High-Frequency Radar (HFR) for Texas Bays and Ports
21-155-002-C874

Final Report
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Project Background

High Frequency Radar (HFR) networks provide near real-time surface current data that is applicable to coastal hydrodynamic characterizations and enables: accurate modeling and assessment of pollutant fate and transport and water quality mechanisms (e.g. previously applied by researchers at Research Applied Technology Education Services (RATES), a 501(C)3, to determine hypoxia mechanisms in Corpus Christi Bay (CC-Bay), coastal erosion; and development of mitigation strategies. The GLO Oil Spill Prevention and Response Program relies heavily on the Texas A&M University-Geophysical Environmental Research Group (GERG) HFR network to track spills and forecast trajectories for effective spill responses. GERG network coverage extends from Bolivar Peninsula and North Padre Island out to ~200 km offshore. However, significant HFR data gaps remain within Texas' major bays that provide valuable natural resources (e.g. coastal fisheries) while supporting anthropogenic activities (e.g. petrochemical production and transport). The broad-spectrum of ecosystem services provided by our bays underlies their vulnerability to chronic environmental impacts (e.g. non-point source pollutant loads) and catastrophic mishaps (e.g. oil spills).

This CMP-26 Project of Special Merit filled important gaps in the State's HFR monitoring program with two networks providing near real time current data for Galveston Bay (GB) and Sabine Lake (SL) that are home to Port of Houston and Sabine-Neches Waterway, ranked 2nd and 4th by tonnage in the in the U.S.A. The overarching project goal was to commission HFR infrastructure to provide direct support to the GLO's mission to preserve and enhance the state's coastal natural resources. Once put into operation, data from the Galveston Bay and Sabine Lake networks was applied to validate SCHISM, a hydrodynamic model being implemented by the Texas Water Development Board, to address coastal data needs with respect to modeling coastal processes including storm surge, coastal flooding, contaminant transport, oil-spill trajectory, and estuarine salinity dynamics.

Leading this project, Dr. Rosa Fitzgerald at the University of Texas at El Paso (UTEP) provided overall project management and directed the hydrodynamic modeling effort. UTEP applied SCHISM model to simulate the surface currents. Although the model had been extensively validated in the scientific literature, analysis of the simulated surface currents have not been previously performed and validated against HF Radar surface current data.

The following steps were undertaken to successfully complete the project:

1. The SCHISM model was compiled and all necessary software components (Perl, Python, NETCDF libraries) were installed in our local workstation.
2. Extensive studies were carried out to understand the model requirements and the type of input data necessary for its operation.
3. The SCHISM input data (April 2023) covering Phase 2 Texas Coast was obtained.
4. SCHISM Simulation was performed using the acquired input data.
5. A specialized python script was developed to analyze the NETCDF output generated from the SCHISM simulations, extracting surface currents specific to Galveston Bay and Sabine Lake.

6. HF Radar data corresponding to April 2023 was sourced via the NOAA NCEI/NDBC Website https://www.ncei.noaa.gov/data/oceans/ndbc/.
7. Python Scripts were written to extract surface currents corresponding to Galveston Bay and Sabine Lake
8. Panoply Software from NASA was used to plot the current vectors derived from the HF Radar data.
9. Comparative Analysis of magnitude and direction of vector currents was performed between the radar and the SCHISM model using Python scripts and Panoply.

SUMMARY OF FINDINGS:

Days characterized by predominant northward currents exhibited significant correlation coefficients exclusively in the northward direction, whether in the Bay or Lake. Similarly, during days dominated by eastward currents, the correlation coefficients for currents measured by both the model and radar were significant only in the eastward direction for either the Bay or Lake. Notably, the SCHISM model and HF radar also effectively captured the trend and magnitude of surface currents on days with both eastward and northward currents in the Bay and Lake.
Intriguingly, a higher number of days with precisely captured currents (correlation coefficient greater than 0.5) were observed in Galveston Bay compared to Sabine Lake. This discrepancy may be attributed to the availability of more current vectors in Galveston Bay, possibly due to Sabine Lake's lower salinity. The variations in density within the lake induced by these factors influence water velocity behavior. The findings underscore the nuanced dynamics of current patterns in these water bodies, emphasizing the effectiveness of both the SCHISM model and HF radar in capturing and correlating these variations. An inter-comparison of a representative case is shown in the Appendix for the Hydrodynamic Modeling.

Lamar University co-investigator, Dr. Liv Halselbach, led project outreach activities. As our local liaison, Dr. Haselbach's leveraged existing relationships establish cooperative project partnerships with U.S.A.C.E.-Port Arthur, City of Port Arthur, Chambers County, and Galveston County.

Sub-recipient, Research, Applied Technology, Education, Services, Inc. (RATES) a 501(c)3 provided existing HFRadar inventory for five (5) remote stations to minimize project costs. Prior to installation, selected CODAR equipment was refurbished to manufacture specifications. RATES co-investigators, Dr. Andrew Ernest and Dr. Christopher Fuller led network commissioning and operations. Following the successful commissioning of five (5) remote CODAR station, near real time current data is being served online at https://data.gcoos.org/hfradar/ and https://hfradar.ndbc.noaa.gov/ through a cooperative agreement with the Gulf of Mexico Coastal Observing System (GCOOS). All five CODAR station are being operated and maintained by RATES, Inc. Efforts are currently underway to secure sustainable funding for the network observation.

Task 1: Quality Assurance Project Plan Deliverables

The U.S. Integrated Ocean Observing System (IOOS) has a vested interest in collecting high quality data for the 26 core variables measured on a national scale. In response to the interest, the U.S. IOOS continues to establish written, authoritative procedures for the quality control (QC) of real-time data through a Quality Assurance/Quality Control of Real-time Oceanographic Data (QARTOD) program. The IOOS Manual for Real-Time Quality Control of High Frequency Radar Surface Current Data represents the ninth core variable to be addressed and served as the shell document for the development of Quality Assurance Project Plan (QAPP) for the Galveston Bay and Sabine Lake HFR networks.

The QC test in the developed HF Radar QAPP represent a compilation of guidance for the HF Radar committee and valuable reviewers, U.S. IOOS/QARTOD manuals, and all QARTOD workshops. Test suggestions came for both operators and HF radar data users with extensive experience. The consideration of operators who ensure the quality of real-time data may be different from those whose data are not published in real time, and these other differences must be balanced according to the specific circumstances of each operator. Although real-time test are required, recommend, suggested, or in development, the operator is ultimately responsible for determining which test are appropriate.

Best Practices for deployment, set-up and operation of CODAR SeaSonde systems have been provided with respect to: Remote Site Requirements, Set-Up, Software, and Routine Maintenance. When and where applicable these best practices will be followed. It is to emphasize that logistical constraints may result in some compromises with respect to strict adherence to the best practices described within the QAPP. Considering limited availability of remote site location, it may be necessary to consider less than ideal remote station locations.

Task 2: HF Radar Network Commissioning and Operation Deliverables

Executed contract with sub-recipients

Upon execution of the prime award with the University of Texas at El Paso, the next order or business was to establish sub-recipient agreements with RATES, Inc. and Lamar University. Both sub-recipient contracts were executed by May 15, 2021.

Map showing station locations

Prerequisite to designing a viable HF Network is development of a map showing proposed stations locations. Such a map provides values with respect to assess proper station spacing to optimize coverage are and to aid subsequent station reconnaissance.
Individual proposed station maps were developed for Galveston Bay (Figure 1) and Sabine Lake (Figure 2). For Galveston Bay, a three proposed station location included Center Point (south of Baytown), Smith Point, and Eagle Point (Figure 1), with colored circles green, yellow, and red representing the theoretical range of each SeaSonde station with nominal operating frequency of 25 MHz, respectively. Similarly, two proposed station locations on Sabine Lake were identified as Sabine Lake North and Sabine Lake South (Figure 2)with yellow and red circles representing the nominal range of each SeaSonde station with a nominal operating frequency of 42 MHz. Theoretical coverage areas for each bay system, are represented as the area of overlapping of two or more coverage circles.

