中山大学，中国
	陈耀祖	中山大学，中国
	张昱威	中山大学，中国
	陈智会	湖北中南鹏力海洋探测系统工程有限公司，中国

ORCA2022 Conference Agenda Program

Online	ZOOM	**Conference ID: 579 566 2744** **Password: 223060** Please make sure that the username of ZOOM is your real name.
Online (Backup)	VooV Meeting (https://voovmeeting.com/)	**Conference ID:** **June 15: 166-776-870** **June 16: 566-227-647** **Password: 223060** **We use ZOOM first. VooV would not be used if ZOOM works well.**
Offline (On-site)	Zhuhai, China	Zhuhai Campus of Sun Yat-sen University, China.

Live	Koushare	https://www.koushare.com/lives/room/390931

线上	ZOOM	**会议 ID:** **579 566 2744** **密码:** **223060** 请将参会账户名改为真实姓名，便于交流。
线上（备用）	VooV（国内通过腾讯会议直接加入）	**会议 ID:** **6 月 15 日:** **166-776-870** **6 月 16 日:** **566-227-647** **密码:** **223060** 我们将优先使用 ZOOM，腾讯会议仅作为应急方案。
线下	广东省珠海市	中山大学珠海校区海琴 4 号楼 B210 环形多功能讲学厅
直播	蔻享	https://www.koushare.com/lives/room/390931

Tuesday, June 14			
09:00-19:00	On-site Registration		
Wednesday, June 15			
07:30-08:30	On-site Registration		
Chairs: Prof. Dongxiao Wang (CHINA)			
Beijing time (UTC+8)	UTC	Title	Speaker
08:30-08:50	00:30-00:50	Opening & Welcoming Remarks	Hui Wang & Dongxiao Wang & Xiongbin Wu
08:50-09:00	00:50-01:00	Group Photo for Memory **Online:** Turn on the camera for a screenshot **On-site:** Outside	
09:00-09:30	01:00-01:30	Research on HF Radar Cross Section Models of Ocean Surface (30 min)	Weimin Huang
09:30-09:55	01:30-01:55	The Global High Frequency Radar Network (25min)	Hugh Roarty
09:55-10:20	01:55-02:20	Application of Oceanic HF Radars: Challenges Remaining (25min)	Xiongbin Wu
10:20-10:45	02:20-02:45	Coffee Break	
10:45-11:10	02:45-03:10	Data product of HF Radar data from Ocean Networks Canada (25min)	Manman Wang
11:10-11:35	03:10-03:35	Submesoscale eddies and tidal currents in eastern Guangdong identified using high-frequency radar observations (25min)	Dongxiao Wang
11:35-12:00	03:35-04:00	Shipborne oceanic high-spectral-resolution lidar for accurate estimation of seawater depth-resolved optical properties (25min)	Yudi Zhou
12:00-13:30	04:00-05:30	Luncheon	
Chairs: Prof. Jun Zhao (CHINA)			
14:30-14:55	06:30-06:55	Marine disaster prevention and mitigation based on big data (25min)	Haoyu Jiang & Lin Mu
14:55-15:20	06:55-07:20	Harvesting energy from ocean waves for powering mobile marine observation platforms: Design, simulation, and experimental tests (25min)	Li Hui & Liguo Wang
15:20-15:45	07:20-07:45	Wave and wind measurements using Multifrequency HF radar (25min)	Chen Zhao
15:45-16:10	07:45-08:10	Study of Lagrangian pair dispersion in the Gulf of Tonkin using surface current data measured by HF radar (25min)	Manh Cuong Tran
16:10-16:25	08:10-08:25	Coffee Break	
16:25-16:50	08:25-08:50	New sights into the ocean surface currents near	Weili Wang

		the Bohai strait revealed by HF radar (25min)	
16:50-17:15	08:50-09:15	Short-term prediction of sea surface flows in the Guangdong-Hong Kong-Macao Greater Bay Area based on High Frequency radar observations (25min)	Lingna Yang & Lei Ren
17:15-17:40	09:15-09:40	High-speed target detection and motion parameters estimation with HF radar (25min)	Gan Liu
17:40-19:30	09:40-11:30	Banquet	
Thursday, June 16			
Chairs: Prof. Xiongbin Wu (CHINA)			
09:00-09:25	01:00-01:25	Multi-scale Analysis and Data Assimilation of HF-Radar Currents (25min)	Jianzhong Ge
09:25-09:50	01:25-01:50	Marine Target Monitoring with Compact HFSWR: From Shore-based to Shipborne Systems (25min)	Yonggang Ji
09:50-10:15	01:50-02:15	ZJU Oceanic lidars: Emulator, Instruments, and Application (25min)	Dong Liu
10:15-10:30	02:15-02:30	Coffee Break	
10:30-10:55	02:30-02:55	Flow dynamics at the coasts of Phu Yen, Vietnam, at the onset of Southwest Monsoon (25min)	Thanh Huyen Tran
10:55-11:20	02:55-03:20	Spaceborne oceanic lidar emulator and its applications (25min)	Qun Liu
11:20-11:50	03:20-03:50	Panel Discussion (30 min)	Dongxiao Wang
11:50-12:00	03:50-04:00	Ending	Dongxiao Wang
12:00-13:30	04:00-05:30	Luncheon	

POSTER (June 15-16)		
Number	Title	Speaker
P1	Surface Currents in the Southwestern Taiwan Strait in winter	Li Wang
P2	An Improved Nonlinear Iterative Method for Directional Ocean Wave Spectrum Inversion with HF Radar	Fuqi Mo
P3	Analysis of Direction-of-Arrival Estimation for a Floating High-Frequency Radar with Yaw Rotation	Xianzhou Yi
P4	Retrieval of Ocean Surface Wind Field Using a Dual-Frequency MIMO HF Surface Wave Radar System	Xiaoyan Li
P5	Research on Characteristics of the First-order Sea Clutter for Floating Platform High Frequency Hybrid Sky-surface Wave Radar	Qing Zhou

CONTENTS

Session 1: Ocean Radar Network

Research on HF Radar Cross Section Models of Ocean Surface

Weimin Huang

Department of Electrical and Computer Engineering, Memorial University, Canada

High frequency surface wave radar (HFSWR) has been widely deployed for ocean remote sensing. The HF radar cross section (RCS) models of sea surface are critical for such application and they can be derived based on either the small perturbation theory or the generalized function approach. In this study, recent progress on the development of HF sea surface RCS models based on the generalized function approach is summarized. These include the HF RCS model for the case of floating platform incorporating the six degree of freedom oscillation motion, a model for mixed-path ionosphere-ocean propagation, and the model of the ocean surface with arbitrary roughness scales. Meanwhile, ongoing research of relevant work is also briefly discussed.

The Global High Frequency Radar Network

Hugh Roarty

Rutgers University, USA

Academic, government, and private organizations from around the globe have established high frequency radar (HFR) networks at regional or national levels. Partnerships have been established to coordinate and collaborate on a single global HFR network. These partnerships were established in 2012 as part of the Group on Earth Observations (GEO) to promote HF radar technology and increase data sharing among operators and users. The main product of High Frequency radar networks are maps of ocean surface currents within 200 km of the coast. The technology is becoming a standard component for ocean observing systems. In 2017 the Global HFR Network was recognized by the Joint Technical Commission for Oceanography and Marine Meteorology as an observing network of the Global Ocean Observing System (GOOS). In this paper we will discuss the development of the network as well as establishing goals for the future.

The U.S. High Frequency Radar Network (HFRNet) has been in operation for over thirteen years, with representation from 31 organizations including measurements from Canada and Mexico. HFRNet currently holds a collection from over 150 radar installations totaling millions of records of surface ocean velocity measurements. During the past 10 years in Europe, HFR networks have been showing steady growth with over 50 stations currently deployed and many in the planning stage. In Asia and Oceania countries, more than 110 radar stations are in operation for marine safety, oil spill response, tsunami warning, coastal zone management and understanding of ocean current dynamics, depending mainly on each country's coastal sea characteristics. These radar networks are examples of national inter-agency and inter-institutional partnerships for improving oceanographic research and operations. As global partnerships grow, these collaborations and improved data sharing enhances our ability to respond to regional, national, and global environmental and management issues.

Keywords: HF radar, remote sensing, ocean observing, global ocean observing system

ZJU Oceanic lidars: Emulator, Instruments, and Application

LIU Dong

Zhejiang University

During the past ten years, Zhejiang Univeristy has developed more than 10 backscatter lidars for atmosphere and ocean studies. In this talk, the emulator developed for forward and backward simulation of oceanic lidar will be presented. With the help of the emulator, the optimized wavelengths of the oceanic lidar will be given with different detecting objects. Introduction of some oceanic lidar instruments will be given and some field experiments will be illustrated. The application of oceanic lidar for suspended particulates like phytoplankton are given.

Keywords: Oceanic lidar; Emulator; phytoplankton; backscatter; multiple scattering

References:

N. Wang, K. Zhang, X. Shen, Y. Wang, J. Li, C. Li, J. Mao, A. Malinka, C. Zhao, L. M. Russell, J. Guo, S. Gross, C. Liu, J. Yang, F. Chen, L. Wu, S. Chen, J. Ke, D. Xiao, Y. Zhou, J. Fang, and D. Liu*, "Dual-field-of-view high-spectral-resolution lidar: Simultaneous profiling of aerosol and water cloud to study aerosol-cloud interaction," Proceedings of the National Academy of Sciences of the United States of America 119, e2110756119 (2022).

Y. Zhou, W. Chen, D. Liu, X. Cui, X. Zhu, Z. Zheng, Q. Liu, and Y. Tao, "Multiple scattering effects on the return spectrum of oceanic high-spectral-resolution lidar," Opt Express 27, 30204-30216 (2019).

D. Liu, Y. Zhou, W. Chen, Q. Liu, T. Huang, W. Liu, Q. Chen, Z. Liu, P. Xu, X. Cui, X. Wang, C. Le, and C. Liu, "Phase function effects on the retrieval of oceanic high-spectral-resolution lidar," Opt Express 27, A654-A668 (2019).

D. Liu, P. Xu, Y. Zhou, W. Chen, B. Han, X. Zhu, Y. He, Z. Mao, C. Le, P. Chen, H. Che, Z. Liu, Q. Liu, Q. Song, and S. Chen, "Lidar Remote Sensing of Seawater Optical Properties: Experiment and Monte Carlo Simulation," IEEE Transactions on Geoscience and Remote Sensing 57, 9489-9498 (2019).

Marine Target Monitoring with Compact HFSWR: From Shore-based to Shipborne Systems

Yonggang Ji[1], Yiming Wang[2], Weifeng Sun[1], Changjun Yu[3], Ming Li[4], Jie Zhang[1]

1. *China University of Petroleum (East China)*
2. *First Institute of Oceanography, Ministry of Natural Resources*
3. *Harbin Institute of Technology (Wei Hai)*
4. *Ocean University of China*

HFSWR can be used for marine target monitoring and sea-state remote sensing, and most HFSWRs for ship target monitoring are large array systems. Compared with the large array system, the compact HFSWRs with small aperture have advantage of smaller radar site occupation, lower power consumption, and therefore can be easier deployment and maintenance. With the development of HFSWR technology, the compact HFSWR can be deployed on the shipborne platform to further expand its detection range. In this talk, firstly, the research progress related to target detection with shore-based compact HFSWR is introduced. Then, three kinds of shipborne HFSWR, including shipborne monostatic HFSWR, coast-ship bistatic HFSWR and shipborne bistatic HFSWR, are introduced. For the shipborne HFSWR, the movement of shipborne platform has a great impact on their radar echoes, thus affects the performance of target detection. Through the simulation of the first-order sea clutter and target echo under different motions of shipborne

platform, the influence of sea clutter broadening and corresponding blind area of sea clutter on target monitoring are analyzed. Then their applicable characteristics and the technical problems to be solved in marine target monitoring for those shipborne HFSWR are discussed. Finally, some experimental results, including target monitoring results and verification using measured data, marine target echo characteristics and motion compensation for shipborne HFSWR, are presented.

New sights into the ocean surface currents near the Bohai strait revealed by HF radar

Weili Wang[1], Wei Hu[1], Shoude Guan[2], Xiongbin Wu[3], Zhihui Chen[4], Xiangyang Zheng[5]

1. *North China Sea Marine Forecasting Center, Ministry of Natural Resources*
2. *Ocean University of China*
3. *Wuhan University*
4. *China Precise Ocean Detection Technology Co. Ltd*
5. *Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences*

The North-West Yellow Sea (NWYS) is a shallow semi-enclosed sea, to the north of Shandong peninsula, which connects the Bohai Sea and Yellow Sea through the Bohai strait. Previous work studied the region mainly by numerical tools or limited measurements from traditional instruments. In this paper, it is for the first time that the surface circulations in a large area are presented with a long time period of two years, with data collected from a routinely operated high-frequency radar (HFR) system with a pair of OSMAR071G type radars.

The HFR system continuously provides mappings of up to 100km off the coast, in near-real-time with high spatial and temporal resolutions. Benefiting from the new equipment, known for precision of the coastal surface current, the sea surface currents in this region are studied in climate. The radar-derived current measurements are examined using ADCP measurements. They are also compared with popular reanalysis datasets.

The flowing pattern varies significantly in different seasons. Seasonal and annual patterns are described. It is ovserved that the North Shandong Coastal Current (NSCC) is more significant in spring and fall rather than in winter and summer when the monsoon is more severe. The currents are observed to show good coincidence with local winds.

Keywords: High-frequency radar, North-West Yellow Sea, North Shandong Coastal Current, surface currents

References:

Ardhuin, F., Marié, L., Rascle, N., Forget, P. and Roland, A. 2009. Observation and estimation of Lagrangian, Stokes, and Eulerian currents induced by wind and waves at the sea surface. Journal of Physical Oceanography, Vol. 39: pp. 2820-2838.

Barrick, D. E., Evans, M. W. and Weber, B. L. 1977. Ocean surface currents mapped by radar. Science, Vol. 198: pp. 138-144.

Chapman, R. D., Shay, L. K., Graber, H. C., Edson, J. B., Karachintsev, A., Trump, C. L. and Ross, D. B. 1997. On the accuracy of HF radar surface current measurements: intercomparisons with ship-based sensors. Journal of Geophysical Research, Vol. 102: pp. 18737-18748.