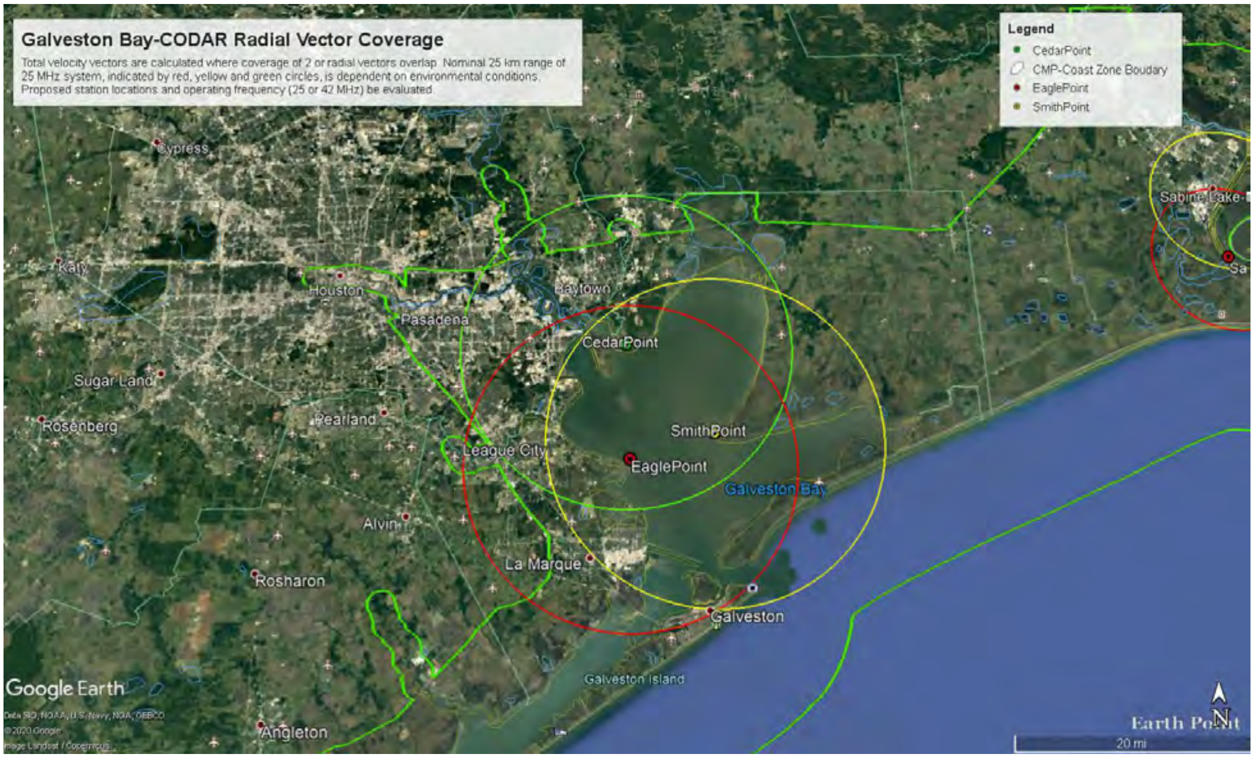


Figure 1 Initial station map for Galveston Bay Stations

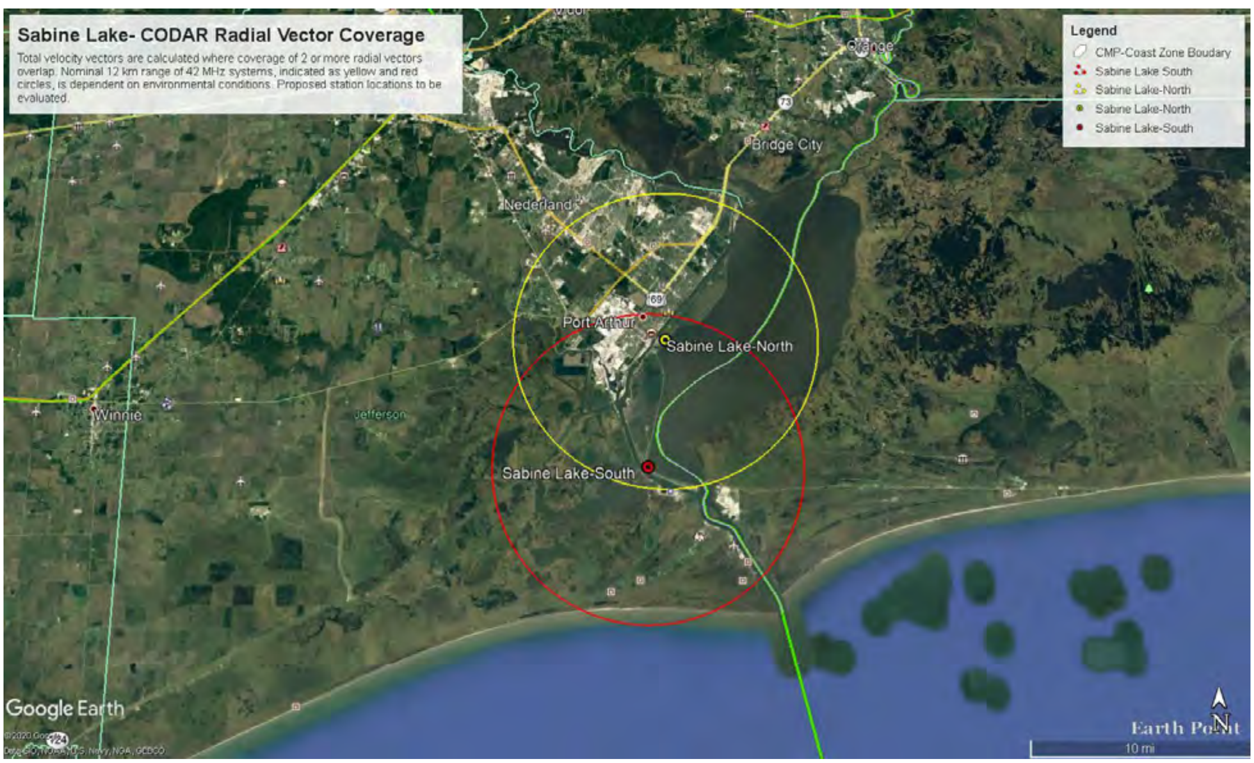


Figure 2 Initial map for Sabine Lake Stations

Remote station Reconnaissance

Following determination of general station location in the initial station map, subsequent preliminary on-site inspections were conducted to further assess location viabilities. These preliminary inspections were useful in refining viable station locations.
For Galveston Bay the three locations were identified for further consideration (Table 1;Figure 3).

Table 1 Galveston Bay CODAR Network-Proposed Antennae Coordinates

Station Name	Latitude	Longitude
McCollum Park	29.744541°	-94.828675°
Smith Point	29.546765°	-94.788082°
Moses Lake Tide Gate	29.445450°	-94.917287°

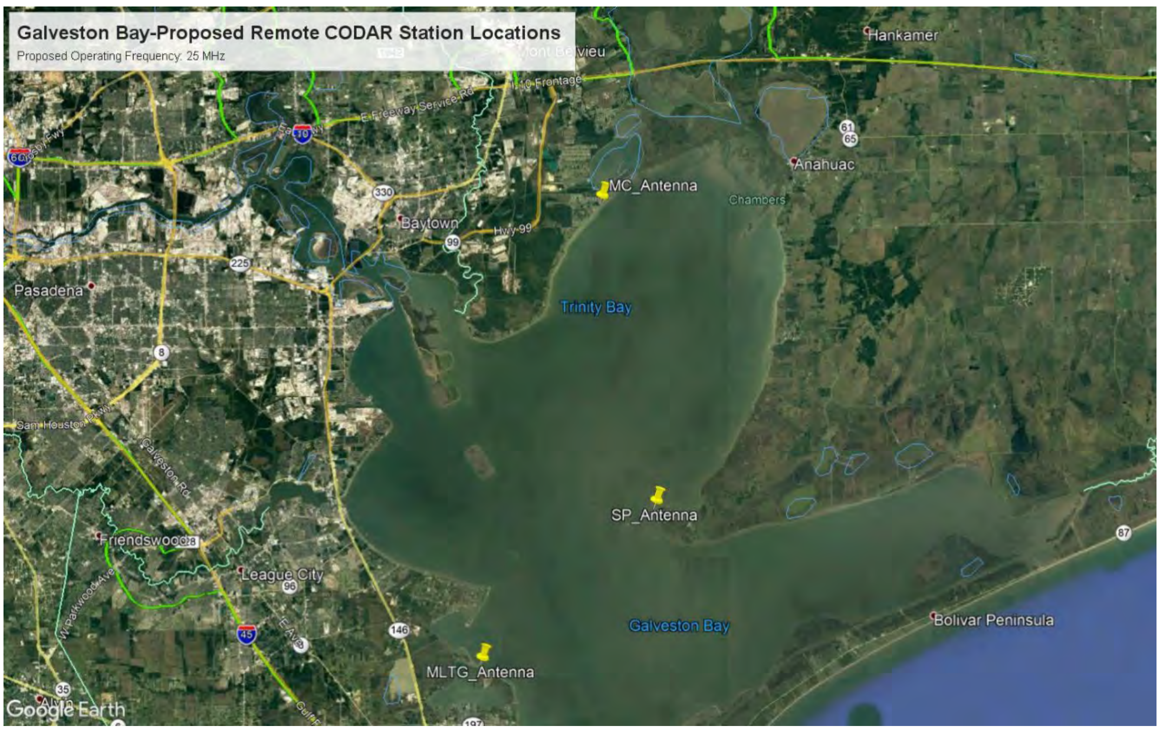


Figure 3 Galveston Bay-Proposed Remote Station Locations

Site reconnaissance visits of the proposed remote CODAR installations on Galveston Bay were conducted on June 7 and June, 2021 in Chambers and Galveston Counties, respectively. Each visit was conducted by CMP-26 project team members from Lamar University and RATES as well as county representatives. These reconnaissance visits were necessary to identify: proper placement of SeaSonde infrastructure (Figure 4); availability of utilities (i.e. power) (Figure 5); presence of interfering structures; and presence of local construction hazards (e.g. buried utilities). Measurements conducted during site inspections were used to generate general deployment plans that proposed general placement locations for station infrastructure (Figure 6).

Figure 4 RATES and Lamar University team members discussing antenna placement with Kirk Sherman-Chambers County Parks Department. McCollum Park, Beach City, TX

Figure 5 Power access via county owned meter at McCollum Park

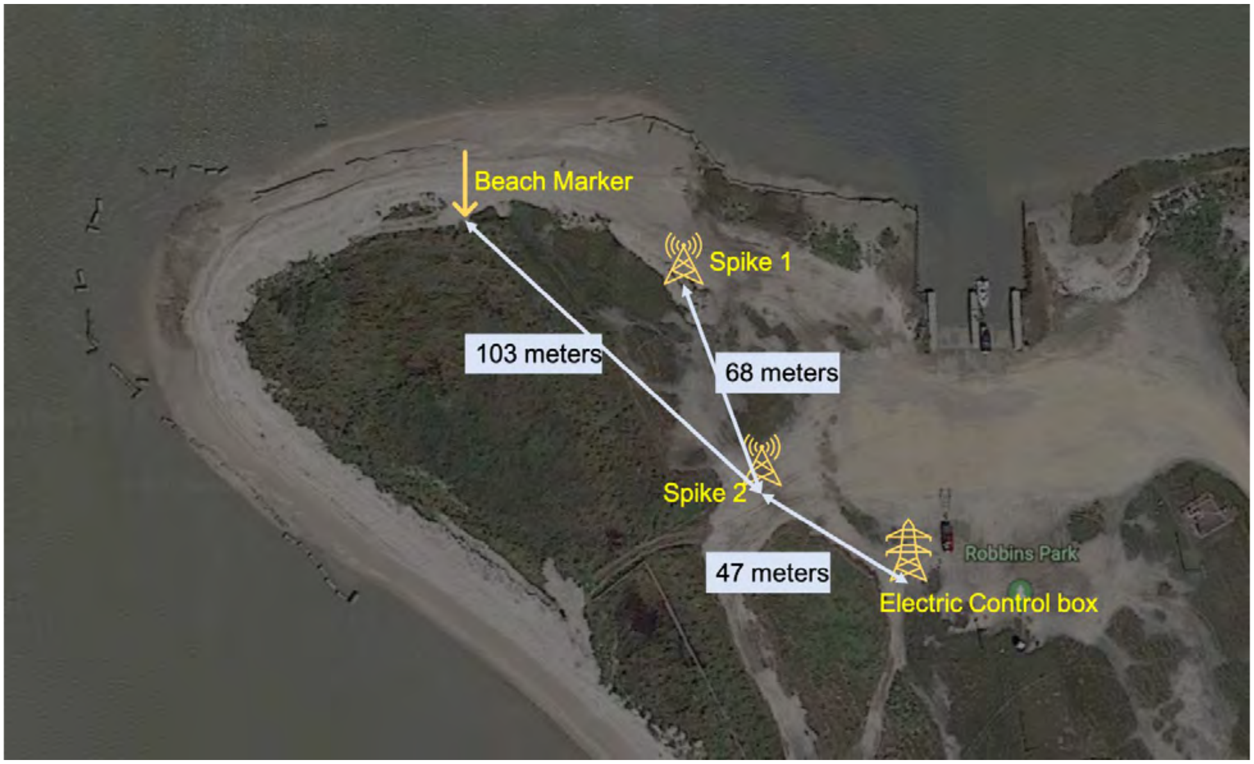


Figure 6 Preliminary lay out for Smith Point Station. Spike 2- proposed location for CODAR enclosure); Spike 1- proposed location for antenna; Electric Control box is location of pre-existing source of power.

Site reconnaissance of two (2) locations on Sabine Lake, each representing a potential SeaSonde station node was conducted on June 10, 2021. Both visits were conducted by Lamar University, RATES, and City of Port Arthur representatives with knowledge of local conditions. An impromptu visit the Timothy Whites- SWG, Port Arthur Resident Engineer, USACE-Port Arthur provided an opportunity to present our project and project needs.

The Sabine Lake inspections helped identify 2 station locations at: 1) Pleasure Island Pier (Figure 7, Figure 8; and 2) USACE Placement 8 Dewatering Levee (Figure 9, Table 2). Similar to the Galveston Bay inspections, the Sabine Lake inspections were useful for identifying placement of CODAR infrastructure, location of utilities and potential interferences. One critical observation made during the Sabine Lake inspections was a lack of grid power at the Placement Area 8 location thus requiring the inclusion of an off-grid power system in station design.

Figure 7 Sabine Lake stations identified during site inspections

Table 2 Sabine Lake Station Locations

Station Name	Latitude	Longitude
Pleasure Island Pier (PIP-Antenna)	29.867086°	-93.921979°
Sabine Lake Levee (SB_Levee-A)	29.795589°	-93.934988°

Figure 8 Pleasure Island Pier-Boat Ramp: 1) White box is ground level electrical box; 2) Boat ramp submerged at high tide; 3) proposed antenna installation in back ground to right of Palm Tree

Figure 9 View of Sabine Lake from top of USACE Placement Area 8 Levee

Following selection of proposed station locations and having obtained tentative verbal agreements from respective land owners/agents, assessment of Radio Frequency spectra scans (Figure 10) were conducted at each site to determine the presence of interfering radio frequency that may impact or be affected by operation of SeaSonde equipment at each location. RF spectra scans were conducted December 12 to December 19, a team of engineers from Lamar University and RATES, Inc. conducted ambient RF Scans at each of the 5 station locations. These assessments involved the temporary deployment of radio spectral scanner at each location to collect ambient radio frequency spectra over the course of a 24-hour period. The spectral data was then sent to CODAR for evaluation. Results from the spectral analysis showed no significant RF noise within the permitted ITU frequency bands for which the SeaSonde equipment would operate. Data collected from spectra analyses was further applied to tune individual SeaSonde transmitters and receivers.