Coscoli, S., Mazzoldi, A. and Gacic, M. 2010. Validation of surface current measurement in the Northern Adriatic Sea from high-frequency radars. Journal of Atmospheric and Oceanic Technology, Vol. 27: pp. 908-919.

Crombie D. D.1955. Doppler spectrum of sea echo at 13.56 Mc./s. Nature, 1955, Vol. 175: pp. 681-682.

Ding, Y., Cao, C. H., Huang, J., Song Y., Liu, G. Y., Wu, L. J. and Wan, Z. W. 2016. Origins and features of oil slicks in the Bohai Sea detected from satelliteSAR images. Marine Pollution Bulletin, Vol.106: pp. 149-154.

Forget, P. 2015. Noise properties of HF radar measurement of ocean surface currents. Radio Science, Vol. 50: pp. 764-777.

Guérin, C. A., Grilli, S. T., Moran, P., Grilli, A. R. and Insua, T. L. 2018. Tsunami detection by high-frequency radar in British Columbia: performance assessment of the time-correlation algorithm for synthetic and real events. Ocean Dynamics, Vol. 68: pp. 423-438.

Hisaki, Y. 2005. Ocean wave directional spectra estimation from an HF ocean radar with a single antenna array : observation. Journal of Geophysical Research, Vol. 110: pp. C11004.

Huang, W. M., Gill, E., Wu, S. C., Wen, B. Y., Yang, Z. J. and Hou, J. C. 2004. Measuring surface wind direction by monostatic HF ground-wave radar at the Eastern China Sea. IEEE Journal of Oceanic Engineering, Vol. 29: pp. 1032-1037.

Ivonin, D. V., Broche, P., Devenon, J. L. and Shrira, V. I. 2004. Validation of HF radar probing of the vertical shearof surface currents by acoustic Doppler currentprofiler measurements. Journal of Geophysical Research. Vol. 109: pp. C04003.

Kim, S. Y., Terrill, E. J., Cornuelle, B. D.Jones, B., Washburn, L., Moline, M. A., Paduan, J. D., Garfield, N., Largier, J. L., Crawford, G. and Kosro P. M. 2011. Mapping the U.S. west coast surface circulation: a multiyear analysis of high-frequency radar observations. Journal of Geophysical Research, Vol. 116: pp. C03011.

Kosro, P. M., Barth, J. A. and Strub, P. T. 1997. The coastal jet: observations of surface currents over the Oregon continental shelf from HF radar. Oceanography, Vol. 10: pp. 53-56.

Lipa, B. J., Barrick, D. E. and Maresca, Jr. J. W.1981. HF radar measurements of long ocean waves. Journal of Geophysical Research, Vol. 86: pp. 4089-4102.

Paduan, J. D. and Rosenfield, L. K. 1996. Remotely sensed surface currents in Monterey bay from shore-based HF radar (Coastal Ocean Dynamics Application Radar).Journal of Geophysical Research, Vol. 101: pp. 20669-20686.

Rubenstein, D. and Newman, F. 1983. A statistical model of vertical shear from moored current meters. Journal of Physical Oceanography, Vol. 13: pp. 966-971.

Sentchev, A., Forget, P., Barbin, Y. and Yaremchuk, M. 2013. Surface circulation in the Iroise Sea (W. Brittany) from high resolution HF radar mapping. Journal of Marine Systems, Vol. 109-110: pp. S153-S168.

Wu, X. B., Yang, S. L., Cheng, F., Wu, S. C., Yang, Z. J., Wen, B. Y., Shi, Z. H., Tian, J. S., Ke, H. Y. and Gao, H. T. 2003. Ocean surface current detection by HF surface wave radar at the Eastern China Sea. Chinese Journal of Geophysics, Vol. 46: pp. 489-498.

Wyatt L. R., Mantovanelli A., Heron M.L., Roughan M., Steinberg C. R. 2018. Assessment of surface currents measured with High-Frequency phased-array radars in two regions of complex circulation. IEEE Journal of Oceanic Engineering. Vol. 43: pp 484-505.

Zheng X, Zhang H, Li Y, Zou T, Liu X, Xing Q (2021) The features and mechanisms of the North Shandong Coastal Current: a case study in 2014.

Shipborne oceanic high-spectral-resolution lidar for accurate estimation of seawater depth-resolved optical

properties

Yudi Zhou[1], Yang Chen[1], Hongkai Zhao[1], Cédric Jamet[2], Davide Dionisi[3], Malik Chami[4], Paolo Di Girolamo[5], James H. Churnside[6], Aleksey Malinka[7], Huade Zhao[8], Dajun Qiu[9], Tingwei Cui[10], Qun Liu[1], Yatong Chen[1], Sornsiri Phongphattarawat[11], Peng Chen[12], Dong Liu[1*]

1. *Zhejiang University*
2. *Univ. Littoral Côte d'Opale*
3. *Italian National Research Council*
4. *Sorbonne Université*
5. *Scuola di Ingegneria*
6. *University of Colorado Boulder and NOAA Chemical Sciences Laboratory*
7. *National Academy of Sciences of Belarus*
8. *National Marine Environmental Monitoring Center*
9. *South China Sea Institute of Oceanology*
10. *Sun Yat-sen University*
11. *Prince of Songkla University*
12. *Second Institute of Oceanography*

Lidar techniques present a distinctive ability to resolve vertical structure of optical properties within the upper water column at both day- and night-time. However, accuracy challenges remain for existing lidar instruments due to the ill-posed nature of elastic backscatter lidar retrievals and multiple scattering. Here we demonstrate the high performance of, to the best of our knowledge, the first shipborne oceanic high-spectral-resolution lidar (HSRL) and illustrate a multiple scattering correction algorithm to rigorously address the above challenges in estimating the depth-resolved diffuse attenuation coefficient Kd and the particulate backscattering coefficient bbp at 532 nm. HSRL data were collected during day- and night-time within the coastal areas of East China Sea and South China Sea, which are connected by the Taiwan Strait. Results include vertical profiles from open ocean waters to moderate turbid waters and first lidar continuous observation of diel vertical distribution of thin layers at a fixed station. The root-mean-square relative differences between the HSRL and coincident in situ measurements are 5.6% and 9.1% for

Kd and bbp, respectively, corresponding to an improvement of 2.7-13.5 and 4.9-44.1 times, respectively, with respect to elastic backscatter lidar methods. Shipborne oceanic HSRLs with high performance are expected to be of paramount importance for the construction of 3D map of ocean ecosystem.

Keywords: high-spectral-resolution lidar; particulate backscatter coefficient; diffuse attenuation coefficient; multiple scattering; thin layer

References:

1. Zhou, Y. et al. Retrieving the seawater volume scattering function at the 180° scattering angle with a high-spectral-resolution lidar. Opt. Express 25, 11813-11826 (2017).

2. Zhou, Y. et al. Multiple scattering effects on the return spectrum of oceanic high-spectral-resolution lidar. Opt. Express 27, 30204-30216 (2019).

3. Liu, D. et al. Lidar remote sensing of seawater optical properties: experiment and Monte Carlo simulation. IEEE Trans. Geosci. Remote Sens. 57, 9489-9498 (2019).

4. Zhou, Y. et al. Validation of the Analytical Model of Oceanic Lidar Returns: Comparisons with Monte Carlo Simulations and Experimental Results. Remote Sens. 11, 1870 (2019).

Session 2: Data Management and Analysis

Multi-scale Analysis and Data Assimilation of HF-Radar Currents

Jianzhong Ge[1], Jingsi Zhang[1], Panjun Du[2]

1. *East China Normal University*

2. *East China Sea Bureau of the Ministry of Natural Resources*

The HF radar data of Zhoushan and Jiangsu coastal areas were applied to study the multi-scale circulation variations and numerical data assimilation. Based on years of HF radar data in Zhoushan sea area, the dynamic processes of surface ocean current at multiple time scales in tidal cycles, monthly, seasonly and inter annual variabilities, and extreme weather condition, are interpreted. Based on the FVCOM model, a Three-Dimensional Variational Assimilation (3D-VAR)

module for unstructured meshes was developed, and a generalized radar assimilation scheme was established.The 3D-VAR scheme was used to carry out surface current assimilation in space and the Nudging scheme was used to extend the assimilation effect of 3D-VAR to the time dimension. The assimilation model was applied to Zhoushan and Jiangsu regions,The 3D-VAR assimilation can effectively improve the correlation between model and radar data in space, and effectively reduce the error between them.

Keywords: HF-Radar; Data Assimilation; FVCOM

Wave and wind measurements using Multifrequency HF radar

Chen Zhao[1], Zezong Chen[1], Fan Ding[1], Min Deng[1]

1. Wuhan University

HF radars have been extensively used for current observation. However, wave and wind measurement with HF radars is challenging. In order to obtain robust wave measurements in complex and various sea states, a wave inversion method is proposed for a multifrequency HF radar. The nondirectional wave spectrum is directly retrieved from the radar echoes collected at various frequencies (up to four), and then, the significant wave height and the mean wave period are obtained from the integration of the derived nondirectional wave spectrum. Simulation analysis is carried out to evaluate the performance of the proposed method for a case in four various radar frequencies. Then, the proposed method is applied to a three-day observation to validate its advantages by comparing the radar-estimated and WaveRider-measured nondirectional wave spectra. In addition, a 14-day dataset collected with an HF radar operating at 8.267 and 19.2 MHz is selected for further validation via comparisons between the radar-estimated and the buoy-measured wave parameters.

Recently, the wind speed inversion method based on the first-order HF radar sea echoes attracts much attention. However, most methods, which use radar data at a fixed operating frequency, provide a limited range for wind speed measurement. To overcome the drawback, a wind speed inversion method based on radar data collected with a multifrequency HF radar is proposed. This new method first fits the relationship between the wind speed and the power of the

broad-beam first-order HF radar sea echoes and then combines the fit models with the multifrequency HF radar data to estimate wind speed. The proposed method makes use of the information contained in the first-order sea echoes of various operating frequencies so as to improve the performance of the wind speed measurements. Finally, a comparison between radar-estimated and anemometer-measured wind speeds is made to validate the proposed method.

Keywords: Multifrequency; HF radar; wave measurements; wind measurements

References:

[1] C. Zhao, M. Deng, Z. Chen, F. Ding, and W. Huang, "Ocean wave parameters and nondirectional spectrum measurements using multifrequency HF radar," IEEE Trans. Geosci. Remote Sens., 60, 4204413, pp. 1-13, 2022.

[2] F. Ding, C. Zhao*, Z. Chen, M. Deng, T. Wang, "Wind Speed Extraction from First-Order Sea Echoes Using a Small-Aperture Multifrequency High Frequency Radar", IEEE Trans. Geosci. Remote Sens., 60, 4206908, pp. 1-8, 2022. [3] C. Zhao, Z. Chen, C. He, F. Xie, X. Chen, and C. Mou, "Validation of sensing ocean surface currents using multi-frequency HF radar based on a circular receiving array," Remote Sens., vol. 10, no. 2, p. 184, 2018. [4] C. Zhao, Z. Chen, J. Li, L. Zhang, W. Huang, and E. W. Gill, "Wind direction estimation using small-aperture HF radar based on a circular array," IEEE Trans. Geosci. Remote Sens., vol. 58, no. 4, pp. 2745–2754, Apr. 2020.

Study of Lagrangian pair dispersion in the Gulf of Tonkin using surface current data measured by HF radar

Manh Cuong Tran[1], Alexei Sentchev[1], Stefano Berti[2]

1. *Laboratory of Oceanology and Geosciences, UMR 8187, CNRS*
2. *Univ. Lille, ULR 7512, Unité de Mécanique de Lille Joseph Boussinesq (UML)*

In recent years, the Lagrangian metrics were extensively used for characterizing the turbulence and mixing of the flow. However, the drifter data are not always available for assessment of the Lagrangian statistic. In this regard, the use of the cost-effective remote sensing technique by HF radar allows assessing the small-scale transport in the coastal region. In this work, surface current data are collected from two long-range CODAR Seasonde HF radar stations operating in the Gulf of Tonkin during two year 2014 - 2016. The surface current fields are

reprocessed by using a variational approach (EOF/2dVar) to provide a gaps-free dataset which allows the spatial and temporal assessment of the surface circulation in the data-poor region of the southern Gulf of Tonkin (the GoT). Comparing with the traditional OMA method for gap-filling, the variational approach shows 30% better of Lagrangian prediction skill. The Lagrangian pair statistics, using the mean square separation of particle pairs and the Finite Scale Lyapunov Exponents (FSLEs), are then investigated using the virtual particles advected by the radar-derived flow field. The analysis suggests a seasonality in the dispersion processes. A further analysis using the high-resolution numerical model suggests an agreement with the one advected by the radar-derived velocity field, however, highlights the impacts of monsoon wind and the river runoff on turbulent dispersion and transport of passive tracers.