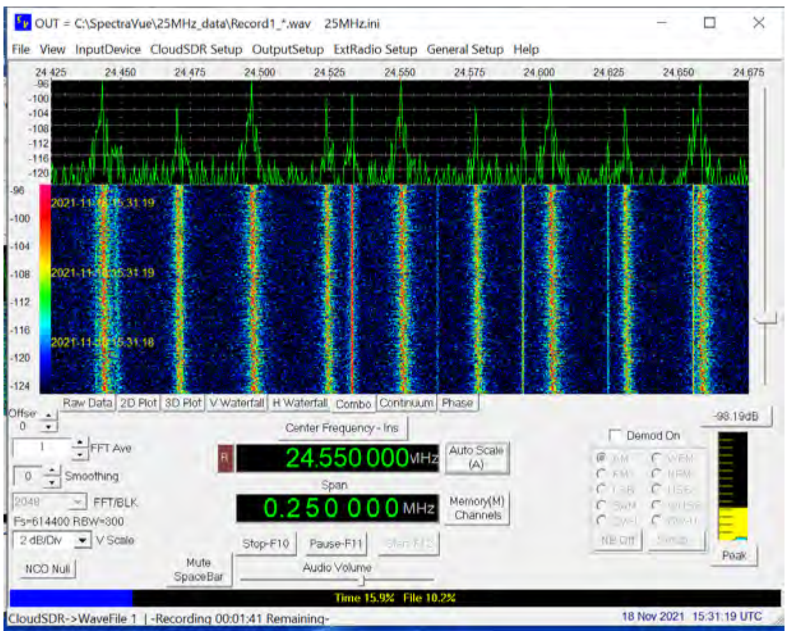


Figure 10 Example of Radio Frequency Spectra (24.54 MHz Center Frequency)

FCC License

With assistance from Brian Zelenke, IOOS Surface Current Program Manager, RATES submitted FCC Applications for Radio Service Authorization. One application was submitted for three 25MHz stations assigned to Galveston Bay. A separate application was submitted for two 42 MHz stations assigned for operation on Sabine Lake. Licenses were granted to RATES, Inc. on 10-13-2022, prior to commencing operation of all statins. Call signs WRUX251 and WRUX252 were assigned to the Sabine Lake and Galveston Bay networks, respectively. Both licenses expire in October 13, 2032.

Network Commissioning

Preparation of sites was initiated in Spring 2022 with construction of enclosure decks, placement of antenna footers, and installation of power service at Smith Point and McCollum Park. Site preparation were then extended to the Moses Lake Tide Gate, Galveston Bay thence to the Sabine Lake Stations Pleasure Pier Blvd. and USACE Placement 8 Levee. Installations at

Sabine Lake posed significant challenges associated with the lack of power at these locations. In the case of USACE Placement Area 8 Levee, remote power required the installation of 12-KW off-grid solar array. At Pleasure Pier Blvd., power required a directional bore in excess of 100 meters. Significant costs of solar array and directional bore were not considered in the original budget.

By the end of 2023, stations were prepared for full commissioning. Photos of fully commissioned station are provided in Figure 11, Figure 12,Figure 13, Figure 14, Figure 15, Figure 16, Figure 17, Figure 18, Figure 19, Figure 20, Figure 21, and Figure 22.

Figure 11 Installed SeaSonde antenna at Moses Lake Tide Gate. Electronics are housed in gate control build in background

Figure 12 Vies of installed SeaSonde antenna at Moses Lake looking east toward Galveston Bay

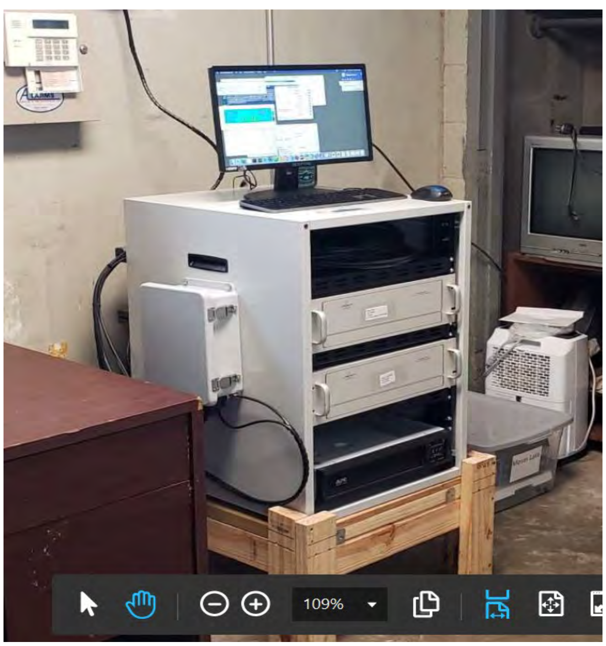


Figure 13 Rack mounted SeaSonde electronics inside Moses Lake Tide Gate Control Building

Figure 14 View of climate-controlled enclosure at McCollum Park

Figure 15 View of antenna a McCollum Park overlooking Trinity Bay

Figure 16 Climate controlled enclosure on elevated deck at Smith Point. Power for statin provided through the meter to the right side of enclosure

Figure 17 View of installed SeaSonde electronics inside climate-controlled enclosure

Figure 18 Antenna installed at Smith Point with Galveston Bay in Background

Figure 19 SeaSonde station at Sabine Lake-USACE Placement Area 8 Levee

Figure 20 Solar power system for USACE Placement Area 8 Station

Figure 21 Enclosure at 600 Pleasure Pier Blvd. Port Arthur, TX, Sabine Lake


Figure 22 SeaSonde Antenna at Pleasure Pier Blvd.

Full commissioning was conducted with the support of CODAR staff through a service contract to ensure optimal performance within acceptable performance standards required for provision of data to the national HFRadar data servers at https://hfradar.ndbc.noaa.gov/ and https://data.gcoos.org/hfradar/. Among multiple QAQC measured applied at each station were Antenna Pattern Measurements (APM) to characterize signal distortions resulting from ambient conditions (Figure 23, Figure 24). APMs are then applied to correct radial velocities measured at each SeaSonde station. APM involved measuring the transmit signal with a CODAR transponder that was routed via an arc with a radius of 1-km around each Combine Transmit/Receive Antenna.

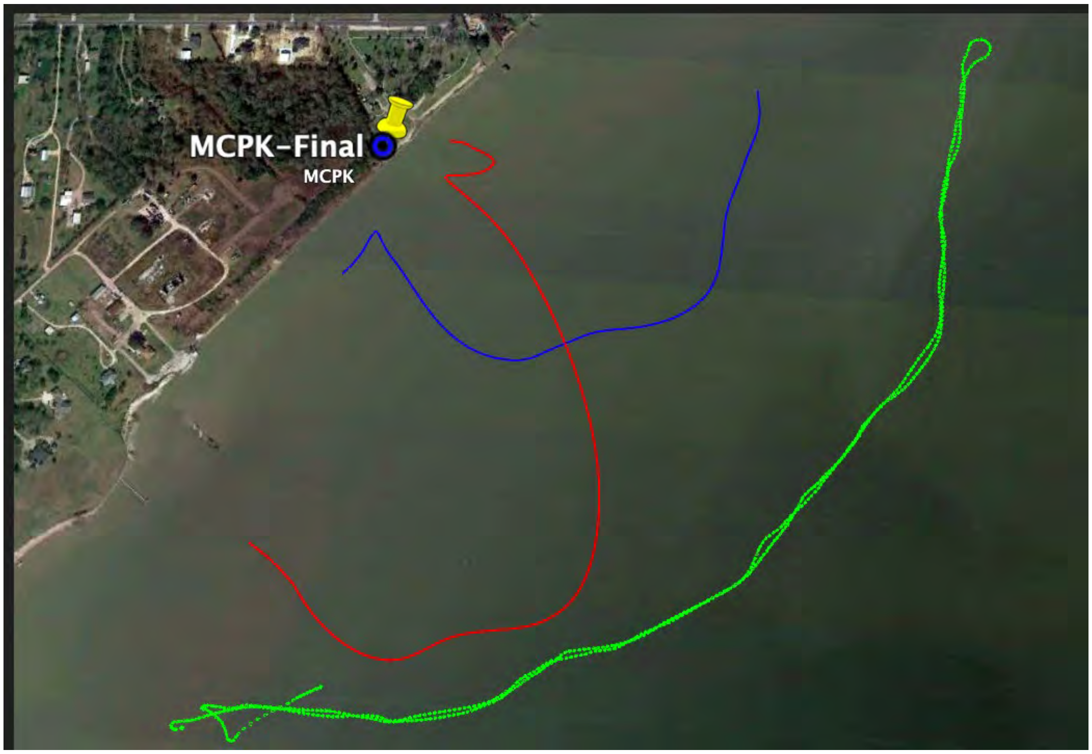


Figure 23 McCollum Park-Antenna Pattern Measurements. Blue Trace is Loop 1 pattern, Red is Loop 2 pattern, Green is transponder/boat track

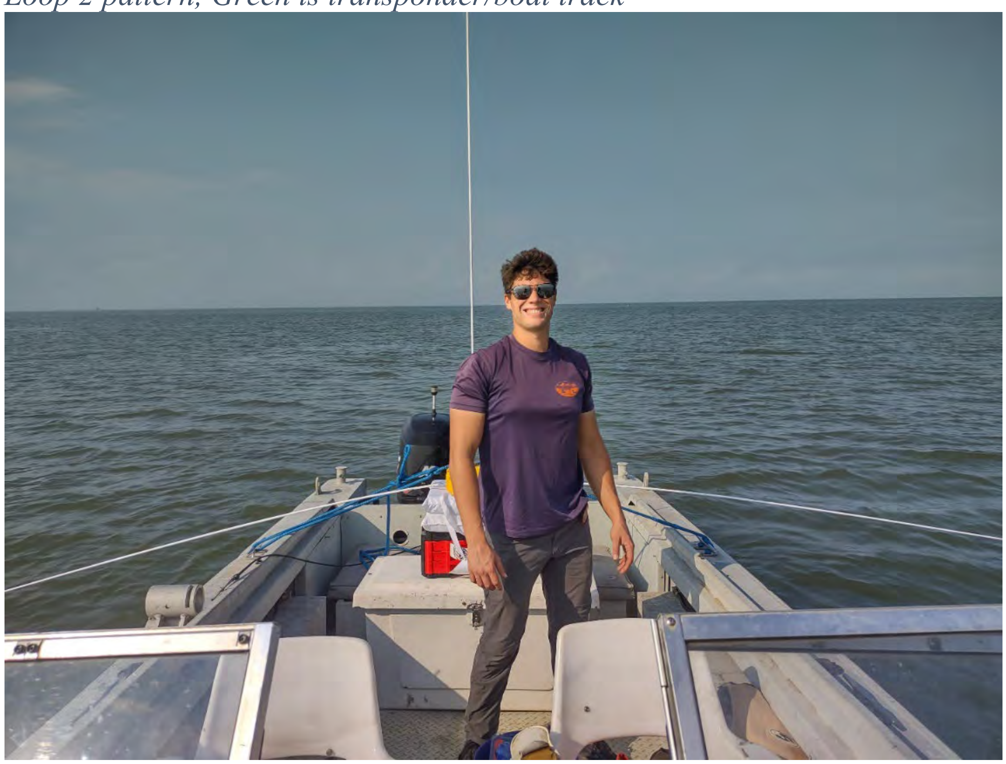


Figure 24 Survey vessel with tronsponder for Antenna Pattern Measurements. Photo taken near Smith Point (December 8, 2022)

Notification of negotiated property access instruments for remote station locations

Having identified possible station locations, it was necessary to obtain authorization from interested parties of each locations. Access to Galveston Bay stations at McCollum Park and Smith Point was granted via a Memorandum of Agreement between Chambers County and RATES, Inc. Access to Galveston Bay Station was granted through a Galveston County permit to Install a HF Radar on the Texas City Hurricane Levee Adjacent to the Moses Lake Tide Gate. Issuance of the Galveston Count permit required prior approval of USACE and authorization by a third party (private land owner) on which SeaSonde infrastructure (i.e. Antenna and buried coax would be installed). Access to the Sabine Lake station at Pleasure Island pier was granted through a Memorandum of Agreement with City of Port Author. Access to Sabine Lake station at Placement Area 8 was granted by official letter from the USACE.

Data availability

On March 2, 2023 all five HF-radar sites operated by RATES were included in real-time vector (RTV) processing by HFRnet through a cooperative effort with the Gulf Coast Ocean Observing System (GCOOS) and with the support of Brian Zelenke, IOOS-Surface Currents Program Manager with data being served to the public via the U.S. Integrated Ocean Observing System (IOOS). The five new sites no being included in RTV processing include:
McCollum Park Beach City, TX (MCPK)
Network: RATES
Latitude: 29.7445
Longitude: -94.8287
Center Frequency: 24.550 MHz
https://hfrnet.ucsd.edu/diagnostics/?p=sta&sta=MCPK

Moses Lake Floodgate, Texas City, TX (MOLA)
Network: RATES
Latitude: 29.4457
Longitude: -94.9171
Center Frequency: 24.550 MHz
https://hfrnet.ucsd.edu/diagnostics/?p=sta&sta=MOLA

Placement 8, Port Arthur,TX (PLA8)
Network: RATES
Latitude: 29.7957
Longitude: -93.9346
Center Frequency: 43.675 MHz
https://hfrnet.ucsd.edu/diagnostics/?p=sta&sta=PLA8

Pleasure Pier Blvd, Port Arthur, TX (PLPI)
Network: RATES
Latitude: 29.8651
Longitude: -93.9238
Center Frequency: 43.675 MHz
https://hfrnet.ucsd.edu/diagnostics/?p=sta&sta=PLPI

Smith Point, Anahuac,TX (SMPT)
Network: RATES
Latitude: 29.5464
Longitude: -94.7881
Center Frequency: 24.550 MHz
https://hfrnet.ucsd.edu/diagnostics/?p=sta&sta=SMPT

Data provided through the HFRnet diagnostics (https://hfrnet.ucsd.edu/diagnostics/) (Figure 25) provides information including station metadata and performance information for each HFR station including but not limited to : Station Name, Latitude, Longitude, Center Operating Frequency; Transmit Power; System Operating Temperature; Most Recent Radial File; Time of most recent file; Range; Number of radial velocity solutions, and data base latency. Additionally, Radial Coverage maps for both Measured and Idealized radial vectors from the most recent data file are provided (Figure 26).

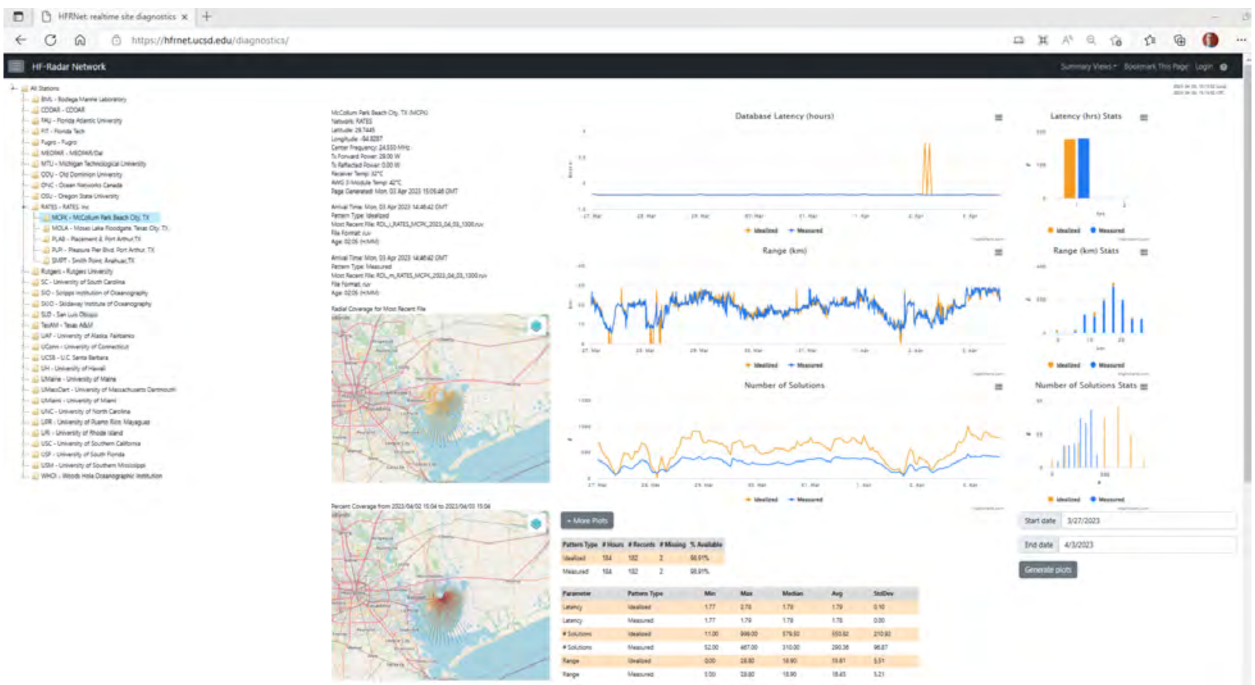


Figure 25 HFRnet diagnostics page for McCollum Park

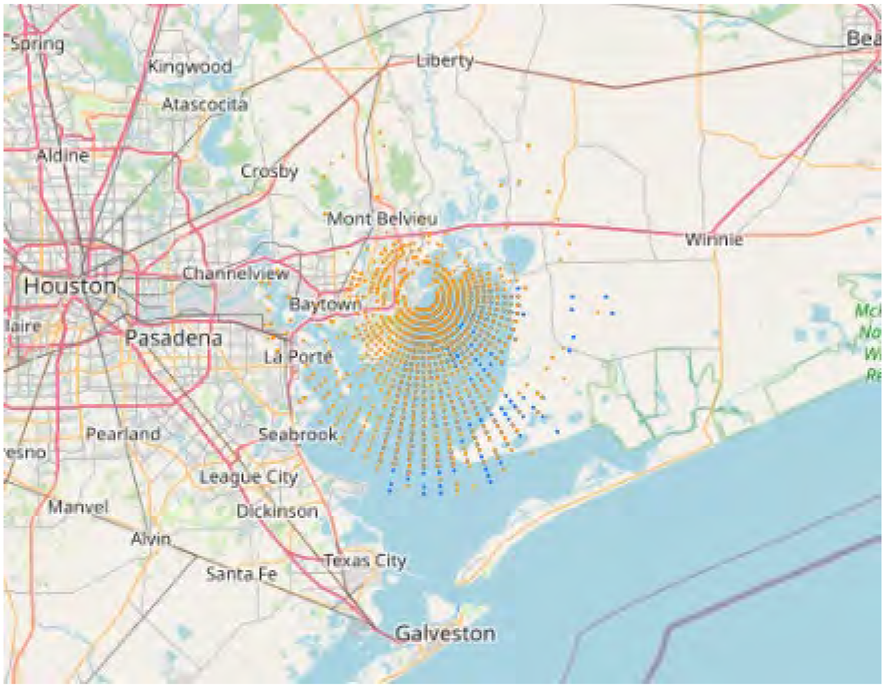


Figure 26 Radial data coverage for McCollum Park station

Near real time data is provided through the NOAA HF Radar National Server at https://hfradar.ndbc.noaa.gov/ , where Real Time Vector (RTV) data is displayed as total vector map (Figure 27) or the most recent total vector files generated from at least two (2) radial files. Total vector maps allow the users to select either 25- hour average or hourly vectors obtained during the previous 25-hours. Selection of "site" allows users to view the stations location. Selecting a single station icon, results in summary window summarizing station Name, ID, Network Operator, Location, Date of Most Recent File, and Operating Frequency (Figure 28). Data age, in hours, for selected stations is also illustrated through a color-coded station icons.

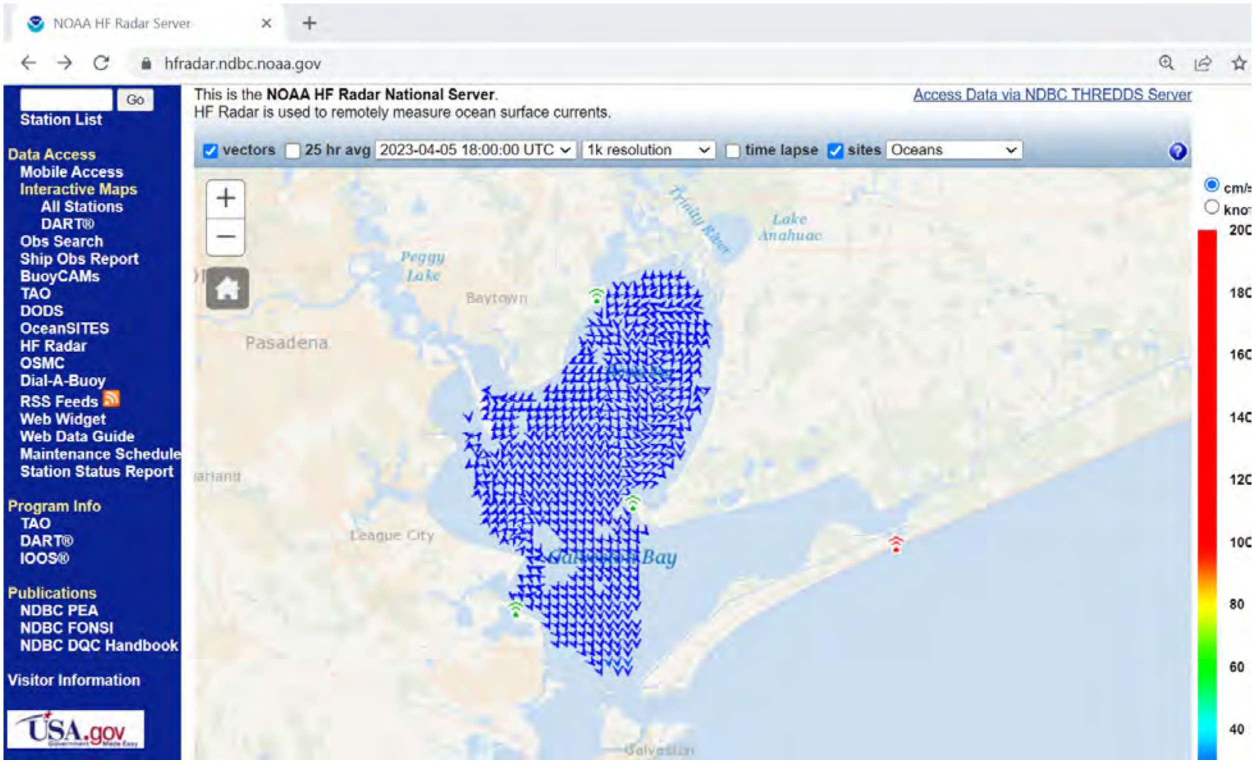


Figure 27 NOAA HFR vector coverage map for Galveston Bay (2023-04-05 18:00 UTC)