Keywords: Relative dispersion; Coastal turbulence; HF radar; Gulf of Tonkin

References:

Berti, S., & Lapeyre, G. (2021). Lagrangian pair dispersion in upper-ocean turbulence in the presence of mixed-layer instabilities. Physics of Fluids, 33(3), 036603. https://doi.org/10.1063/5.0041036

Haza, A. C., Özgökmen, T. M., Griffa, A., Molcard, A., Poulain, P.-M., & Peggion, G. (2010). Transport properties in small-scale coastal flows: relative dispersion from VHF radar measurements in the Gulf of La Spezia. Ocean Dynamics, 60(4), 861–882. https://doi.org/10.1007/s10236-010-0301-7

Hernández-Carrasco, I., Solabarrieta, L., Rubio, A., Esnaola, G., Reyes, E., & Orfila, A. (2018). Impact of HF radar current gap-filling methodologies on the Lagrangian assessment of coastal dynamics. Ocean Science, 14(4), 827–847. https://doi.org/10.5194/os-14-827-2018

Schroeder, K., Haza, A. C., Griffa, A., Özgökmen, T. M., Poulain, P. M., Gerin, R., Peggion, G., & Rixen, M. (2011). Relative dispersion in the Liguro-Provençal basin: From sub-mesoscale to mesoscale. Deep Sea Research Part I: Oceanographic Research Papers, 58(3), 209–228. https://doi.org/10.1016/j.dsr.2010.11.004

Tran, M. C., Sentchev, A., & Nguyen, K. C. (2021). Multi-scale variability of circulation in the Gulf of Tonkin from remote sensing of surface currents by high-frequency radars. Ocean Dynamics, 71(2), 175–194. https://doi.org/10.1007/s10236-020-01440-x

Yaremchuk, M., Spence, P., Wei, M., & Jacobs, G. (2016). Lagrangian predictability in the DWH region from HF radar observations and model output. Deep-Sea Research Part II: Topical Studies in Oceanography, 129, 394–400. https://doi.org/10.1016/j.dsr2.2013.05.035

Yaremchuk, M., & Sentchev, A. (2011). A combined EOF/variational approach for mapping radar-derived sea surface currents. Continental Shelf Research, 31(7–8), 758–768. https://doi.org/10.1016/j.csr.2011.01.009

Data product of HF Radar data from Ocean Networks Canada

Manman Wang[1], Alice Bui[1], Richard Dewey[1], Steven F Mihaly[1], Kevin Bartlett[1]

1. Ocean Networks Canada, Victoria, BC, Canada (Corresponding author's e-mail: manmanw@oceannetworks.ca)

Juan de Fuca Strait: VJOR, VROC, 16 MHz

Prince Rupert: VDIG, VRID, 25 MHz

SOG: VION, VGPT, VATK, VCOL, 25MHz

WERA: Tofino, 13.5 MHz

Hecate Strait: SAND, BONI, 5MHz

Halifax Harbour: SCOV, 5MHz

1 Introduction

Ocean Networks Canada (ONC), an initiative of the University of Victoria, operates 11 high-frequency (HF) radar systems along Canada's west coast and operating another one from the east coast of Canada in Halifax Harbour with various frequency. Four radars from manufacture of SeaSonde (CODAR) with frequency of 25 MHz have been installed in the strait of Georgia since 2011; and two additional CODAR systems with the same frequency have been used to collect data since 2016 in Prince Rupert. Two CODAR systems with lower frequency of 16 MHz have been fully operated in Juan de Fuca Strait since 2019. The department of Fishers and Oceans Canada has transferred two other CODAR systems to ONC that are operating in northern part of Vancouver Island in Hecate Strait. A single WERA array operates at 13.5 MHz in Tofino, on the west coast of Vancouver Island. ONC also operates two X-band Wave Monitoring Systems (WaMoS) at 10 GHz.

In addition to the quality-controlled data products, heat maps that are showing spatial availability are also accessible through ONC's data system webpage, Ocean3.0. Other data product such as high level of QC'd data, temporal availability, tides information. Last but most importantly is the application of trajectory tracking, the preliminary work of which has been done (Figure 3), which will be presented.

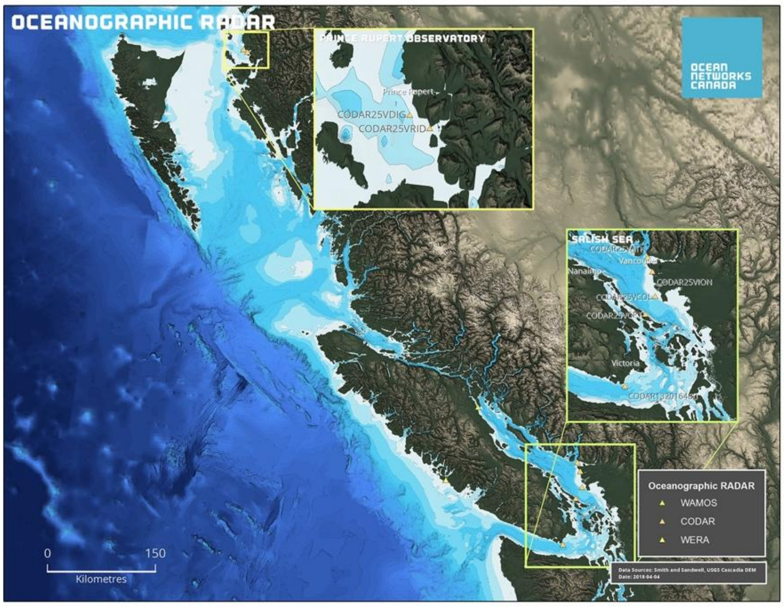

Figure 1. Maps showing radars operated by Ocean Networks Canada.

2 Background and Quality Control results

2.1 Background

Environmental conditions impact the quality and accuracy of ocean surface currents data measured with HF radar installations (Panduan et al., 2006). The main influencers in the data quality can be classified into three general areas: characteristics of the wind and waves, surface salinity in the coverage area, and complexity of the ocean current pattern. Tidal currents are strong throughout the Strait of Georgia and seasonal wind forcing causes large-scale coastal upwelling and downwelling currents. In addition, localized freshwater river flow from the Fraser River has a large effect on the coverage and quality of CODAR observations in the Salish Sea (Halverson and Pawlowicz, 2016).

2.2 Quality control results

Ocean Networks Canada aims for the highest standards of data Quality Assurance and Quality Control (QA/QC) testing and reporting. In order to provide a fast and accurate assessment of the data quality, ONC has adopted the guidelines of the Quality Assurance of Real-Time

Oceanographic Data (QARTOD), from which quality tests are applied to both radial and total ocean current data (Fig. 2). In particular, five different tests for quality evaluation are applied to our CODAR data:

1.Radials test

2.Syntax test

3.Maximum threshold test, depending on the maximum velocity during storm event

4.Valid location test

5.Geometric Dilution of Precision (GDOP) threshold taking an extremely strict value of 1.25, which can be adjusted in order to meet different levels of science research.

The CODAR data is filtered based on the results of these five tests to provide accurate and reliable data products. Raw data, filtered data and data products such as images, are available for download with their corresponding metadata.

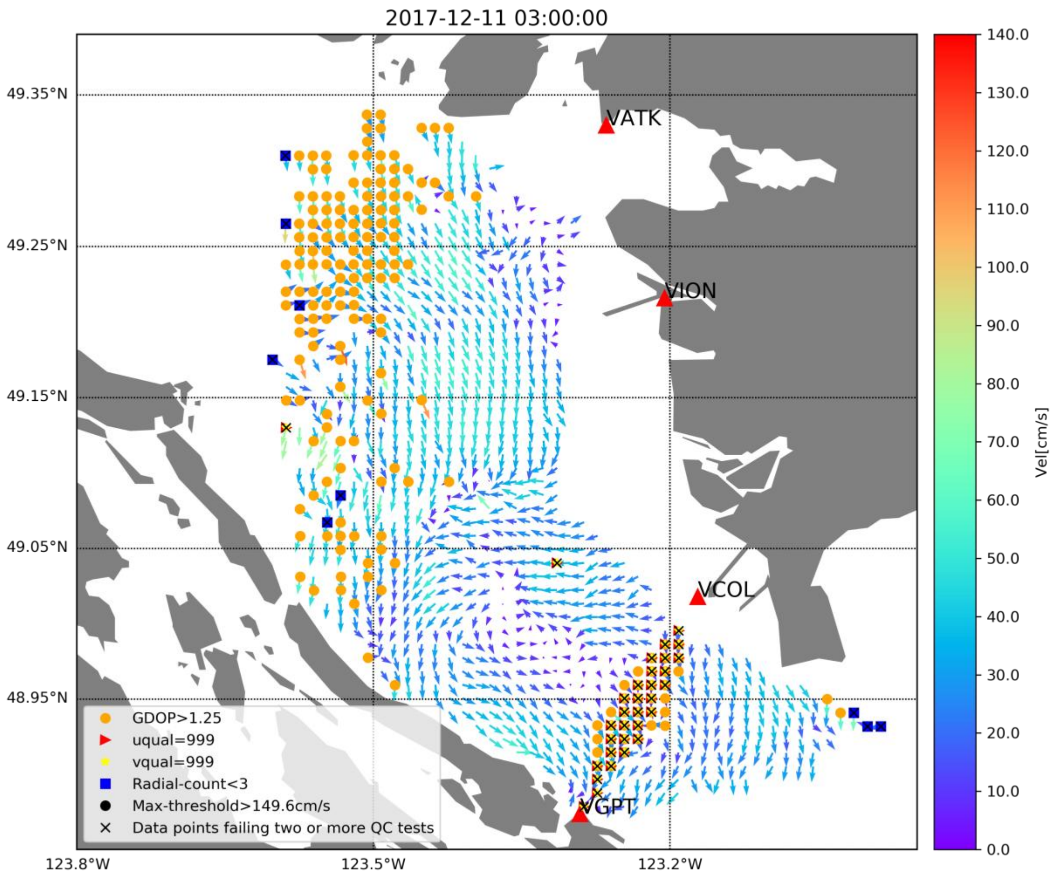

Figure 2: Map showing raw total vectors in the strait of Georgia. Grid points where QC tests failed are marked by different shapes and color according the test that failed. Legend shows tests applied to total vectors.

2.3 Data Products

In addition to the quality-controlled data products, heat maps that are showing spatial availability are also accessible through ONC's data system webpage, Ocean3.0. Other data product such as high level of QC'd data, temporal availability, tides information. Last but most importantly is the application of trajectory tracking, the preliminary work of which has been done (Figure 3), which will be presented.

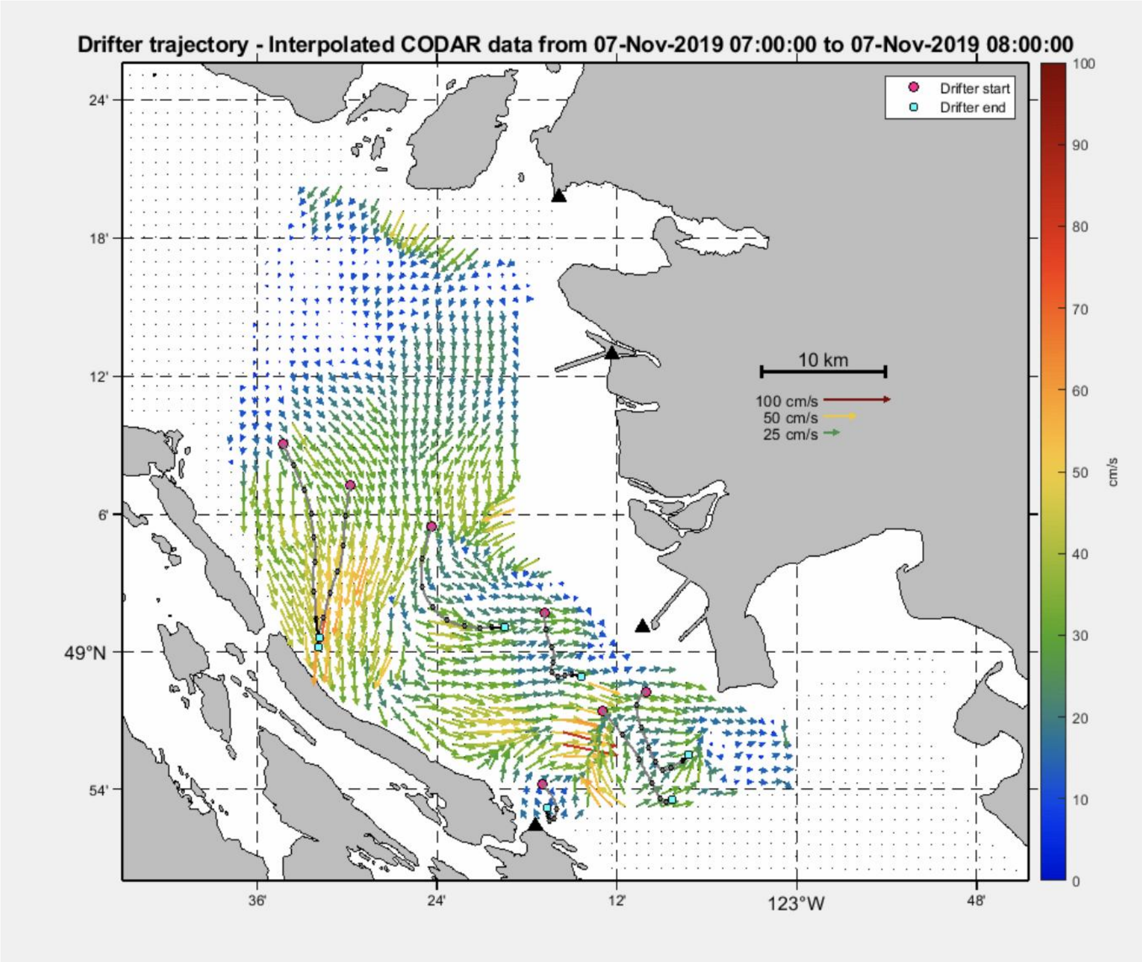

Figure 3. Drifter tracks that are calculated every hour.

3 Summary

Ocean Networks Canada's goal is to develop and provide high quality radar data products to our users.

Currently ONC has applied quality controls for CODAR radar data based on QARTOD standards. High level of data products is under development. More applications of HF Radar data is very promising.

WERA and WaMoS data are currently provided based on the QA/QC process provided by the supplier. New data products are under development for these two systems, including two tsunami detection algorithms for the WERA system based on surface current measurements (Dzvonkovskaya et al., 2017, Grilli et al., 2017, Guérin et al., 2018).

References

Dzvonkovskaya, A., Petersen, L., Insua, T. (2017). Real-Time Capability of Meteotsunami Detection by WERA Ocean Radar System. Proceedings of the 18th International Radar Symposium, 10p, Prague, Chez Republic, June 28-30, 2017. IEEE Explore. DOI: 10.23919/IRS.2017.8008096

Grilli, S.T., Shelby, M., Grilli, A.R., Guérin, C-A., Moran, P., Grosdidier, S., Insua, T.L. (2017). Tsunami detection by High Frequency Radar beyond the continental shelf: II. Extension of algorithms and validation on realistic case studies. Pure and applied geophysics, 174, 3003-3028, DOI: 10.1007/s00024-017-1619-6

Guérin, C-A., Grilli, S.T., Shelby, Moran, P., Grilli, A.R., Insua, T.L. (2018). Tsunami detection by High Frequency Radar in British Columbia: performance assessment of the Time-Correlation Algorithm for synthetic and real events. Ocean Dynamics, 1-16, DOI: 10.1007/s10236-018-1139-7

Panduan, J., Kim, K. C., Cook, M., and Chavez, F (2006). Calibration and validation of direction-finding high-frequency radar ocean surface current observations. IEEE Journal of Oceanic Engineering, 31 (4), 862-875. DOI: 10.1109/JOE/2006.886195

Halverson, M.J., and Pawlowicz, R. (2016). Tide, wind, and river forcing of the surface currents in the Fraser River plume. Atmosphere-Ocean, 54, 131-152, DOI: 10.1080/07055900.2016.1138927

Session 3: Application and Research Results

High-speed target detection and motion parameters

estimation with HF radar

Gan Liu[1], Yingwei Tian[1], Shengmo Ma[1]

1. *School of Electronic Information, Wuhan University, Wuhan, China 430072*

High frequency radar is one of the effective means in over-the-horizon (OTH) detection of high-speed targets with good anti-stealth performance. However, the range dimension and Doppler frequency dimension will expand severely during a long-time observation due to the high maneuverability of targets. The conventional moving target detection (MTD) algorithms cannot effectively accumulate the energy of targets because of range migration (RM) and Doppler frequency migration (DFM), which make the target detection and parameter estimation challenging. The long time coherent integration (LTCI) algorithms utilize the phase information of the echo to correct RM and compensate the DFM, which can enormously improve the integration gain and detection performance of the target echo.

However, complex background noise, mismatched motion model and flickering target signal-to-noise ratio (SNR) in real data will seriously degrades the integration gain of the LTCI algorithms. To solve the above issues, a modified generalized Radon Fourier transform (MGRFT) algorithm based on sliding windows (SW-MGRFT) is proposed. A motion model with the angle between target moving direction and radar line of sight is constructed to match the trajectory for non-radially moving targets, which used in MGRFT algorithm enables effective energy integration on characteristic invariant with feasible computation complexity. Then the SW-MGRFT algorithm makes use of the correlation of inter-windows and in-windows to accomplish coherent integration in each sliding window, and then perform incoherent integration of the SW-MGRFT results exceed the threshold. Finally, numerical simulation and field experiment results show that the proposed algorithm improves the detection performance and the accurate parameter estimation results in contrast with the existing LTCI algorithms.

Keywords: Long-time coherent integration, high-speed target detection, parameter estimation, high frequency radar, sliding windows, modified GRFT

References:

[1] J. Su, M. Xing, G. Wang, and Z. Bao, “High-speed multitarget detection with narrowband radar,” IET radar, sonar & navigation, vol. 4, no. 4, pp. 595–603, 2010.

[2] S. Zhu, G. Liao, D. Yang, and H. Tao, “A new method for radar high-speed maneuvering weak target detection and imaging,” IEEE Geoscience and Remote Sensing Letters, vol. 11, no. 7, pp. 1175–1179, 2013.

[3] X. Chen, J. Guan, N. Liu, and Y. He, “Maneuvering target detection via radon-fractional fourier transform-based long-time coherent integration,” IEEE Transactions on Signal Processing, vol. 62, no. 4, pp. 939–953, 2014.

[4] P. Huang, G. Liao, Z. Yang, X.-G. Xia, J.-T. Ma, and J. Ma, “Long-time coherent integration for weak maneuvering target detection and high-order motion parameter estimation based on keystone transform,” IEEE Transactions on Signal Processing, vol. 64, no. 15, pp. 4013–4026, 2016.

[5] W. Cui, S. Wu, Q. Shen, J. Tian, S.-L. Wu, and X.-G. Xia, “Parameter estimation method for radar maneuvering target with arbitrary migrations,” IEEE Transactions on Aerospace and Electronic Systems, vol. 55, no. 5, pp. 2195–2213, 2018.

[6] K. Jin, T. Lai, Y. Wang, G. Li, and Y. Zhao, “Radar coherent detection for doppler-ambiguous maneuvering target based on product scaled periodic lv’s distribution,” Signal Processing, vol. 174, p. 107617, 2020.

[7] J. Tian, W. Cui, X.-G. Xia, and S. Wu, “A new motion parameter estimation algorithm based on sdfc-lvt,” IEEE Transactions on Aerospace and Electronic Systems, vol. 52, no. 5, pp. 2331–2346, 2016.

[8] R. Perry, R. Dipietro, and R. Fante, “Sar imaging of moving targets,”IEEE Transactions on Aerospace and Electronic Systems,vol. 35, no. 1, pp. 188–200, 1999.

[9] D. Zhu, Y. Li, and Z. Zhu, “A keystone transform without interpolation for sar ground moving-target imaging,” IEEE Geoscience and Remote Sensing Letters, vol. 4, no. 1, pp. 18–22, 2007.

[10] J. Xu, J. Yu, Y.-N. Peng, and X.-G. Xia, “Radon-fourier transform for radar target detection, i: generalized doppler filter bank,” IEEE transactions on aerospace and electronic systems, vol. 47, no. 2, pp. 1186–1202, 2011.

[11] J. Xu, J. Yu, Y.-N. Peng, X.-G. Xia, and T. Long, “Spacetime radon-fourier transform and applications in radar target detection,” IET Radar, Sonar & Navigation, vol. 6, no. 9, pp. 846–857, 2012.

[12] J. Zheng, T. Su, W. Zhu, X. He, and Q. H. Liu, “Radar high-speed target detection based on the scaled inverse fourier transform,” IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 8, no. 3, pp. 1108–1119,2014.

[13] J. Zheng, T. Su, H. Liu, G. Liao, Z. Liu, and Q. H. Liu,“Radar high-speed target detection based on the frequency domain deramp-keystone transform,” IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing,vol. 9, no. 1, pp. 285–294, 2015.

[14] G. Li, X.-G. Xia, and Y.-N. Peng, “Doppler keystone transform:An approach suitable for parallel implementation of sar moving target imaging,” IEEE Geoscience and Remote Sensing Letters,vol. 5, no. 4, pp. 573–577, 2008.

[15] D. Kirkland, “Imaging moving targets using the second-order keystone transform,” IET radar, sonar & navigation, vol. 5,no. 8, pp. 902–910, 2011.

[16] G. Sun, M.-D. Xing, Y. Wang, F. Zhou, Y. Wu, and Z. Bao,“Improved ambiguity estimation using a modified fractional radon transform,” IET radar, sonar & navigation, vol. 5, no. 4,pp. 489–495, 2011.

[17] J. Tian, W. Cui, Q. Shen, Z. Wei, and S. Wu, “High-speed maneuvering target detection approach based on joint rft and keystone transform,” Science China Information Sciences, vol. 56,no. 6, pp. 1–13, 2013.

[18] X. Chen, J. Guan, N. Liu, W. Zhou, and Y. He, “Detection of a low observable sea-surface target with micromotion via the radon-linear canonical transform,” IEEE Geoscience and Remote Sensing Letters, vol. 11, no. 7, pp. 1225–1229, 2013.

[19] X. Chen, Y. Huang, N. Liu, J. Guan, and Y. He, “Radon fractional ambiguity function-based detection method of low-observable maneuvering target,” IEEE Transactions on Aerospace and Electronic Systems, vol. 51, no. 2, pp. 815–833,2015.

[20] X. Chen, J. Guan, Y. Huang, N. Liu, and Y. He, “Radon-linear canonical ambiguity function-based detection and estimation method for marine target with micromotion,” IEEE Transactions on Geoscience and Remote Sensing, vol. 53, no. 4, pp. 2225–2240, 2014.

[21] X. Chen, J. Guan, X. Li, and Y. He, “Effective coherent integration method for marine target with micromotion via phase differentiation and radon-lv’s distribution,” IET Radar,Sonar & Navigation, vol. 9, no. 9, pp. 1284–1295, 2015.

[22] P. Huang, X.-G. Xia, X. Liu, and G. Liao, “Refocusing and motion parameter estimation for

ground moving targets based on improved axis rotation-time reversal transform," IEEE Transactions on Computational Imaging, vol. 4, no. 3, pp. 479–494,2018.

[23] G. Zhou, Z. Xu, and Y. Yang, "Coherent integration for targets with constant cartesian velocities based on accurate range model," Digital Signal Processing, vol. 116, p. 103092, 2021.

[24] J. Tsao and B. D. Steinberg, "Reduction of sidelobe and speckle artifacts in microwave imaging: The CLEAN technique," IEEE Transactions on Antennas and Propagation, vol. 36, no. 4, pp.543–556, 1988.

[25] H. Deng, "Effective clean algorithms for performance-enhanced detection of binary coding radar signals," IEEE Transactions on Signal Processing, vol. 52, no. 1, pp. 72–78, 2004.

[26] Q. Wang, M. Xing, G. Lu, and Z. Bao, "Srmf-clean imaging algorithm for space debris," IEEE Transactions on Antennas and Propagation, vol. 55, no. 12, pp. 3524–3533, 2007.

Short-term prediction of sea surface flows in the Guangdong-Hong Kong-Macao Greater Bay Area based on High Frequency radar observations

Lei Ren[1], Lingna Yang[1], Jun Wei[1]

1. Sun Yat-sen University

Sea currents prediction is not only important content of marine meteorological research, but also a key scientific issue to be solved in coastal engineering construction. In this research, temporal and spatial characteristics of sea surface currents for the Guangdong- Hong Kong-Macao Greater Bay Area was analyzed firstly, and then a short-term sea surface currents prediction model was established based on the continuous sea surface currents using integrated machine learning algorithm and shore-based High Frequency radar observations. Random forest algorithm was applied to assess variable importance during establishing the short-term forecasting model based on the AdaBoost algorithm. A number of sensitivity tests and comparisons were undertaken. The results indicate that when the prediction window period for sea surface flow fields is 10 steps, the trend of the sea surface flow field based on the integrated algorithm is in good agreement with the measured flow fields. These findings will provide scientific basis and important reference for marine engineering construction, disaster prevention and reduction and

coastal rescue in this area.

Keywords: forecasting, random forests, AdaBoost, HF radar

References:

[1] Orfila A, Molcard A, Sayol J M, Marmain J, Bellomo L, Quentin C, Barbin Y. Empirical Forecasting of HF-Radar Velocity Using Genetic Algorithms[J]. Ieee Transactions on Geoscience and Remote Sensing, 2015, 53(5): 2875-2886.

[2] Chen H, Tang T, Ait-Ahmed N, Benbouzid M E H, Machmoum M, Zaim M E-H. Attraction, Challenge and Current Status of Marine Current Energy[J]. Ieee Access, 2018, 6: 12665-12685.

[3] Kim S J, Korgersaar M, Ahmadi N, Taimuri G, Kujala P, Hirdaris S. The influence of fluid structure interaction modelling on the dynamic response of ships subject to collision and grounding[J]. Marine Structures, 2021, 75.

Marine disaster prevention and mitigation based on big data

Lin Mu

Shenzhen University

The ocean is becoming a new space for human development and marine disaster prevention and mitigation are the important parts of ensuring marine economic construction. The improvement of the marine disaster prevent ability is the primary task of “strengthening areas of weakness” in the capacity of marine construction. This report inllustrates the importance of the disaster prevention and mitigation based on big data in two aspects of “natural disaster” and “man-made disater”, which indicates the key points of marine informatiztion “understanding the basics” “professional monitoring” “accurate modelling” and “intensified application”. In view of the existing problems of marine disaster prevention and mitigation at present, in terms of "natural disasters", this report expounds in detail the sources of marine big data and the main technologies of storm surge risk zoning research. Taking Shenzhen city as an example, it introduces storm surge risk zoning from four aspects: risk, exposure, vulnerability and disaster prevention and mitigation ability. As for "man-made disasters", aiming at the problems of the lack of original technology that can be applied in the marine environmental protection system, the poor integration of multi-source information, and the lack of convergence of cross-domain technologies, we fully integrated the

marine radar observation data, put forward the design concept of "three integrations" of the protection system, and developed the "China Sea Oil Spill Drift and Rescue Integrated Forecast and Early Warning System". Considering the joint effect of high-resolution wind-wave-current coupling model on oil spill diffusion, the multi-dimensional Monte Carlo random statistical method is introduced to analyze the spatial and temporal randomness of drift diffusion targets and the error uncertainty of numerical prediction field, which improves the simulation accuracy of oil spill expansion and drift range. The convex hull algorithm of topological geometry is introduced to calculate the oil spill diffusion range, which greatly improves the calculation efficiency. At the same time, considering the commonness of oil spill and rescue target, the prediction results of oil spill and rescue target are integrated with the emergency resource database, so as to realize the rapid prediction and early warning of oil spill, people in distress and ship drift.

Submesoscale eddies and tidal currents in eastern Guangdong identified using high-frequency radar observations

Dongxiao Wang

Sun Yat-sen University

The statistical characteristics and mechanism underlying the generation of submesoscale eddies in eastern Guangdong were examined using high-frequency radar (HFR) observations of surface currents during 2019_2021. By applying the vector geometry-based (VG) eddy detection algorithm to HFR datasets, 313 submesoscale eddies with 229 cyclones and 84 anticyclones were identified. Cyclonic eddies were significantly more common than the anticyclonic eddies, but they had similar distributions in terms of eddy lifespan and radius. The trajectories showed that the submesoscale eddies within the study area tended to move northward and westward. Submesoscale eddies revealed annual variations with decreasing cyclonic eddies and increasing anticyclonic eddies during the observation period. Submesoscale eddies displayed a remarkable spatial distribution. Cyclonic (anticyclonic) eddies frequently occurred at the eastern and southeastern regions of the Huilai Headland (south of the Nanao Island). Eddy evolution was linked to the production of vorticity in a narrow layer along the headland, the injection of vorticity

into the interior at the point of flow separation, and vorticity damping by bottom friction. The application of HFR allows us to obtain high resolution tidal currents. Tidal harmonic analysis results show that the tide in this area mostly belongs to regular semidiurnal tide, and the shallow water components are not negligible. The M2 tide current is mainly counterclockwise reciprocating flow. The direction is along the northwest-southeast.

Application of Oceanic HF Radars: Challenges Remaining

Wu Xiongbin

School of Electronic Information, Wuhan University, Wuhan, China 430072

Oceanic HF radars have been installed along many coasts all around the world, most of which happened within the recent two decades. It is believed that surface dynamics such as currents, waves and winds field could be extracted from HF radar ocean echoes, because the radar backscatter signals are obviously modulated by them when we look into the Doppler spectra of the echo's time series. However, only currents field results are of reluctantly enough credibility to be applied in oceanographic studies and marine engineering, while the wave and wind outputs, especially the mid or long range ones, could not satisfy the application requirements and the situation may cause some doubts on the applicability of HF radar in marine activities. To tackle this problem, the HF radar community needs put more efforts on the following aspects.