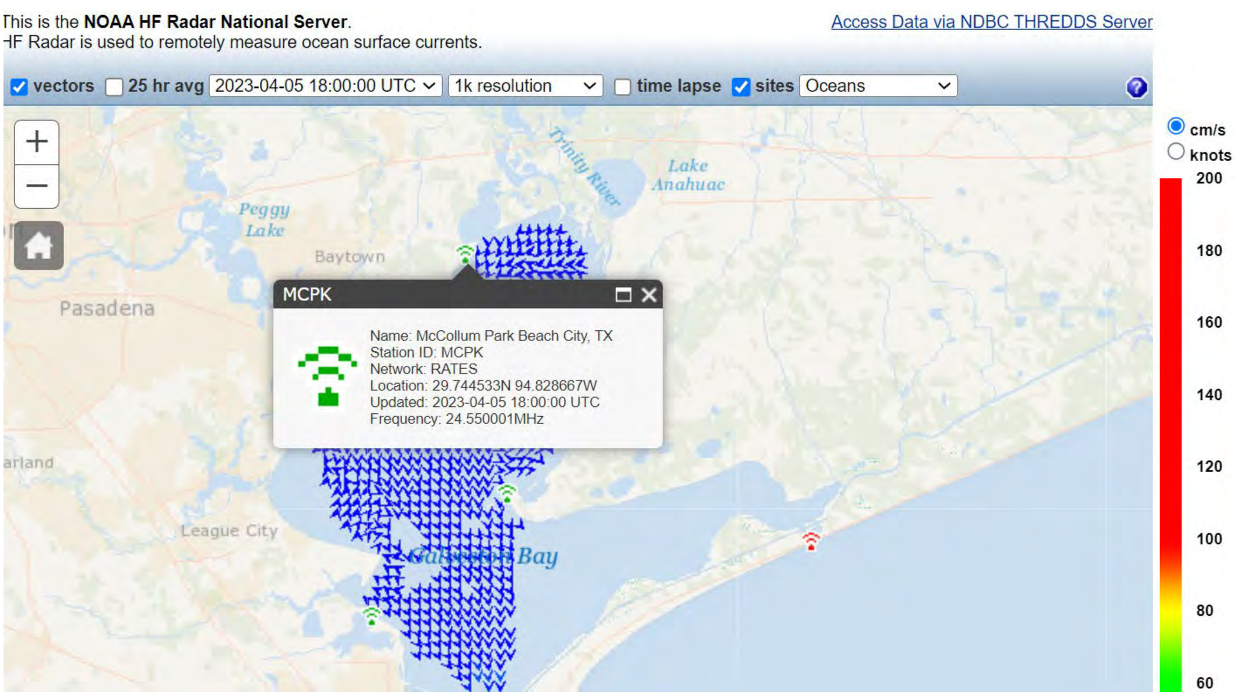
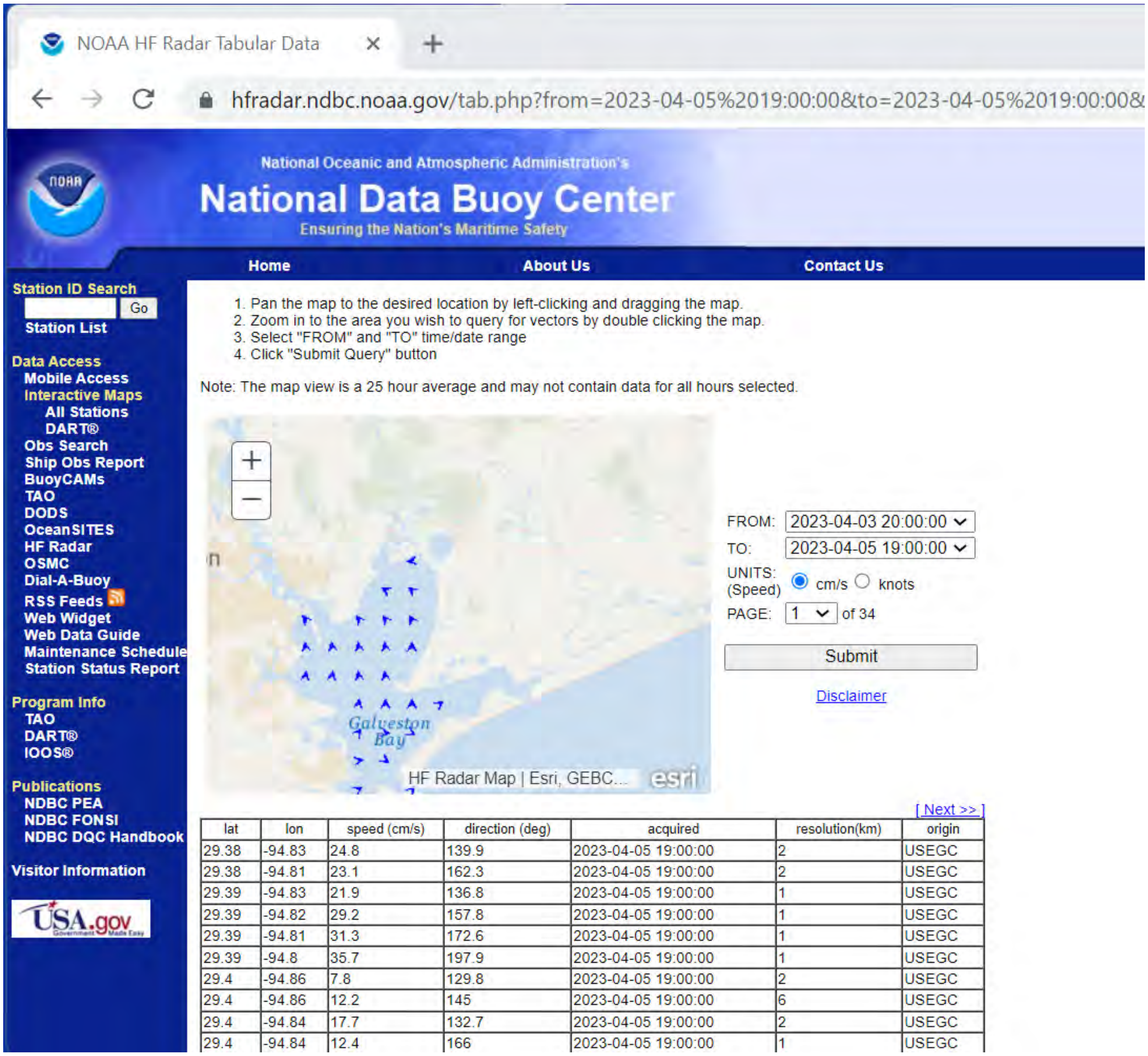


Figure 28 Site specific information window for McCollum Park-Galveston Bay

Total Vector Data for the previous 48- hours can also be viewed in tabular form by selecting "View HF Rata Data in Tabular Format" which takes the user to https://hfradar.ndbc.noaa.gov/tab.php where data from the selected observation is provided an tabular form with headers for Lat, Lon, Speed (cm/s or knots), direction, acquired, resolution, and origin (USEGC = US East Gulf Coast) (Figure 29). This page allows users to download results as Tab-Separated Values File or Comma-Separated Values file (Figure 30).



lat	lon	speed (cm/s)	direction (deg)	acquired	resolution(km)	origin
29.38	-94.83	24.8	139.9	2023-04-05 19:00:00	2	USEGC
29.38	-94.81	23.1	162.3	2023-04-05 19:00:00	2	USEGC
29.39	-94.83	21.9	136.8	2023-04-05 19:00:00	1	USEGC
29.39	-94.82	29.2	157.8	2023-04-05 19:00:00	1	USEGC
29.39	-94.81	31.3	172.6	2023-04-05 19:00:00	1	USEGC
29.39	-94.8	35.7	197.9	2023-04-05 19:00:00	1	USEGC
29.4	-94.86	7.8	129.8	2023-04-05 19:00:00	2	USEGC
29.4	-94.86	12.2	145	2023-04-05 19:00:00	6	USEGC
29.4	-94.84	17.7	132.7	2023-04-05 19:00:00	2	USEGC
29.4	-94.84	12.4	166	2023-04-05 19:00:00	1	USEGC

Figure 29 Tabular data for Galveston Bay total vectors

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hfradar-20230405213131
File    Edit    View

lat   lon   "speed (cm/s)"   "direction (deg)" acquired    "resolution (km)" origin
29.38 -94.83      24.8  139.9 "2023-04-05 19:00:00"   2      USEGC
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29.4  -94.86      12.2  145   "2023-04-05 19:00:00"   6      USEGC
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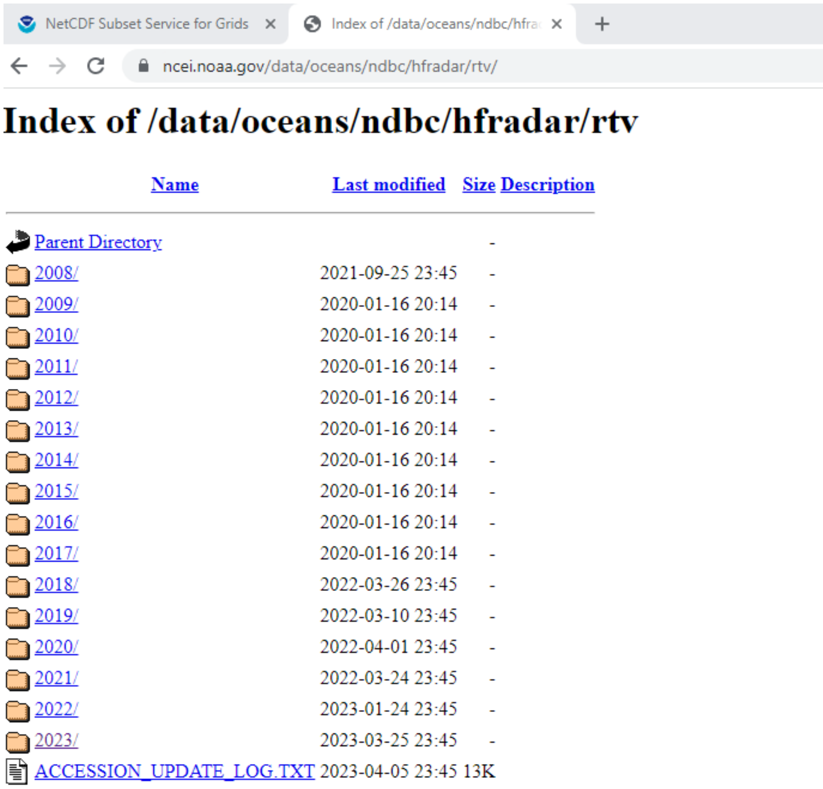
29.41 -94.85      7.2   123.7 "2023-04-05 19:00:00"   1      USEGC
29.41 -94.84      14.2  140.7 "2023-04-05 19:00:00"   2      USEGC
29.41 -94.84      14.3  114.8 "2023-04-05 19:00:00"   1      USEGC
```

Figure 30 CSV data file for Galveston Bay

The number of radial and total resolved vectors varies with time as a function of each SeaSonde station's measurement range which varies as a function of environmental conditions including sea state and salinity. During times or areas with calm wave conditions, backscattered signals can be insufficient for SeaSonde measurements. Further, Seasonde ranges can be limited at times when salinity levels in surface waters are low (e.g. fresh water). For the Galveston Bay and Sabine Lake networks, 1 km grid spacing has been observed on the NOAA NDBC.

Archived data from all HF Radar Stations served by HFRnet be accessed via the https://www.ncei.noaa.gov/data/oceans/ndbc/hfradar/rtv/ . This link takes the user to annual index for each year data HFRadar data is available (Figure 31). Selection of an annual directory will show a sub-folder for each month of archived data (Figure 32). Each monthly data folder is sub-divided into regional folders for US East Coast and Gulf of Mexico (USEGC); US West Coast (USWC); Great Lakes North America (GLNA); US Hawaii (USHI) ; and Puerto Rico/Virgin Islands (PRVI) (Figure 33). Each regional folder (Figure 34) includes multiple files for each hour of RTV vector data where the file name has the following format: yyyymmddhhmm_hfr_region_resolution_RTV_uwls_NDBC.nc. The file extension .nc indicates the data format as network common data format (netCDF) for Total Velocity Data.



Index of /data/oceans/ndbc/hfradar/rtv

Name	Last modified	Size	Description
Parent Directory		-	
2008/	2021-09-25 23:45	-	
2009/	2020-01-16 20:14	-	
2010/	2020-01-16 20:14	-	
2011/	2020-01-16 20:14	-	
2012/	2020-01-16 20:14	-	
2013/	2020-01-16 20:14	-	
2014/	2020-01-16 20:14	-	
2015/	2020-01-16 20:14	-	
2016/	2020-01-16 20:14	-	
2017/	2020-01-16 20:14	-	
2018/	2022-03-26 23:45	-	
2019/	2022-03-10 23:45	-	
2020/	2022-04-01 23:45	-	
2021/	2022-03-24 23:45	-	
2022/	2023-01-24 23:45	-	
2023/	2023-03-25 23:45	-	
ACCESSION_UPDATE_LOG.TXT	2023-04-05 23:45	13K	

Figure 31HFRadar Index of Archived Total Vectors

Index of /data/oceans/ndbc/hfradar/rtv/2023

Name	Last modified	Size	Description
Parent Directory		-	
202301/	2023-02-24 07:56	-	
202302/	2023-03-25 08:25	-	

Figure 32 Index of Real Time Vector File-Annual Sub-Directory

NetCDF Subset Service for Grids | Index of /data/oceans/ndbc/hfra

ncei.noaa.gov/data/oceans/ndbc/hfradar/rtv/2023/202302/

Index of /data/oceans/ndbc/hfradar/rtv/2023/202302

Name	Last modified	Size	Description
Parent Directory		-	
GAK/	2023-03-25 08:09	-	
GLNA/	2023-03-25 08:09	-	
PRVI/	2023-03-25 08:11	-	
USEGC/	2023-03-25 08:19	-	
USHI/	2023-03-25 08:25	-	
USWC/	2023-03-25 08:35	-	

Figure 33 Real Time Vector Index- Sub-directory

NetCDF Subset Service for Grids | Index of /data/oceans/ndbc/hfra

ncei.noaa.gov/data/oceans/ndbc/hfradar/rtv/2023/202302/USEGC/

Index of /data/oceans/ndbc/hfradar/rtv/2023/202302/USEGC

Name	Last modified	Size	Description
Parent Directory		-	
202302010000_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	736K	
202302010000_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	271K	
202302010000_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	145K	
202302010100_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	736K	
202302010100_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	271K	
202302010100_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	141K	
202302010200_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	736K	
202302010200_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	278K	
202302010200_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	135K	
202302010300_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	736K	
202302010300_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	278K	
202302010300_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	132K	
202302010400_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	736K	
202302010400_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	285K	
202302010400_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	132K	
202302010500_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	735K	
202302010500_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	284K	
202302010500_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	130K	
202302010600_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	735K	
202302010600_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	284K	
202302010600_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	130K	
202302010700_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	735K	
202302010700_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	283K	
202302010700_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	132K	
202302010800_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	734K	
202302010800_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	286K	
202302010800_hfr_usegc_6km_rtv_uwls_NDBC.nc	2023-03-14 06:00	136K	
202302010900_hfr_usegc_1km_rtv_uwls_NDBC.nc	2023-03-14 06:00	734K	
202302010900_hfr_usegc_2km_rtv_uwls_NDBC.nc	2023-03-14 06:00	285K	

Figure 34 Real Time Vector Files for US East and Gulf Coast for 2023-February

Archived radial data from individual SeaSonde stations will be served at https://www.ncei.noaa.gov/data/oceans/ndbc/hfradar/radial/ for each year SeaSonde Data is available (Figure 35). Sub-folders are provided for each month of archived data (Figure 36) . Each monthly data folder is sub-divided with respect to data provider (Figure 37), which in our case will be RATES. Data provided by each provider are further organized in separate folders for each SeaSonde Station specified by a unique station identify (E.g. PINS for Padre Island National Sea Shore) where each folder contains radial data files for each hour (Figure 38). Unlike total vector file (.nc), radial files (.ruv) may be downloaded at human readable text files ('.ll" fomat separated by tabs Figure 39). **At this time of original report preparation, neither Real-Time-Vectors nor Radial Vector files have been archived for the period of March-2023 when our data uploads to HFRnet began.**

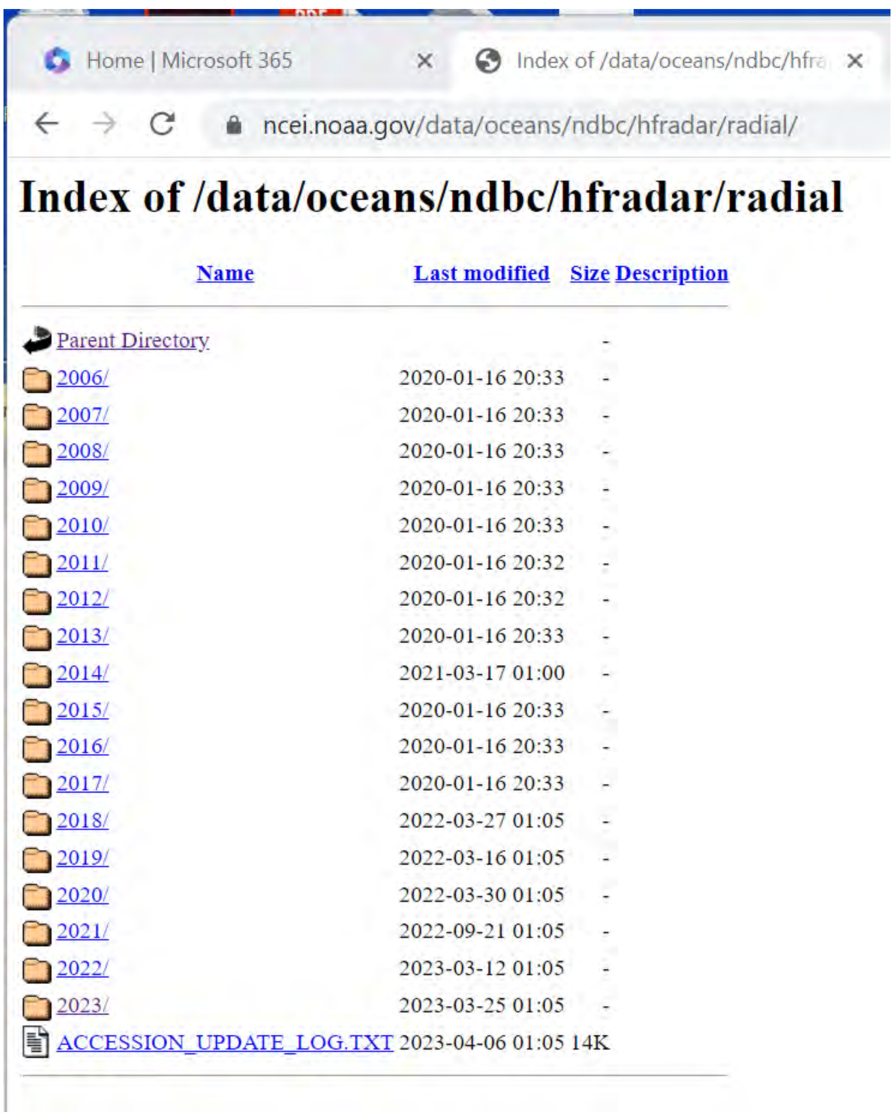


Figure 35 Index of archived HFRadar Radial Vector Files

Figure 36 Monthly sub-folders for radial vector data

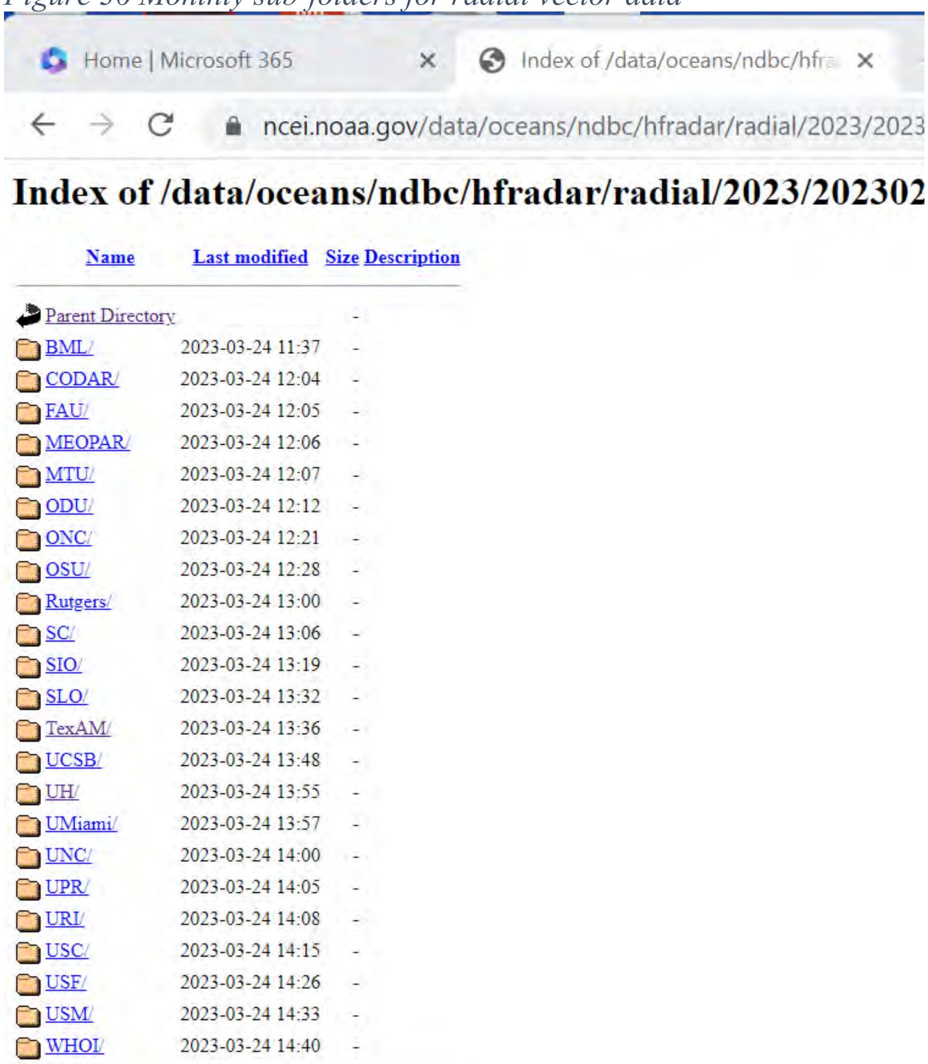


Figure 37 Radial data provider directory

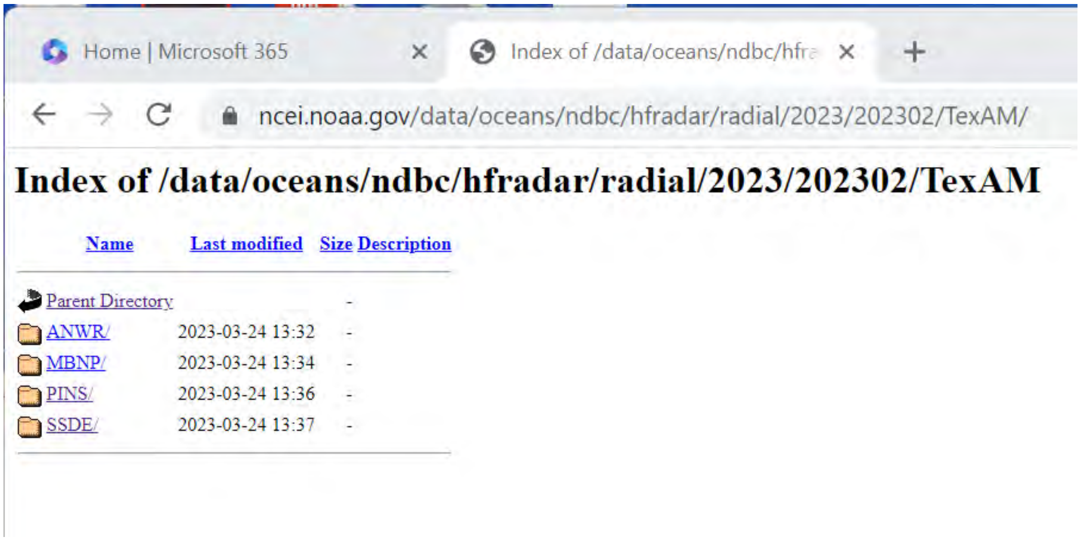
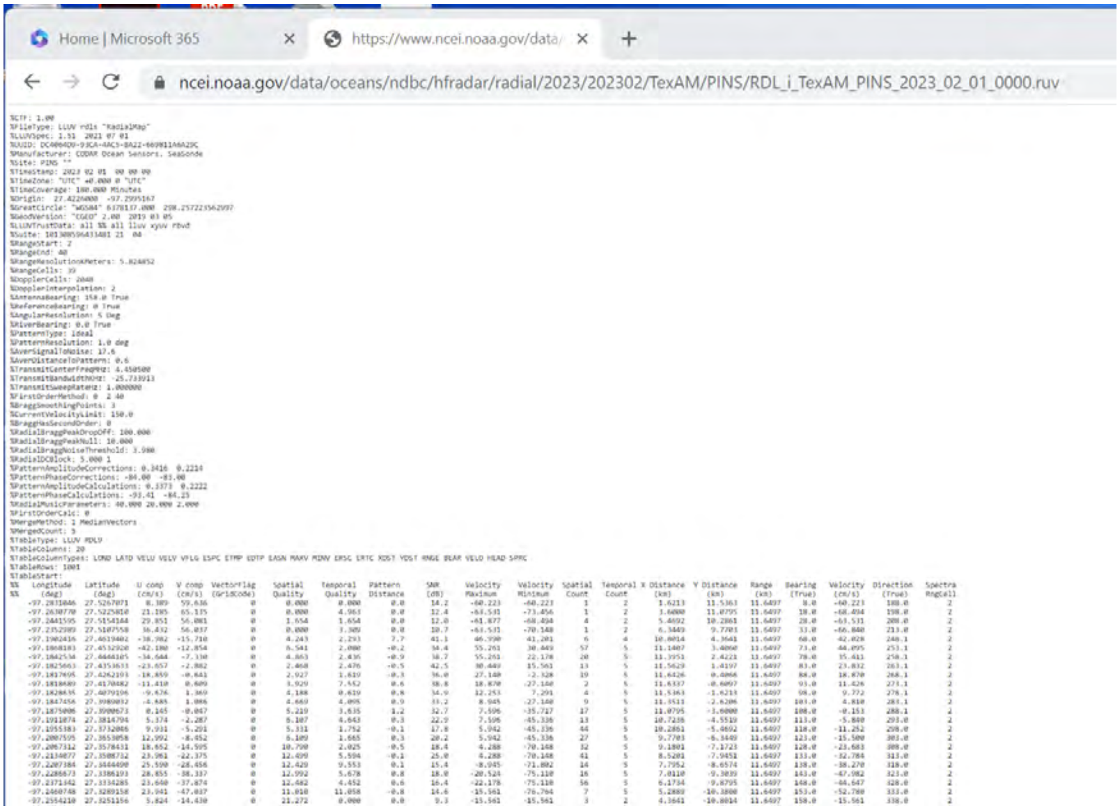


Figure 38 Example of station specific folders for radial vectors. This example show Texas A&M Station for which radial vector data was collected during 2023-February



- *Figure 39 Example of radial vector file*

Deliverable 8 Reports for routine remote station maintenance

All five Galveston Bay and Sabine HFR stations are maintained by RATES, Inc. Maintenance activities include routine inspection of NOAA and GCOOS web portals to ensure availability or real time current data. Disruptions in service trigger remote inspections via TeamViewer connections. Site visits are triggered if and when service disruptions cannot be corrected through remote connections. Beginning in February 2023, routine site visits (every 4-6 weeks) have been conducted to conduct physical maintenance and inspection of station infrastructure. The most recent site inspections were conducted in February 2024. A copy of the most recent Remote Station Maintenance Report #5 for the Period Jan-Mar 2024 is provided in **Exhibit A.**

Task 3: Hydrodynamic and Water Quality Modeling Integration SCHISM Deliverables

Addressing a significant data gap in the Texas Water Development Board coastal hydrodynamic modeling program, a major project objective was to apply the HFR total current vector data to validate SCHISM modeled currents for Galveston Bay and Sabine Lake. Where the benefits of a validated coastal hydrodynamic model include increased confidence in model surface current data as it relates the State's initiatives including: oil spill response, estuarine fresh water flows program, and coastal flooding. Other benefits of increased model confidence directly address the needs of non-point source transport modeling, maritime safety, and search and rescue operation. The validation showed good correlation between modeled (SCHISM) and observed (HF Radar) currents for both Galveston Bay and Sabine Lake. A copy of the modeling manuscript, Ogbodo et al. 2024 is provided as **Exhibit B**.

The modeling team also investigated: 1) integration of HFR current data within CE-QUAL-W2, a two-dimensional, hydrodynamic and water-quality model originally developed by the U.S. Army Corps of Engineer (**Exhibit C)**; and 2) and the application of normal mode analysis to fill gaps in total vector coverage due to a lack of multiple intersecting radial vectors (i.e. to derive total current vectors for areas observed by a single HFR station) (**Exhibit D**).

The following deliverables were completed:

- Deliverable 1 UTEP HPC account and purchase of workstation
- Deliverable 2 SCHISM model source code download
- Deliverable 3 Model build and library linkages
- Deliverable 4 Pre-processing and post processing tools
- Deliverable 5 SCHISM Verification/Test RUN
- Deliverable 6 Expected Input for TWDB SCHISM development team
- Deliverable 7 Run SCHISM simulation (test) with input data covering Texas Coast
- Deliverable 8 Develop Python code to extract currents for SCHISM simulations at Galveston Bay and Sabine Lake.
- Deliverable 9 Model validation at Galveston Bay
- Deliverable 10 Model validation at Sabine Lake
- Deliverable 11 Application of Normal Mode Analysis in Corpus Christi Bay
- Deliverable 12 Assessment of possible HF Radar Data integration within CE-QUAL-W2

Task 4: Project Dissemination and Outreach Activities

Dissemination and outreach deliverables were considered key components to maximize use of HFRadar data products and help ensure the sustainable operation of Galveston Bay and Sabine Lake HFR networks. Among the required outreach activities were multiple presentations to the Southeast Texas Flood Coordination Study hosted by co-PI Dr. Liv Haselbach at Lamar University a presentation at the Clean Gulf Conference 2022- New Orleans. Other important outreach venues included presentation at:

- NOAA EPP/MSI 10th Biennial Education and Science Forum. University of Texas-El Paso, Lamar University-2022;
- Lamar University- 8th Annual Undergraduate Research EXPO;
- Lamar University Coastal Science and Engineering Collaborative Workshop;Lamar University Center for Resiliency;
- USACE Galveston District (SWG) Summer Stakeholder Partnering Forum-Moody Gardens; and
- Texas Integrated Flooding Framework (TIFF) Nearshore Wave Workshop.

Addressing the needs of the scientific communities, two journal articles have been prepared and submitted for peer review publication including:

- Fuller, C., Ernest, A., Scoggins, M., Haselbach, L., Wu, X., Ogbodo, C., Fitzgerald, R. (in review) Long-Term Coastal Observatory-High Frequency Radar Commissioning Process and Considerations. Discover Water-Springer Nature.
- Cletus Ogbodo, Rosa Fitzgerald, Christopher Fuller, Roberto Perea, Jungwoo Lee, Liv Haselbach, Andrew Ernst, (in preparation), Intercomparison of Surface Current Produced by SCHISM Model and HF Radar in Galveston Bay and Sabine Lake Texas, 2024.

Task 5: Partnership Development

To ensure long-term sustainability and maintenance of Texas Bays and Ports HFR networks, UTEP and project team host a workshop for Galveston Bay Area and Sabine Neches Area stakeholder to raise project awareness among those with vested interest with coastal hydrodynamic data The workshop was conducted on May 16, 2023 at Lamar University-Science and Technology Building. The workshop included presentations by participants for Lamar University, RATES, Inc. University of El Paso, Gulf of Mexico Coastal Observing System, US Army Corps of Engineers, USGS, Texas A&M University-Kingsville, and Cameron County. The workshop was attended by eleven (11) in-person attendees and 14-virtual attendees. Presentations demonstrated the applicability of HF Current data for coastal resiliency issues including: flood and storm-surge modeling, sediment transport modeling, maritime safety, water quality and natural resource protections. Comments by workshop participant were generally positive and encouraged continued operation of HF Radar Networks on Galveston Bay and Sabine Lake and expansion of HF Radar coverage to other Texas bays.