First of all, theories on how to evaluate the credibility of HF radar outputs should be established. They would facilitate the users on deciding how much weight assigned to radar results and on judging to what extent the radar results could be used in their investigations. In addition, the purpose of verification tests should be changed from verifying radar's detection capability to verifying the validity of the credibility model of each HF radar system. Secondly, studies on the HF radio wave scattering mechanisms by sea surface should be intensified. Though there exist good theories on the mechanisms, inconsistences between theories and real Doppler spectra still can be observed especially in higher order backscatter spectra. Even in the first order backscatter, the two ± Bragg peaks had been found be affected by slightly different currents where the difference could be larger than 10cm/s. Thirdly, we should answer the question on whether the wind velocity can be inversed from HF radar echoes. Studies found that the wind spreading factor could be extracted from HF radar data, where this is an impressive and unique merit of HF radar detection, but there exists velocity ambiguity between wind spreading and wind velocity, as indicated by the Mitsuyasu relationship. Multi-frequency HF radar system may alleviate this problem but essentially it only shift the ambiguity wind velocity limit to higher values. Fourthly, directional waveheight spectra inversion algorithms need more study as new scattering mechanisms may be achieved. Fifthly, novel radar system techniques should be applied to make oceanic HF radar more applicative to marine users. For example, MIMO techniques have been applied in HF radars and the area requirement on array occupation had been reduced a lot without sacrificing the system's DOA estimation capability.

Flow dynamics at the coasts of Phu Yen, Vietnam, at the onset of Southwest Monsoon

Thanh Huyen Tran[1], Alexei Sentchev[2], Sylvain Ouillon[3]

1. *Department of Water – Environment – Oceanography, Univ. Sci. Tech. Hanoi; Laboratory of Oceanology and Geosciences (CNRS UMR 8187 LOG), ULCO*
2. *Laboratory of Oceanology and Geosciences (CNRS UMR 8187 LOG), ULCO*
3. *Laboratory of Space Geophysical and Oceanographic Studies (UMR 5566 LEGOS), Univ. Toulouse; Department of Water – Environment – Oceanography, Univ. Sci. Tech. Hanoi*

Sea surface currents (SSC) used in this report were obtained from WERA HF Radar measurements deployed in May, 2019 at Phu Yen coasts of Vietnam and have been reconstructed by 2DVar/EOF technique. Spectral analysis (SA) approach was conducted to assess the flow regimes in the regions. The results showed that the flow variability is largely governed by inertial forces (50-hour period equiv. 2.08 days) and diurnal tidal constituents (21~23-hour period equiv. 0.88~0.97 days) (Fig.1). In terms of spectral analysis along cross-shore and long-shore dimensions, the energy spectra vary more largely in long-shore compared to those in cross-shore dimension. However, both were in agreements with the shape of energy cascade curve (k-5/3)[1], [2], where the kinetic energy comes from larger scale (non-local) processes (Fig. 2). A power spectral density (PSD) front was found at the range of ~20km far from the coast (Fig1-b,c) which corresponded to the front of sea surface temperature (SST) obtained from global reanalysis data. From the middle of May, the drop in SST in association with the divergence of SSC nearshore were observed which indicated the presence of an upwelling - an interesting feature of this area during the Southwest Monsoon. To conclude, the flow variability in the area is governed largely by non-local processes i.e. winds and larger-scale circulations and can be well captured by HF Radar system. These findings are consistent with results from existing studies in the region [3], [4].

Keywords: Flow dynamics, HF Radar, sea surface current, upwelling

References:

[1] A. Foussard, S. Berti, X. Perrot, and G. Lapeyre, "Relative dispersion in direct cascades of generalized two-dimensional turbulence," ERCOFTAC Ser., vol. 26, no. May, pp. 217–226, 2019, doi: 10.1007/978-3-030-12547-9_23.

[2] A. Foussard, S. Berti, X. Perrot, and G. Lapeyre, "Relative dispersion in generalized two-dimensional turbulence," J. Fluid Mech., vol. 821, pp. 358–383, 2017, doi: 10.1017/jfm.2017.253.

[3] T. T. Duy et al., "Role of wind , mesoscale dynamics and coastal circulation in the interannual variability of South Vietnam Upwelling , South China Sea . Answers from a high resolution ocean model," no. January, pp. 1–34, 2022.

[4] N. D. Da, M. Herrmann, R. Morrow, F. Niño, N. M. Huan, and N. Q. Trinh, "Contributions of Wind, Ocean Intrinsic Variability, and ENSO to the Interannual Variability of the South Vietnam Upwelling: A Modeling Study," J. Geophys. Res. Ocean., vol. 124, no. 9, pp. 6545–6574, Sep. 2019, doi: 10.1029/2018JC014647.

New sights into the ocean surface currents near the Bohai strait revealed by HF radar

Weili Wang[1], Wei Hu[1], Shoude Guan[2], Xiongbin Wu[3], Zhihui Chen[4], Xiangyang Zheng[5]

6. *North China Sea Marine Forecasting Center, Ministry of Natural Resources*
7. *Ocean University of China*
8. *Wuhan University*
9. *China Precise Ocean Detection Technology Co. Ltd*
10. *Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences*

The North-West Yellow Sea (NWYS) is a shallow semi-enclosed sea, to the north of Shandong peninsula, which connects the Bohai Sea and Yellow Sea through the Bohai strait. Previous work studied the region mainly by numerical tools or limited measurements from traditional instruments. In this paper, it is for the first time that the surface circulations in a large area are presented with a long time period of two years, with data collected from a routinely operated high-frequency radar (HFR) system with a pair of OSMAR071G type radars.

The HFR system continuously provides mappings of up to 100km off the coast, in near-real-time with high spatial and temporal resolutions. Benefiting from the new equipment, known for precision of the coastal surface current, the sea surface currents in this region are studied in climate. The radar-derived current measurements are examined using ADCP measurements. They are also compared with popular reanalysis datasets.

The flowing pattern varies significantly in different seasons. Seasonal and annual patterns are described. It is ovserved that the North Shandong Coastal Current (NSCC) is more significant in spring and fall rather than in winter and summer when the monsoon is more severe. The currents are observed to show good coincidence with local winds.

Keywords: High-frequency radar, North-West Yellow Sea, North Shandong Coastal Current, surface currents

References:

Ardhuin, F., Marié, L., Rascle, N., Forget, P. and Roland, A. 2009. Observation and estimation of Lagrangian, Stokes, and Eulerian currents induced by wind and waves at the sea surface. Journal of Physical Oceanography, Vol. 39: pp. 2820-2838.

Barrick, D. E., Evans, M. W. and Weber, B. L. 1977. Ocean surface currents mapped by radar. Science, Vol. 198: pp. 138-144.

Chapman, R. D., Shay, L. K., Graber, H. C., Edson, J. B., Karachintsev, A., Trump, C. L. and Ross, D. B. 1997. On the accuracy of HF radar surface current measurements: intercomparisons with ship-based sensors. Journal of Geophysical Research, Vol. 102: pp. 18737-18748.

Coscoli, S., Mazzoldi, A. and Gacic, M. 2010. Validation of surface current measurement in the Northern Adriatic Sea from high-frequency radars. Journal of Atmospheric and Oceanic Technology, Vol. 27: pp. 908-919.

Crombie D. D.1955. Doppler spectrum of sea echo at 13.56 Mc./s. Nature, 1955, Vol. 175: pp.

681-682.

Ding, Y., Cao, C. H., Huang, J., Song Y., Liu, G. Y., Wu, L. J. and Wan, Z. W. 2016. Origins and features of oil slicks in the Bohai Sea detected from satelliteSAR images. Marine Pollution Bulletin, Vol.106: pp. 149-154.

Forget, P. 2015. Noise properties of HF radar measurement of ocean surface currents. Radio Science, Vol. 50: pp. 764-777.

Guérin, C. A., Grilli, S. T., Moran, P., Grilli, A. R. and Insua, T. L. 2018. Tsunami detection by high-frequency radar in British Columbia: performance assessment of the time-correlation algorithm for synthetic and real events. Ocean Dynamics, Vol. 68: pp. 423-438.

Hisaki, Y. 2005. Ocean wave directional spectra estimation from an HF ocean radar with a single antenna array : observation. Journal of Geophysical Research, Vol. 110: pp. C11004.

Huang, W. M., Gill, E., Wu, S. C., Wen, B. Y., Yang, Z. J. and Hou, J. C. 2004. Measuring surface wind direction by monostatic HF ground-wave radar at the Eastern China Sea. IEEE Journal of Oceanic Engineering, Vol. 29: pp. 1032-1037.

Ivonin, D. V., Broche, P., Devenon, J. L. and Shrira, V. I. 2004. Validation of HF radar probing of the vertical shearof surface currents by acoustic Doppler currentprofiler measurements. Journal of Geophysical Research. Vol. 109: pp. C04003.

Kim, S. Y., Terrill, E. J., Cornuelle, B. D.Jones, B., Washburn, L., Moline, M. A., Paduan, J. D., Garfield, N., Largier, J. L., Crawford, G. and Kosro P. M. 2011. Mapping the U.S. west coast surface circulation: a multiyear analysis of high-frequency radar observations. Journal of Geophysical Research, Vol. 116: pp. C03011.

Kosro, P. M., Barth, J. A. and Strub, P. T. 1997. The coastal jet: observations of surface currents over the Oregon continental shelf from HF radar. Oceanography, Vol. 10: pp. 53-56.

Lipa, B. J., Barrick, D. E. and Maresca, Jr. J. W.1981. HF radar measurements of long ocean waves. Journal of Geophysical Research, Vol. 86: pp. 4089-4102.

Paduan, J. D. and Rosenfield, L. K. 1996. Remotely sensed surface currents in Monterey bay from shore-based HF radar (Coastal Ocean Dynamics Application Radar).Journal of Geophysical Research, Vol. 101: pp. 20669-20686.

Rubenstein, D. and Newman, F. 1983. A statistical model of vertical shear from moored current meters. Journal of Physical Oceanography, Vol. 13: pp. 966-971.

Sentchev, A., Forget, P., Barbin, Y. and Yaremchuk, M. 2013. Surface circulation in the Iroise Sea (W. Brittany) from high resolution HF radar mapping. Journal of Marine Systems, Vol. 109-110: pp. S153-S168.

Wu, X. B., Yang, S. L., Cheng, F., Wu, S. C., Yang, Z. J., Wen, B. Y., Shi, Z. H., Tian, J. S., Ke, H. Y. and Gao, H. T. 2003. Ocean surface current detection by HF surface wave radar at the Eastern China Sea. Chinese Journal of Geophysics, Vol. 46: pp. 489-498.

Wyatt L. R., Mantovanelli A., Heron M.L., Roughan M., Steinberg C. R. 2018. Assessment of surface currents measured with High-Frequency phased-array radars in two regions of complex circulation. IEEE Journal of Oceanic Engineering. Vol. 43: pp 484-505.

Zheng X, Zhang H, Li Y, Zou T, Liu X, Xing Q (2021) The features and mechanisms of the North Shandong Coastal Current: a case study in 2014.

Spaceborne oceanic lidar emulator and its applications

Qun Liu[1], Xiaoyu cui[2], Yatong Chen[2], Dong Liu[2]

1. Zhejiang University, Ningbo

2. Zhejiang University

The ecological environment of the ocean is closely related to the earth's climate and human life. Phytoplankton in the upper ocean provide nearly half of the earth's primary productivity and play an essential role in the marine environment and the earth's carbon cycle[1, 2]. Spaceborne lidar is an active remote sensing tool for detecting the optical characteristics of the upper ocean[3, 4]. It has the advantages of broad coverage, high temporal and spatial resolution, free from the limit of solar altitude angle and vertical resolution, etc[5]. Spaceborne lidar has shown significant advantages in detecting phytoplankton in the upper ocean[6, 7]. However, there is no spaceborne lidar dedicated to ocean exploration at present. The existing spaceborne lidar CALIOP and ICESat-2 have disadvantages such as low vertical resolution and shallow detection depth, and their data products can only be applied to primary verification research[8-10]. Therefore, there is an urgent need to develop new spaceborne oceanic lidar, in which China has a first-mover advantage[11], but the development of satellite payload needs strict demonstration. An oceanic lidar simulator can provide an effective tool for satellite parameter demonstration, lidar signal simulation, data processing, and application[12].

This paper introduces a spaceborne oceanic lidar emulator, including its principle, composition, software, simulation results, and applications. The emulator can simulate the global ocean lidar return signal, help to build the spaceborne lidar data inversion algorithm, and evaluate the lidar hardware parameters. The comparisons between the simulations and shipborne lidar experiments are given. Finally, the research progress of the simulator in the evaluation of the detection depth and the optimal detection wavelength of spaceborne oceanic lidar is presented.

Keywords: Oceanic Lidar; lidar emulator; radiative transfer

References:

[1] FIELD C B, BEHRENFELD M J, RANDERSON J T, et al. Primary Production of the Biosphere: Integrating Terrestrial and Oceanic Components [J]. Science, 1998, 281(5374): 237-40.

[2] SENGUPTA A, CARRARA F, STOCKER R. Phytoplankton can actively diversify their migration strategy in response to turbulent cues [J]. Nature, 2017, 543(7646): 555-8.

[3] JAMET C, IBRAHIM A, AHMAD Z, et al. Going Beyond Standard Ocean Color Observations: Lidar and Polarimetry [J]. Frontiers in Marine Science, 2019, 6(251): 1-24.

[4] HOSTETLER C A, BEHRENFELD M J, HU Y, et al. Spaceborne Lidar in the Study of Marine Systems [J]. Annual Review of Marine Science, 2017, 10(13): 1-27.

[5] CHURNSIDE J H. Review of profiling oceanographic lidar [J]. Opt Eng, 2014, 53(5): 051405.

[6] BEHRENFELD M J, HU Y, HOSTETLER C A, et al. Space-based lidar measurements of global ocean carbon stocks [J]. Geopysical Research Letters, 2013, 40(16): 4355-60.

[7] LU X, HU Y, TREPTE C, et al. Ocean subsurface studies with the CALIPSO spaceborne lidar [J]. Journal of Geophysical Research Oceans, 2014, 119(7): 4305-17.

[8] LU X, HU Y, YANG Y. Ocean Subsurface Study from ICESat-2 Mission; proceedings of the 2019 Photonics & Electromagnetics Research Symposium - Fall (PIERS - Fall), F 17-20 Dec. 2019, 2019 [C].

[9] LU X, HU Y, VAUGHAN M, et al. New attenuated backscatter profile by removing the CALIOP receiver's transient response [J]. Journal of Quantitative Spectroscopy and Radiative Transfer, 2020, 255(107244.

[10] LU X, HU Y, YANG Y, et al. Antarctic spring ice-edge blooms observed from space by

ICESat-2 [J]. Remote Sensing of Environment, 2020, 245(111827.

[11] CHEN G, TANG J, ZHAO C, et al. Concept Design of the “Guanlan” Science Mission: China’s Novel Contribution to Space Oceanography [J]. Frontiers in Marine Science, 2019, 6(194): 1-14.

[12] LIU Q, CUI X, JAMET C, et al. A Semianalytic Monte Carlo Simulator for Spaceborne Oceanic Lidar: Framework and Preliminary Results [J]. Remote Sensing, 2020, 12(2820).

Session 4: POSTER

Surface Currents in the Southwestern Taiwan Strait in winter

Li Wang[1], Xianchang Yue[1], Xiongbin Wu[1], *

1. School of Electronic Information, Wuhan University, Wuhan 430072, China;

* *Correspondence: xbwu@whu.edu.cn; Tel.: +86-189-9564-0072*

High Frequency Surface Wave Radar (HFSWR) is a remote sensing technology which can monitor the dynamic parameters of ocean surface such as winds, waves and currents in a wide range, all-weather and all-time[1-4]. Research on the currents measured by HFSWR in the southwestern Taiwan Strait in 2013 is helpful in improving understanding of offshore physical phenomena and ocean dynamic processes.

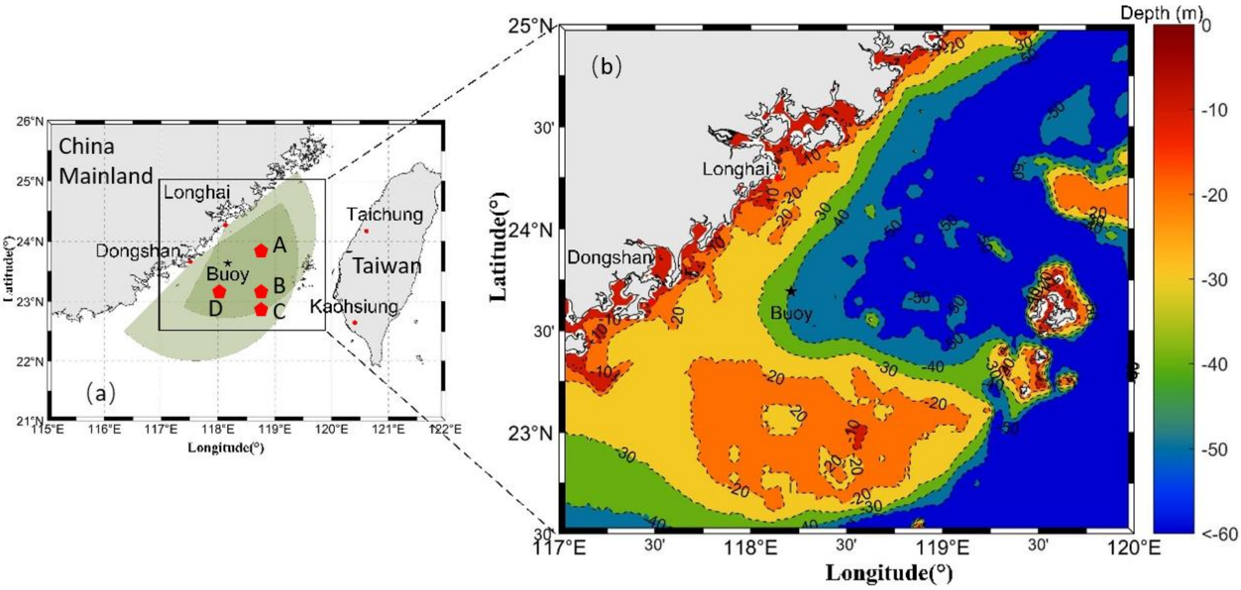

Figure 1 (a) Map of the southwestern Taiwan Strait and HF radar coverage areas. (b) The bathymetry of research region. One can see the Dongshan and Longhai radar stations marked as red points, one mooring site of the Buoy marked as a black five-point star.

To investigate the characteristics of ocean tidal currents at various locations, currents at four grid points (radiolabeled A, B, C and D in Figure 1) are compared.

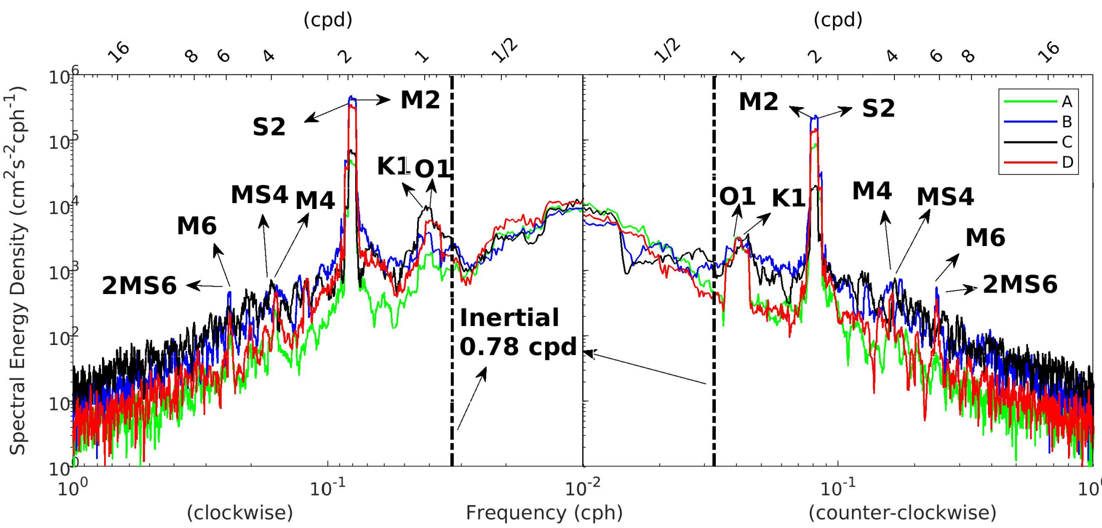

Figure 2 Two-sided (clockwise and counterclockwise) rotary spectral estimates of the surface currents measured at point A, B, C, and D. The eight largest statistically significant tidal constituents obtained from tidal harmonic analysis are labeled.

A rotary spectrum analysis conducted at these four locations (Figure 4) shows large peaks at semi-diurnal frequencies for both counterclockwise and clockwise components[5]. Smaller and slightly broader peaks exist at diurnal frequencies. Moreover, harmonic analysis suggests that statistically significant spectral lines at the nonlinear harmonic frequencies of 4 and 6 cycles per day are also present, albeit with amplitudes at most 2% as large as those of the source astronomical constituents. These “shallow water” constituents, arising from interactions between the largest astronomical tides, are visible but not prominent in the spectra. There is no significant peak at the inertial frequency (0.78 cpd at 23°N) in both vector and radial currents. Most of the residual currents occur at periods of 2 days or longer.

We separate the ocean surface vector currents U into a tidal part and a residual, U_{tidal} and $U_{residual}$ respectively:

$$U = U_{tidal} + U_{residual} \qquad (1)$$

To further explain the detail of dynamics in this area, we examine the along and cross-strait momentum balance within the framework of time and space. Considering a barotropic dynamics[6-9], we take into account surface wind stress and bottom friction. The momentum equations for horizontal velocity in the along-strait and cross-strait directions are:

$$\begin{cases} \frac{\partial u}{\partial t} + \left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) - fv = \frac{\tau_x}{\rho_w H} - g\frac{\partial \eta}{\partial x} - Ru \\ \frac{\partial v}{\partial t} + \left(u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right) + fu = \frac{\tau_y}{\rho_w H} - g\frac{\partial \eta}{\partial y} - Rv \end{cases} \qquad (2)$$

where *x, y* represent along and across directions, ρ_w is density of seawater, τ is wind stress derived by wind speed at 10 m height from CCMP dataset (Large & Pond, 1981), $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$ is horizontal advection in *u* direction, *R* is a friction coefficient, here we use $R = 1.43 \times 10^{-5}\, s^{-1}$, whose inverse is a characteristic decay time. We used a tuned value (details are explained below), with a decay time of a little less than a day. *H* is the ocean depth. We show the overall importance of each term by making maps of its mean value (Figure 3 and 4).

In the cross-strait direction (Figure 3), the momentum is clearly dominated by the geostrophic balance over the entire region, as the patterns and magnitudes of mean value between the Coriolis and pressure gradient terms closely match. In contrast, the mean value in the frictional and time-dependent acceleration terms is at least two orders of magnitude lower, and the mean value in nonlinear advection and wind stress terms even smaller.

In the along-strait direction (Figure 4) the balance is more complicated. Nonlinear advection remains negligible, so that the dynamics are inherently linear, and the Coriolis and pressure gradient terms are (mostly) the largest, especially over the deeper water north of the Taiwan Bank (TWB). Thus the geostrophic balance holds for both directions in deeper water. However, directly over the TWB it is the wind stress and pressure gradient terms that are the largest. The time-dependent acceleration term approaches significance only in the shallow areas close to the Chinese coastline and the northwest edge of the TWB.

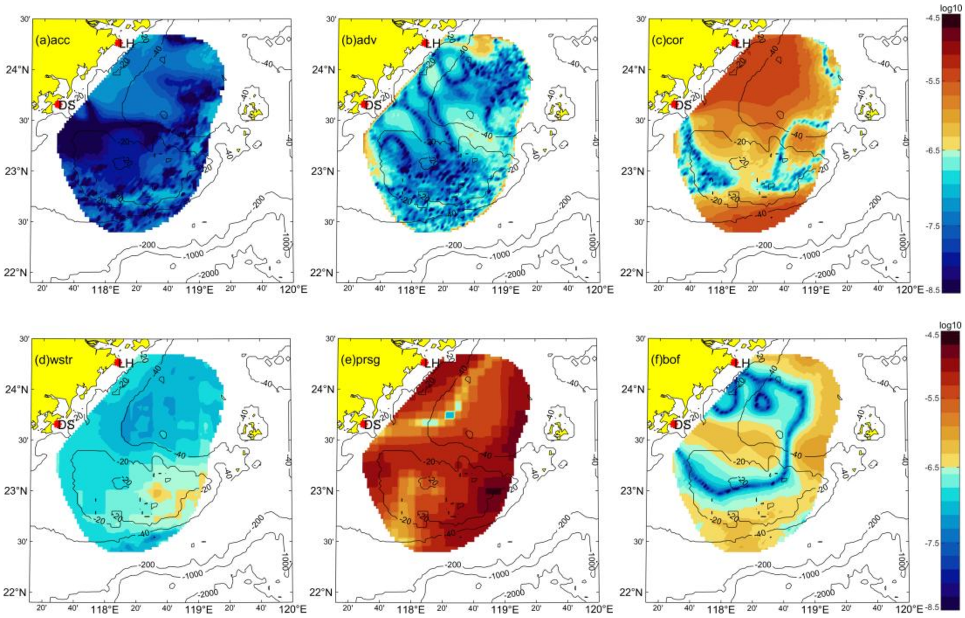

Figure 3 Mean value of (a) acceleration, (b) horizontal advection, (c) Coriolis, (d) wind stress, (e) pressure gradient and (f) bottom friction term in cross-strait direction. Units are in log 10(m/s−2).

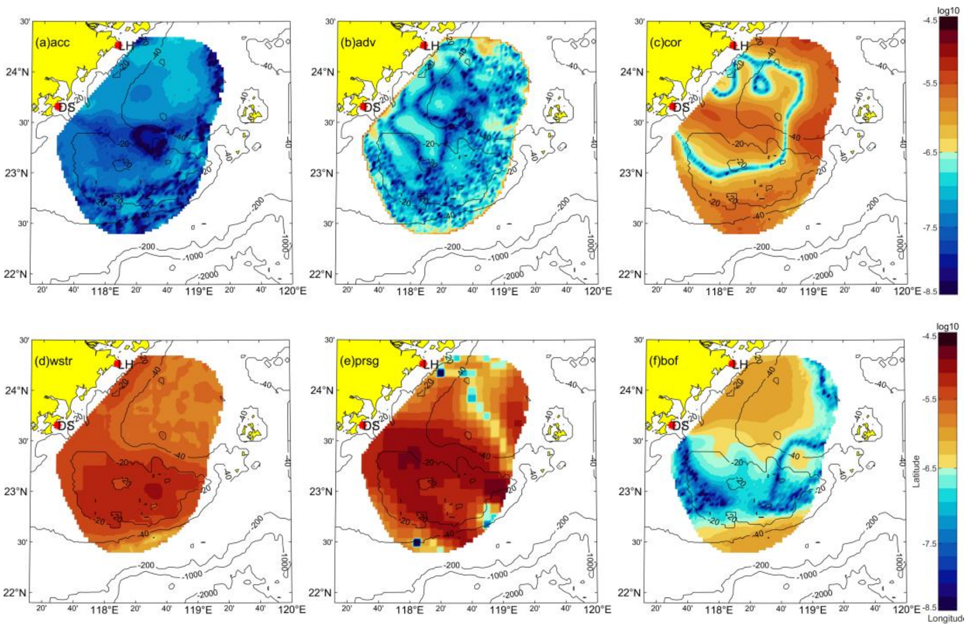

Figure 4 Mean value of (a) acceleration, (b) horizontal advection, (c) Coriolis, (d) wind stress, (e) pressure gradient and (f) bottom friction term in cross-strait direction. Units are in log 10(m/s−2).

References

[1] Teague C, Tyler G, Stewart R. Studies of the sea using HF radio scatter[J]. IEEE Journal of Oceanic Engineering, 1977,2(1):12-19.

[2] Liu Y, Xu R, Zhang N. Progress in HFSWR research at Harbin Institute of Technology[A]. In: 2003 Proceedings of the International Conference on Radar (IEEE Cat. No. 03EX695), 2003[C]. IEEE.

[3] 吴雄斌, 张兰, 柳剑飞. 海洋雷达探测技术综述[J]. 海洋技术, 2015,34(3):8.

[4] Stewart R H, Joy J W. HF radio measurements of surface currents[A]. In: Deep sea research and oceanographic abstracts, 1974[C]. Elsevier.

[5] Wang L, Pawlowicz R, Wu X, et al. Wintertime Variability of Currents in the Southwestern Taiwan Strait[J]. Journal of Geophysical Research: Oceans, 2021,126(5).

[6] Shen J, Qiu Y, Guo X, et al. The spatio-temporal variation of wintertime subtidal currents in the western Taiwan Strait[J]. Acta Oceanologica Sinica, 2017,36(11):4-13.

[7] Oey L Y, Chang Y L, Lin Y C, et al. Cross Flows in the Taiwan Strait in Winter*[J]. Journal of Physical Oceanography, 2014,44(3):801-817.

[8] Liao E, Oey L Y, Yan X, et al. The Deflection of the China Coastal Current over the Taiwan Bank in Winter[J]. Journal of Physical Oceanography, 2018,48(7):1433-1450.

[9] Wang D, Hong B, Gan J, et al. Numerical investigation on propulsion of the counter-wind current in the northern South China Sea in winter[J]. Deep Sea Research Part I: Oceanographic Research Papers, 2010,57(10):1206-1221.

An Improved Nonlinear Iterative Method for Directional Ocean Wave Spectrum Inversion with HF Radar

Fuqi Mo[1], Xiaoyan Li[1], Xiongbin Wu[1], Zhangyou Chen[1], Yilin Luo[1]

1. School of Electronic Information, Wuhan University, Wuhan, China 430072

Directional ocean wave spectrum extraction for high frequency radar has been a challenge with limitations of the existing inversion approaches and oceanic rough surface scattering model. Barrick et al. established the relationship between radar Doppler echoes and the ocean wave

spectrum, and then researchers developed series of processes to implement the inversion. Commonly adapted means is linearization of the integral equation under some assumptions that is not applicable in lower radar frequency or high sea state. In addition, the nature of departure from the second-order theory in such conditions has been reported to result in significant bias. In this article, an improved nonlinear iterative method is proposed with new perspective to the scattering mechanism in consideration of the higher-order Stokes wave. The corresponding formula has been deduced and numerical simulations of Doppler spectrum show higher consistency with the actual situation. Due to the nonlinear nature of these equations, an iterative algorithm is designed for each spectral point with enough signal to noise ratio. The iterative errors are monitored in order to eliminate abnormal spectral points in terms of certain criteria. Preliminary inversed results of field data indicate the validity and feasibility of the propose approaches.

Keywords: Directional Ocean Wave Spectrum；Nonlinear Iterative Method

References:

[1] Wyatt L R. Limits to the Inversion of HF Radar Backscatter for Ocean Wave Measurement[J]. Journal Of Atmospheric And Oceanic Technology, 2000,17(12): 1651-1666.

[2] Wyatt L R. High order nonlinearities in HF radar backscatter from the ocean surface[J]. IEEE Proceedings-Radar Sonar And Navigation, 1995,142(6): 293-300.

[3] Shahidi R, Gill E W. A New Automatic Nonlinear Optimization-Based Method for Directional Ocean Wave Spectrum Extraction From Monostatic HF-Radar Data[J]. IEEE Journal of Oceanic Engineering, 2021,46(3): 900-918.

[4] Silva M T, et al. Nonlinear Extraction of Directional Ocean Wave Spectrum From Synthetic Bistatic High-Frequency Surface Wave Radar Data[J]. IEEE Journal of Oceanic Engineering, 2019: 1-18.

[5] Hisaki Y. Nonlinear Inversion of the Integral Equation to Estimate Ocean Wave Spectra From HF Radar[J]. Radio Science, 1996,31(1): 25-39.

Analysis of Direction-of-Arrival Estimation for a Floating High-Frequency Radar with Yaw Rotation

Yi Xianzhou[1], Zhang Lan[1], Yu Liang[1], Wang Mingtao[1], Wu Xiongbin[1]

1. *Wuhan University*

Mounting one high-frequency (HF) radar on a floating platform can gain more flexibility and maneuverability, but the direction-of-arrival (DOA) estimation will suffer from the yaw rotation. Some experiments tried to avoid apparent rotations so that the DOA estimation is just the same as onshore, so the DOA estimation problem for apparent rotations can be ignored. The analysis of DOA estimation is needed to evaluate and optimize adaptive beamforming methods of yaw compensation. Two key parameters, the gain of noise power (GNP) and the beam shape keeping factor (BSKF), are proposed to analyze the DOA estimation. GNP is defined based on the quadratic norm of the adaptive weights of beamforming. A larger GNP means a smaller signal-to-noise ratio (SNR), so GNP can explain the stability of DOA estimation. The BSKF is constructed by the steering vector errors between the real-time rotating array and the assumed fixed array. A smaller BSKF means a less biased DOA estimation, so the BSKF can explain the bias of DOA estimation. In previous work, we have introduced one adaptive beamforming method called global pseudo-fixed beamforming (GPFB) by minimizing the BSKF. We further introduce another adaptive beamforming method called balanced global pseudo-fixed beamforming (BGPFB) by balancing the GNP and the BSKF. BGPFB can avoid the SNR loss of GPFB by making the GNP less than 0 dB, so BGPFB's DOA estimation is more stable. BGPFB's BSKF is larger than that of GPFB, so BGPFB's DOA bias is larger than that of GPFB. Simulations of one object, simulations of radial current, and field experiments of radial current all confirm the two parameters' effectiveness in evaluating the stability and bias of DOA estimation of the two adaptive methods. For the experiment current inversion, GPFB makes the number of points that the occurrence of inversion current is more than 90% CITs decrease by 30% for the CIT set that yaw range is more than 40 degrees. The average RMSE decrease of GPFB is 1.7 cm/s and the decrease of BGPFB is 1.2 cm/s. Because the echoes' SNR in the comparation area is high and the DOA bias of GPFB is less biased, GPFB is superior to BGPFB in the comparation area.

Keywords: floating high-frequency surface wave radar (HFSWR), yaw compensation, adaptive beamforming, direction-of-arrival (DOA) estimation.

Retrieval of Ocean Surface Wind Field Using a

Dual-Frequency MIMO HF Surface Wave Radar System

Xiaoyan Li[1], Fuqi Mo[1], Xiongbin Wu[1], Xianchang Yue[1], Yilin Luo[1]

1.Wuhan University

Retrieval of ocean surface wind field information from first-order ocean echo of HF surface wave radar has been troubled many investigators. In previous studies, our team extracted the directional spreading factor of ocean wave spectrum from the first-order echoes of HF surface wave radar, and tried to reconstruct wind speed information based on this parameter. However, it was indicated from the measured data that the spreading factor is positively correlated with the wind speed within a lower wind speed, while negatively correlated when the wind speed is higher, which is similar to the property observed by Mitsuyasu (1975) with a cloverleaf buoy. In this study, we use a dual-frequency MIMO radar system to extract the spreading factors of Bragg waves of 0.2874Hz and 0.3587Hz, corresponding to the radar frequency of 7.9398MHz and 12.3648MHz respectively. We find that the responses of spreading factors to wind speed vary between the two frequencies. Based on this an empirical parabolic model is established by the least square method with radar data and ERA5 measured wind speed, which is finally applied to invert the ocean surface wind field. More than two months of observed radar results are also evaluated at two locations which are 70km and 100km away from both the two radar stations respectively. It shows that the correlation coefficients between estimated wind speed and ERA5 measured wind speed are higher than 0.8 and the RMS differences are less than 2.5m/s at both locations selected.

Keywords: HF surface wave radar, dual-frequency, MIMO, first-order echo, spreading factor, wind field

References:

[1] Li C, Wu X, Yue X, et al. Extraction of Wind Direction Spreading Factor From Broad-Beam High-Frequency Surface Wave Radar Data[J]. IEEE Transactions on Geoscience and Remote Sensing, 2017, PP(9):1-11.

[2] Mitsuyasu H, Tasai F, Suhara T, et al. Observations of the Directional Spectrum of Ocean Waves Using a Cloverleaf Buoy[J]. J.phys.oceanogr, 2010, 5(2):286-296.

Research on Characteristics of the First-order Sea Clutter for Floating Platform High Frequency Hybrid Sky-surface Wave Radar

Qing Zhou[1], Lan Zhang[1], Xianchang Yue[1], Heng Zhou[1], Xiongbin Wu[1]

1. Wuhan University

The high-frequency hybrid sky-surface wave radar (HSSWR) is a hybrid radar developed based on the traditional over-the-horizon radar (OTHR) and the surface wave radar (SWR) systems. The complementary advantages of the two radar systems have been realized, and they have been preliminarily applied in the fields of ocean dynamic parameter inversion and low-speed target detection. The first-order sea echo spectrum is an essential part of the radar received echo spectrum, and it is also one of the prominent carriers for extracting ocean state parameters. Compared with the traditional SWR, the modulation experienced by the first-order sea echo spectrum received by the floating-platform HSSWR is more complicated, including modulation of the echo spectrum by passive interference such as ionospheric phase path disturbance. The modulation introduced by the oscillation motion of the receiving platform will also affect the shape and distribution of the sea echo spectrum. The premise of using the sea echo signal received by the floating-platform HSSWR for ocean dynamic parameter inversion is to compensate and suppress the modulation of the sea echo spectrum. The effective interference suppression algorithm is based on a complete understanding of the characteristics of the echo spectrum influenced by the interference, and it is necessary to construct a set of feasible sea echo spectrum models to guarantee related research.

This paper studies the echo characteristics of HSSWR on a floating platform with sway and yaw motion by theoretical model and experimental analysis. Based on the scattering model of sky-surface wave mode, the first order cross section for the floating platform sky-surface wave radar with platform sway and yaw motion is derived and simulated. Experiments are conducted with the newly-developed HSSWR system, of which the receiving arrays are simultaneously deployed on a floating platform and the shoreside. Experimental measurements concerning the frequency shift, Doppler width, and the arrival angle of the E-layer/F-layer ionosphere reflected direct wave are compared and analyzed. The study demonstrates the feasibility of the proposed modeling and provides valuable guidelines for the sea clutter characteristics analysis and the data quality assessments of the floating-platform HSSWR.

Keywords: Hybrid Sky Surface Wave Radar; Radar Cross Section

ORCA Families

Canada			
Professor	Weimin Huang	Memorial University	weimin@mun.ca
Junior Staff Scientist	Manman Wang	University of Victoria	manmanw@uvic.ca
France			
Professor	Alexei Sentchev	Laboratoire d'Océanologie et de Géosciences, ULCO	alexei.sentchev@univ-littoral.fr
Japan			
Professor	Naoto Ebuchi	Hokkaido University	ebuchi@lowtem.hokudai.ac.jp
Professor	Satoshi Fujii	Univ. of Ryukyu	fujii@eve.u-ryukyu.ac.jp
Korea			
Professor	Sung Yong Kim	Korea Advanced Institute of Science and Technology (KAIST)	syongkim@kaist.ac.kr
	Changsoo Kim	Kunsan national university	
Sales Manager	HongBae Moon	OCEANTECH	hongbae9@gmail.com
Director (Ph.D.)	Daehyun Kim	Oceantech Co., Ltd.	daehyun@gmail.com
Professor	Sang-Ho Lee	KUNSAN NATIONAL UNIVERSITY	sghlee@kunsan.ac.kr

Assistant Manager	Moon Jin Kim	Oceantech Co.,Ltd	blueskydl11@naver.com
President	Jung-Hoon Kim	SETsystem, Inc.	kim@setsystem.co.kr
New Zealand			
Research Scientist	Andrew Middleditch	Xerra Earth Observation Institute	middle207@googlemail.com
Sri Lanka			
Senior Professor	Tilak P D Gamage	University of Ruhuna	tilak@fish.ruh.ac.lk
USA			
Sales Director	Laura Pederson	CODAR Ocean Sensors	laura@codar.com
CTO/COO	Chad Whelan	CODAR Ocean Sensors	chad@codar.com
Surface Currents Program Manager	Brian Zelenke	National Oceanic and Atmospheric Administration (NOAA)	brian.zelenke@noaa.gov
Manager(Technical Support & Services, Software QA)	Hardik Parikh	CODAR Ocean Sensors	hardik@codar.com
Professor	Pierre Flament	University of Hawaii	pflament@hawaii.edu
Research Project Manager	Hugh Roarty	Rutgers University	hroarty@marine.rutgers.edu
Vietnamese			
PhD student	Thanh Huyen Tran	Department of Water –	huyentt.d21.weo@st.usth.ed

		Environment – Oceanography, Univ. Sci. Tech. Hanoi	u.vn
PhD student	Tran Manh Cuong	Laboratoire d'Océanologie et de Géosciences, ULCO	manh-cuong.tran@univ-littoral.fr
中国台湾 （Taiwan, China）			
Sales Engineer	Li Chang	鎮儀企業有限公司(SINO Instruments Co., Ltd.)	changlsino@gmail.com
業務經理 (business manager)	黄一剛(Yigang Huang)	鎮儀企業有限公司（SINO instrument）	yigangsino@gmail.com
Research Fellow	Jianwu Lai	National Academy of Marine Research	laijw0915@gmail.com
中国 (China)			
技术总监（CTO）	常博 (Bo Chang)	广州和时通电子科技有限公司(Guangzhou Heston Electronic Technology Co.,Ltd)	252037121@qq.com
高级工程师 (Senior Engineer)	陈智会 (Zhihui Chen)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	tujiaren1980@126.com
总经理 (General Manager)	陈玉蕉 (Yujiao Chen)	广州和时通电子科技有限公司(Guangzhou Heston Electronic Technology Co.,Ltd)	425966037@qq.com
高级工程师 (Senior Engineer)	杨凡 (Fan Yang)	珠海海洋环境监测中心站 (Zhuhai Marine Environmental Monitoring	yangfan@sml-zhuhai.cn

		Central Station of the State Oceanic Administration, Guangdong, China)	
博士研究生（PhD student）	王力 (Li Wang)	武汉大学 (Wuhan University)	warren@whu.edu.cn
讲师（Lecturer）	袁瑞 (Rui Yuan)	上海海事大学 (Shanghai Maritime University)	yuanrui@shmtu.edu.cn
硕士研究生(Master student)	张何朕加 (Hezhenjia Zhang)	上海海事大学 (Shanghai Maritime University)	zh2000330@126.com
教授 (Professor)	纪永刚 (Yonggang Ji)	中国石油大学(华东)(China University of Petroleum（East China）)	jiyonggang@upc.edu.cn
工程师 (Engineer)	谭鹏 (Peng Tan)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	fm_pong@foxmail.com
副教授 (Associate Professor)	赵晨 (Chen Zhao)	武汉大学 (Wuhan University)	zhaoc@whu.edu.cn
教授级高工(Senior Engineer)	周水华 (Shuihua Zhou)	国家海洋局南海预报中心 (South China Sea Marine Forecast Center, Ministry of Natural Resources of China)	zsh@hyyb.org
教授 (Professor)	刘东 (Dong Liu)	浙江大学(Zhejiang University)	liudongopt@zju.edu.cn
研究员 (research	葛建忠（Jianzhong Ge）	华东师范大学(East China Normal University)	jzge@sklec.ecnu.edu.cn

scientist)			
工程师 (Engineer)	陈鼎豪（Dinghao Chen)	南方海洋科学与工程广东省实验室（珠海）(Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai))	chendinghao@sml-zhuhai.cn
副教授 (Associate Professor)	贺志刚（Zhigang He)	厦门大学(Xiamen University)	zghe@xmu.edu.cn
高级工程师（Senior Engineer)	魏国妹（Guomei Wei)	厦门大学(Xiamen University)	weiguomei@163.com
算法工程师 (Algorithm engineer)	杨树（Shu Yang)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	1728421900@qq.com
高级工程师(Senior Engineer)	付伟（Wei Fu)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	236763612@qq.com
副教授 (Associate Professor)	孔祥鹏 (Xiangpeng Kong)	大连海事大学(Dalian Maritime University)	kxp@dlmu.edu.cn
研究生（Postgraduate）	于彩彩（Caicai Yu)	中国海洋大学(Ocean university of China)	yucaicai@stu.ouc.edu.cn
教授 (Professor)	吴雄斌（Xiongbin Wu)	武汉大学（Wuhan University)	xbwu@whu.edu.cn
工程师	黄财京(Caijing	国家海洋局南海信息中心	huangcaijing15@mails.ucas.

(Engineer)	Huang)	(South China Sea Information Center, State Ocean Administration)	ac.cn
总工(Chief Engineer)	王蕾 (Lei Wang)	国家海洋局南海信息中心 (South China Sea Information Center, State Ocean Administration)	wangl@scs.mnr.gov.cn
副教授 (Associate Professor)	田应伟 (Yingwei Tian)	武汉大学 (Wuhan University)	tianyw@whu.edu.cn
博士研究生(PhD student)	刘赣 (Gan Liu)	武汉大学 (Wuhan University)	liugan@whu.edu.cn
博士研究生(PhD student)	马盛波 (Shengbo Ma)	武汉大学 (Wuhan University)	mashengbo@whu.edu.cn
高级工程师(Senior Engineer)	徐新军 (Xinjun Xu)	武汉海兰瑞海海洋科技有限公司 (Wuhan Hailan Ruihai Ocean Technology Co., Ltd)	xuxj@highlander.com.cn
教授 (Professor)	牟林 (Lin Mu)	深圳大学(Shenzhen University)	moulin1977@hotmail.com
助理工程师 (Assistant Engineer)	金颖 (Ying Jin)	自然资源部第二海洋研究所 (Second institute of oceanography, MNR)	jinying@sio.org.cn
正高级工程师 (Senior Engineer)	张涛 (Tao Zhang)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	zhangtao@sio.org.cn

教授 (Professor)	董英凝（Yingning Dong)	哈尔滨工业大学(Harbin Institute of Technology)	dongyn@hit.edu.cn
副教授 (Associate Professor)	任磊（Lei Ren)	中山大学(Sun Yat-sen University)	renlei7@mail.sysu.edu.cn
院长/教授（Dean/Professor）	王东晓 (Dongxiao Wang)	中山大学(Sun Yat-sen University)	dxwang@mail.sysu.edu.cn
助理研究员 (Assistant researcher)	周雨迪（Yudi Zhou)	浙江大学（Zhejiang University）	zhouyudi@zju.edu.cn
工程师（Engineer）	王炜荔（Weili Wang)	国家海洋局北海预报中心（North China Sea Marine Forecasting Center）	wangweiliee@hotmail.com
助理研究员（Assistant Researcher）	丁睿彬（Ruibin Ding）	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	dingruibin@sio.org.cn
硕士研究生（Master student)	杨凌娜（Lingna Yang)	中山大学(Sun Yat-sen University)	yangln7@mail2.sysu.edu.cn
博士研究生（PhD student)	莫富琪（Fuqi Mo)	武汉大学（Wuhan University)	mfq2014@whu.edu.cn
博士研究生（PhD student)	李小砚（Xiaoyan Li)	武汉大学（Wuhan University)	lixiaoyan@whu.edu.cn

教授级高工(Senior Engineer)	陈鹏 (Peng Chen)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	chenpeng@sio.org.cn
研究生（Postgraduate）	陆蔼莹 (Aiying Lu)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	
研究生（Postgraduate）	赵益智 (Yizhi Zhao)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	
教授 (Professor)	沈蔚 (Wei Shen)	上海海洋大学（Shanghai Ocean University）	wshen@shou.edu.cn
博士研究生 (PhD student)	周庆（Qing Zhou）	武汉大学 (Wuhan University)	ztsing@whu.edu.cn
博士研究生 (PhD student)	易先洲（Xianzhou Yi）	武汉大学 (Wuhan University)	xianzhouyi@whu.edu.cn
副教授 (Associate Professor)	王立国 (Liguo Wang)	中山大学(Sun Yat-sen University)	wanglg7@mail.sysu.edu.cn
硕士研究生(Master student)	李会 (Hui Li)	中山大学(Sun Yat-sen University)	lihui98@mail2.sysu.edu.cn
本科生（Undergraduate）	姜俊川 (Junchuan Jiang)	中山大学(Sun Yat-sen University)	jiangjch25@mail2.sysu.edu.cn

技术总监 (CTO)	常博 (Bo Chang)	广州和时通电子科技有限公司(Guangzhou Heston Electronic Technology Co.,Ltd)	252037121@qq.com
高级工程师 (Senior Engineer)	陈智会 (Zhihui Chen)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	tujiaren1980@126.com
总经理 (General Manager)	陈玉蕉 (Yujiao Chen)	广州和时通电子科技有限公司(Guangzhou Heston Electronic Technology Co.,Ltd)	425966037@qq.com
高级工程师 (Senior Engineer)	杨凡 (Fan Yang)	珠海海洋环境监测中心站 (Zhuhai Marine Environmental Monitoring Central Station of the State Oceanic Administration, Guangdong, China)	yangfan@sml-zhuhai.cn
博士研究生（PhD student）	王力 (Li Wang)	武汉大学 (Wuhan University)	warren@whu.edu.cn
讲师（Lecturer）	袁瑞 (Rui Yuan)	上海海事大学 (Shanghai Maritime University)	yuanrui@shmtu.edu.cn
硕士研究生(Master student)	张何朕加 (Hezhenjia Zhang)	上海海事大学 (Shanghai Maritime University)	zh2000330@126.com
教授 (Professor)	纪永刚 (Yonggang Ji)	中国石油大学(华东)(China University of Petroleum（East China）)	jiyonggang@upc.edu.cn

工程师(Engineer)	谭鹏 (Peng Tan)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	fm_pong@foxmail.com
副教授(Associate Professor)	赵晨 (Chen Zhao)	武汉大学 (Wuhan University)	zhaoc@whu.edu.cn
教授级高工(Senior Engineer)	周水华 (Shuihua Zhou)	国家海洋局南海预报中心(South China Sea Marine Forecast Center ，Ministry of Natural Resources of China)	zsh@hyyb.org
教授(Professor)	刘东 (Dong Liu)	浙江大学(Zhejiang University)	liudongopt@zju.edu.cn
研究员(research scientist)	葛建忠（Jianzhong Ge）	华东师范大学(East China Normal University)	jzge@sklec.ecnu.edu.cn
工程师(Engineer)	陈鼎豪(Dinghao Chen)	南方海洋科学与工程广东省实验室（珠海）(Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai))	chendinghao@sml-zhuhai.cn
副教授(Associate Professor)	贺志刚 (Zhigang He)	厦门大学(Xiamen University)	zghe@xmu.edu.cn
高级工程师(Senior Engineer)	魏国妹 (Guomei Wei)	厦门大学(Xiamen University)	weiguomei@163.com
算法工程师	杨树 (Shu Yang)	湖北中南鹏力海洋探测系统工程有限公司(China Precise	1728421900@qq.com

(Algorithm engineer)		Ocean Detection Technology Co.Ltd)	
高级工程师(Senior Engineer)	付伟（Wei Fu)	湖北中南鹏力海洋探测系统工程有限公司(China Precise Ocean Detection Technology Co.Ltd)	236763612@qq.com
副教授(Associate Professor)	孔祥鹏(Xiangpeng Kong)	大连海事大学(Dalian Maritime University)	kxp@dlmu.edu.cn
研究生（Postgraduate）	于彩彩（Caicai Yu)	中国海洋大学(Ocean university of China)	yucaicai@stu.ouc.edu.cn
教授(Professor)	吴雄斌（Xiongbin Wu)	武汉大学（Wuhan University)	xbwu@whu.edu.cn
工程师(Engineer)	黄财京（Caijing Huang)	国家海洋局南海信息中心(South China Sea Information Center, State Ocean Administration)	huangcaijing15@mails.ucas.ac.cn
总工(Chief Engineer)	王蕾（Lei Wang)	国家海洋局南海信息中心(South China Sea Information Center, State Ocean Administration)	wangl@scs.mnr.gov.cn
副教授(Associate Professor)	田应伟（Yingwei Tian)	武汉大学（Wuhan University)	tianyw@whu.edu.cn
博士研究生(PhD student)	刘赣（Gan Liu)	武汉大学（Wuhan University)	liugan@whu.edu.cn
博士研究	马盛波（Shengbo	武汉大学（Wuhan	mashengbo@whu.edu.cn

生(PhD student)	Ma)	University)	
高级工程师(Senior Engineer)	徐新军（Xinjun Xu)	武汉海兰瑞海海洋科技有限公司(Wuhan Hailan Ruihai Ocean Technology Co., Ltd)	xuxj@highlander.com.cn
教授(Professor)	牟林（Lin Mu)	深圳大学(Shenzhen University)	moulin1977@hotmail.com
助理工程师（Assistant Engineer）	金颖（Ying Jin)	自然资源部第二海洋研究所(Second institute of oceanography, MNR)	jinying@sio.org.cn
正高级工程师(Senior Engineer)	张涛（Tao Zhang)	自然资源部第二海洋研究所(Second institute of oceanography, Ministry of Natural Resources)	zhangtao@sio.org.cn
教授(Professor)	董英凝（Yingning Dong)	哈尔滨工业大学(Harbin Institute of Technology)	dongyn@hit.edu.cn
副教授(Associate Professor)	任磊（Lei Ren)	中山大学(Sun Yat-sen University)	renlei7@mail.sysu.edu.cn
院长/教授（Dean/Professor）	王东晓(Dongxiao Wang)	中山大学(Sun Yat-sen University)	dxwang@mail.sysu.edu.cn
助理研究员(Assistant researcher)	周雨迪（Yudi Zhou)	浙江大学（Zhejiang University）	zhouyudi@zju.edu.cn
工程师（Engineer	王炜荔（Weili Wang)	国家海洋局北海预报中心（North China Sea Marine	wangweiliee@hotmail.com

）		Forecasting Center）	
助理研究员（Assistant Researcher）	丁睿彬（Ruibin Ding）	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	dingruibin@sio.org.cn
硕士研究生(Master student)	杨凌娜（Lingna Yang)	中山大学(Sun Yat-sen University)	yangln7@mail2.sysu.edu.cn
博士研究生(PhD student)	莫富琪（Fuqi Mo)	武汉大学（Wuhan University)	mfq2014@whu.edu.cn
博士研究生(PhD student)	李小砚（Xiaoyan Li)	武汉大学（Wuhan University)	lixiaoyan@whu.edu.cn
教授级高工（(Senior Engineer)）	陈鹏(Peng Chen)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	chenpeng@sio.org.cn
研究生（Postgraduate）	陆蔼莹（Aiying Lu)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	
研究生（Postgraduate）	赵益智（Yizhi Zhao)	自然资源部第二海洋研究所 (Second institute of oceanography, Ministry of Natural Resources)	
教授 (Professor)	沈蔚（Wei Shen)	上海海洋大学（Shanghai Ocean University）	wshen@shou.edu.cn

博士研究生(PhD student)	周庆 （Qing Zhou）	武汉大学 (Wuhan University)	ztsing@whu.edu.cn
博士研究生(PhD student)	易先洲（Xianzhou Yi）	武汉大学 (Wuhan University)	xianzhouyi@whu.edu.cn
副教授 (Associate Professor)	王立国 (Liguo Wang)	中山大学(Sun Yat-sen University)	wanglg7@mail.sysu.edu.cn
硕士研究生(Master student)	李会 (Hui Li)	中山大学(Sun Yat-sen University)	lihui98@mail2.sysu.edu.cn
本科生（undergraduate）	姜俊川 (Junchuan Jiang)	中山大学(Sun Yat-sen University)	jiangjch25@mail2.sysu.edu.cn
助理研究员 (Assistant research fellow)	刘群 (Qun Liu)	浙江大学(Zhejiang University)	liuqun@zju.edu.cn
无	陈硕 (Shuo Chen)	中山大学(Sun Yat-sen University)	chenshuo@mail.sysu.edu.cn
无	林奇琦 (Qiqi Lin)	中山大学(Sun Yat-sen University)	linqq3@mail.sysu.edu.cn
无	曾瑛 (Ying Zeng)	中山大学(Sun Yat-sen University)	zengy83@mail.sysu.edu.cn
	孟峥 (Zheng Meng)	中山大学(Sun Yat-sen University)	mengzh6@mail.sysu.edu.cn

无	陈哲正 (Zhezheng Chen)	中山大学(Sun Yat-sen University)	chenzhzh33@mail.sysu.edu.cn
无	陈耀祖（Yaozu Chen)	中山大学(Sun Yat-sen University)	chenyz6@mail.sysu.edu.cn
无	张昱威（Yuwei Zhang)	中山大学(Sun Yat-sen University)	zhangyuwei@sml-zhuhai.cn
高级工程师（Senior Engineer)	周峰华（Fenghua Zhou）	中科院南海海洋研究所 (South China Sea Institute of Oceanology, CAS)	zhoufh@scsio.ac.cn