In an effort to seek continued operational and maintenance funding two proposal packages were prepared and submitted for consideration including:

- Coast wide monitoring program: High-Frequency Radar for Texas Bays. CMP-29-PSM. Submitted: June 7, 2023. Project Not Selected.
- Invited proposal: Galveston Bay and Sabine Lake High Frequency Radar Networks: Operation and Maintenance. GCOOS Omnibus proposal in response to announcement for funding availability under Biden Administration- Inflation Reduction Act. Submitted January 9, 2024. Proposal-Under Review.
    - Proposal request base funding for routine operation of Galveston Bay and Sabine Lake networks for a period of 5-years.

Task 6: Project Monitoring and Reporting

In accordance with project scope of work, a total of 11 progress reports were submitted Quarterly over the 36-month project duration. In partial fulfillment of project deliverables, the 12th and Final Report summarizes the work completed in the performance of this contract 21-155-002-C874.

A final project deliverable is completion of the GOMESA Performance Measures spreadsheet (**Exhibit E**).

Acknowledgements:

The authors wish to acknowledge the efforts by all who contributed to the success of this project.

RATES' field engineers lead by Mr. Mitch Scoggins and Mr. Benjamin Vondrak who addressed multiple challenges during the commissioning process. RATES CEO Dr. Andrew Ernest, for his recognition of the project value and continuous support in light challenges faced. Galveston County, Chambers County, City of Port Arthur, USACE-Port Arthur Field Office, and USACE-Galveston District for their gracious support and assistance with securing access for station operation. Cletus Ogbodo at the University of Texas-El Paso for his work involved with demonstrating the applicability of project data to address coastal resiliency issues. Lamar University graduate students who assisted in initial site surveys and coordination of numerous field activities.

Exhibit A Remote Station Maintenance Report #5

UNIVERSITY OF TEXAS AT EL PASO
Task 2 HF Radar Network Commissioning and Operation Deliverable 8: Reports for Remote Station Maintenance Report #5
For Performance Period: Jan-March 2024 Submitted: March 11, 2024

(Project Name)

CMP-26 Project of Special Merit: HF Radars for Texas Bays and Ports

(GLO Contract No.)
21-155-002-C874

Galveston Bay Stations	Service Visit Dates	Report Page #
Moses Lake (MOLA)	04 Jan 24 29 Feb 24	2 6
McCollum Park (MCPK)	14 Jan 24 27 Jan 24 29 Feb 24	10 14 15
Smith Point (SMPT)	14 Jan 24 27 Jan 24 29 Feb 24	16 20 21
Sabine Lake Stations		
Pleasure Pier Blvd. (PLPI)	18 Jan 24 01 Mar 24	25 29
Placement Area 8 (PLA8)	18 Jan 24 01 Mar 24	33 37

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024

Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.

Location: MOLA **Date and Time:** 07:00 04 Jan 2024 **Personnel Present:** Mitch S.

Site Visit Report: MOLAVR06012404JAN24 **Is this a routine station check or a "system down" service call?** Routine

Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder? No

Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**

Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes

Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B) Yes

Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C)
Yes **Actual:** 38

Is the FCC designated Call Sign properly set at this station? (Note D) Yes

Have you verified at least one call sign broadcast? (Note E) Yes

Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes

No. Visible? 10 Full

Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)

Active Transmission cycle FWD PWR observed: 24.2W **Active Transmission REV PWR observed:** 0.1W10:12:1

5VDC Monitored Reading: 5.17VDC **24VDC Monitored Reading:** 25.08VDC

Chassis Temperature, C and F: 26/79 **Amplifier Temperature, C and F:** 27/81

Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Good

Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly? Yes

Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**

Data Back Up Performed on this visit? No **(this is required ~ every six months)**

Are the Cabinet Locks functioning smoothly? N/A **Were they graphite treated during this visit?** N/A

Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? N/A

(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)

What is the overall condition of the deck? List issues in Notes, if any: N/A

Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes

Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) 1.2 ohms, good

Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)

Yes, good
What is the overall Antenna Base Condition? List any issues in the Notes section: **Good**
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes, see notes
Are there any signs of vandalism, theft, or interference with the Codar Station? No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit?
No pictures taken this trip
Upon departure, is this station fully operational or down for parts/repairs? Fully operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer?
Yes, verified.
Duplicate this hand scribed ticket with a properly typed copy, then place the resulting word doc pdf form in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.

/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:

More spot treatment of conduit exposures 3 bags of gravel and 6 bags of dirt on this site visit.

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: MOLA **Date and Time:** 07:10 29 Feb 2024 **Personnel Present:** Mitch S.
Site Visit Report: MOLAVR07022429FEB24 **Is this a routine station check or a "system down" service call?** Routine
Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?
No
Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**
Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes
Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B)
Yes
Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C)
borderline **Actual:** 40
Is the FCC designated Call Sign properly set at this station? (Note D) Yes
Have you verified at least one call sign broadcast? (Note E) Yes
Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 8 full/ 4 partial
Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)
Active Transmission cycle FWD PWR observed: 31.2W **Active Transmission REV PWR observed:** 0.1W12:14:1
5VDC Monitored Reading: 5.27VDC **24VDC Monitored Reading: 24.14VDC**
Chassis Temperature, C and F: 26/79 **Amplifier Temperature, C and F:** 26/79
Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Good
Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes
Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**
Data Back Up Performed on this visit? No **(this is required ~ every six months)**
Are the Cabinet Locks functioning smoothly? N/A **Were they graphite treated during this visit?** N/A
Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? N/A
(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)
What is the overall condition of the deck? List issues in Notes, if any: N/A
Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes
Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM

that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) 0.9 ohms, good
Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)
Yes, good
What is the overall Antenna Base Condition? List any issues in the Notes section: Good
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes, see notes
Are there any signs of vandalism, theft, or interference with the Codar Station? No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit?
No pictures taken this trip
Upon departure, is this station fully operational or down for parts/repairs? Fully operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer?
Yes, verified**.**
Duplicate this hand scribed ticket with a properly typed copy, then place the resulting word doc pdf form in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.

/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:

More spot treatment of conduit exposures 1 bag of gravel and 5 bags of dirt on this site visit.

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: MCPK Date and Time: 13:00 14 Jan 2024 **Personnel Present:** Mitch S. & Chris F. **Site Visit Report:** MCPKVR10012414JAN24 **Is this a routine station check or a "system down" service call?** Routine
Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?
No
Problem Resolved or Purpose of Visit Achieved? Yes Details in Notes at bottom of form:
Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes
Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B)
Yes
Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C)
Borderline Actual: 40-42
Is the FCC designated Call Sign properly set at this station? (Note D) Yes
Have you verified at least one call sign broadcast? (Note E) Yes
Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes
No. Visible? 9 full
Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)
Active Transmission cycle FWD PWR observed: 25.8W **Active Transmission REV PWR observed:** 0.1W16:13:1
5VDC Monitored Reading: 5.05VDC **24VDC Monitored Reading:** 24.24VDC
Chassis Temperature, C and F: 26/79 **Amplifier Temperature, C and F:** 27/81
Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Good
Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly? Yes
Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**
Data Back Up Performed on this visit? No **(this is required ~ every six months)**
Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** Yes
Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes
(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)
What is the overall condition of the deck? List issues in Notes, if any: Good, but may have to adjust the under-deck leveling jacks soon
Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes
Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) 0.5 ohms, good

Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)
Yes, good
What is the overall Antenna Base Condition? List any issues in the Notes section: Good
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes, see notes
Are there any signs of vandalism, theft, or interference with the Codar Station? No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit?
No pictures taken this trip
Upon departure, is this station fully operational or down for parts/repairs? Fully operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer?
Did not do this.
Duplicate this hand scribed ticket with a properly typed copy, then place the resulting word doc pdf form in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.

/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:

Conduit exposures in the vicinity of the deck. We laid1-1/2 bags of gravel and 2 bags of dirt on this site visit.

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: **MCPK** **SMPT MOLA PLPI PLA8** **Date and Time:** 12:00 27 Jan 2024
Personnel Present: **Mitch S. & Chris F.** **Site Visit Report:** MCPKVR1103241427JAN24 **Is this a routine station check or a "system down" service call?** **SYSTEM DOWN FOR PART SWAP**
Explain:
Because we are attempting to maintain optimal coverage of East Galveston Bay, and in consideration of our realization that MCPK offers the least overall coverage of our three stations MCPK, MOLA and SMPT, we have elected to remove the Transmit Chassis from this station for use at the SMPT station in consideration that it is down for an issue with its Xmit Chassis Front Panel Control PCB.
MCPK has been made inactive. SSTX Chassis SN 2003083 removed from system for transfer to SMPT.
MCPK is now offline for the time being.

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: **MCPK** **Date and Time:** 12:00 29 Feb 2024
Personnel Present: **Mitch S.** **Site Visit Report:** MCPKVR12032429FEB24 **Is this a routine station check or a "system down" service call?** **SYSTEM DOWN FOR PARTS**
Explain:
MCPK is inactive. SSTX Chassis SN 2003083 wasremoved from system for transfer to SMPT on 27 Jan24.
Modem,UPS and PC are online for remote monitoring, Dessicants were swapped today while the cabinet/deck area was cleaned and the base antenna checked.

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: **SMPT** **Date and Time:** 12:00 14 Jan 2024 **Personnel Present:** Mitch S. & Chris F. **Site Visit Report:** SMPTVR09012414JAN24 **Is this a routine station check or a "system down" service call?** **Routine**
Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?
No
Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**
Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes
Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B)
Yes
Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C)
inoperative sensor
Actual: unknown
Is the FCC designated Call Sign properly set at this station? (Note D) Yes
Have you verified at least one call sign broadcast? (Note E) Yes
Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 5 full
Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)
Active Transmission cycle FWD PWR observed: 50W **Active Transmission REV PWR observed:** 0.1W14:13:1
5VDC Monitored Reading: 5.10VDC **24VDC Monitored Reading:** **24.9VDC**
Chassis Temperature, C and F: 20/68 **Amplifier Temperature, C and F:** 24/73
Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Good
Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes
Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**
Data Back Up Performed on this visit? No **(this is required ~ every six months)**
Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** Yes
Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes
(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)
What is the overall condition of the deck? List issues in Notes, if any: Good
Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes
Have you verified that the DDB enclosure and cable GND Wires are both properly

connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) not checked due to access issues

Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)

Not this trip

What is the overall Antenna Base Condition? List any issues in the Notes section: Good

Did you carefully walk the length of the conduit run(s) to check for damage or exposure?

Yes

Are there any signs of vandalism, theft, or interference with the Codar Station? No **Describe in Notes**

Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**

Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit?

No pictures taken this trip

Upon departure, is this station fully operational or down for parts/repairs? Fully operational

Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer?

Did not do this.

Duplicate this hand scribed ticket with a properly typed copy, then place the resulting word doc pdf form in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.

/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:

No comments for this particular site visit

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: **MCPK** **SMPT** **MOLA PLPI PLA8** **Date and Time:** 15:00 27 Jan 2024

Personnel Present: **Mitch S. & Chris F.** **Site Visit Report:**
SMPTVR100022427JAN24 **Is this a routine station check or a "system down" service call?** **SYSTEM DOWN…reactivated**

Explain:
The SSTX Chassis SN 2004116 Front Panel Control Board was determined to be bad. We removed SSTX Chassis SN 2003083 from MCPK and installed it at this location. Re-normalized system for operation

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: SMPT Date and Time: 12:00 29 Feb 2024
Personnel Present: Mitch S. Site Visit Report: SMPTVR11042429FEB24 **Is this a routine station check or a "system down" service call? Routine**
Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?
Yes
Problem Resolved or Purpose of Visit Achieved? Yes Details in Notes at bottom of form:
Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes
Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B)
Yes
Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C)
Yes
Actual: 37
Is the FCC designated Call Sign properly set at this station? (Note D) Yes
Have you verified at least one call sign broadcast? (Note E) Yes
Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 7 Full
Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)
Active Transmission cycle FWD PWR observed: 50W **Active Transmission REV PWR observed:** 0.1W14:13:1
5VDC Monitored Reading: 5.16VDC **24VDC Monitored Reading: 24.7VDC**
Chassis Temperature, C and F: 25/76 **Amplifier Temperature, C and F:** 26/78
Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Good
Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes
Is there any evidence of corrosion, rust, or other humidity damage? No If so, describe in Notes.
Data Back Up Performed on this visit? No **(this is required ~ every six months)**
Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** Yes
Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes
(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)
What is the overall condition of the deck? List issues in Notes, if any: Good
Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes
Have you verified that the DDB enclosure and cable GND Wires are both properly

connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) Yes, 0.3 ohms

Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)

Yes

What is the overall Antenna Base Condition? List any issues in the Notes section: Good

Did you carefully walk the length of the conduit run(s) to check for damage or exposure?

Yes

Are there any signs of vandalism, theft, or interference with the Codar Station? No

Describe in Notes

Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**

Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit?

No pictures taken this trip

Upon departure, is this station fully operational or down for parts/repairs? Fully operational

Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer?

Yes, verified.

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/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:

No comments for this particular site visit

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024
Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.
Location: PLA8 **Date and Time:** 08:40 04 Jan 2024
Personnel Present: Mitch S. **Site Visit Report:** PLA809012404JAN24 **Is this a routine station check or a "system down" service call?** Routine
Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?
Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**
Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes
Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B) Yes
Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C) Yes **Actual:** 37
Is the FCC designated Call Sign properly set at this station? (Note D) Yes
Have you verified at least one call sign broadcast? (Note E) Yes
Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 6 Full/4 partial
Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)
Active Transmission cycle FWD PWR observed: 26.2W **Active Transmission REV PWR observed:** 2.1W
5VDC Monitored Reading: 5.26VDC **24VDC Monitored Reading:** 26.01VDC
Chassis Temperature, C and F: 23/76 **Amplifier Temperature, C and F:** 26/83
Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Yes, Fair
Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes
Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**
Data Back Up Performed on this visit? No **(this is required ~ every six months)**
Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** No
Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes
(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)
What is the overall condition of the deck? List issues in Notes, if any: Good
Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes
Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) Yes, 0.7 ohm
Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)

Yes
What is the overall Antenna Base Condition? List any issues in the Notes section: Good
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes
Are there any signs of vandalism, theft, or interference with the Codar Station? No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit? No
Upon departure, is this station fully operational or down for parts/repairs? Operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer? Yes, verified
Duplicate this hand scribed ticket with a properly typed copy, then place both copies, the scanned original and word doc in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.
/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:
CLEARED BRUSH, Five Hours

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024

Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.

Location: MCPK SMPT MOLA PLPI PLA8 **Date and Time:** 10:00 29 FEB 2024
Personnel Present: Mitch S. and Chris F. **Site Visit Report:** PLA810022429FEB24
Is this a routine station check or a "system down" service call? Routine
Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?
Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**
Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes
Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B)
Yes
Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C)
Yes **Actual:** 39
Is the FCC designated Call Sign properly set at this station? (Note D) Yes
Have you verified at least one call sign broadcast? (Note E) Yes
Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 5 Full/7 partial
Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)
Active Transmission cycle FWD PWR observed: 18.7W **Active Transmission REV**

PWR observed: 1.7W
5VDC Monitored Reading: 5.21VDC **24VDC Monitored Reading:** 25.10VDC
Chassis Temperature, C and F: 26/83 **Amplifier Temperature, C and F:** 26/83
Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Yes, Fair
Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes
Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**
Data Back Up Performed on this visit? No **(this is required ~ every six months)**
Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** Yes
Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes
(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)
What is the overall condition of the deck? List issues in Notes, if any: Good
Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes
Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) Yes, 0.4 ohm
Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)
Yes
What is the overall Antenna Base Condition? List any issues in the Notes section: Good
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes
Are there any signs of vandalism, theft, or interference with the Codar Station?No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit? No
Upon departure, is this station fully operational or down for parts/repairs? Operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer? Yes, verified
Duplicate this hand scribed ticket with a properly typed copy, then place both copies, the scanned original and word doc in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the

server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.

Summarize specific actions taken during this site visit that require further elucidation:

CLEARED BRUSH, Three Hours

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024

Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.

Location: PLPI **Date and Time:** 14:20 04 Jan 2024

Personnel Present: Mitch S. **Site Visit Report:** PLPI09012404JAN24

Is this a routine station check or a "system down" service call? Routine

Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?

Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**

Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes

Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B) Yes

Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C) Yes **Actual:** 36

Is the FCC designated Call Sign properly set at this station? (Note D) Yes

Have you verified at least one call sign broadcast? (Note E) Yes

Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 9 FULL

Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)

Active Transmission cycle FWD PWR observed: 16.2W **Active Transmission REV PWR observed:** 0.9W

5VDC Monitored Reading: 5.48VDC **24VDC Monitored Reading:** 25.17VDC

Chassis Temperature, C and F: 26/83 **Amplifier Temperature, C and F:** 26/83

Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Yes, Fair to Good

Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes

Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**

Data Back Up Performed on this visit? No **(this is required ~ every six months)**

Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** Yes

Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes

(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)

What is the overall condition of the deck? List issues in Notes, if any: Good

Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes

Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) Yes, 0.7 ohm

Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)
Yes
What is the overall Antenna Base Condition? List any issues in the Notes section: Good
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes
Are there any signs of vandalism, theft, or interference with the Codar Station? No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit? No
Upon departure, is this station fully operational or down for parts/repairs? Operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer? Yes, verified
Duplicate this hand scribed ticket with a properly typed copy, then place both copies, the scanned original and word doc in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.
/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:
Everything looks good

R A T E S . O R G C O D A R S E R V I C E T I C K E T Rev. A 01/2024

Please make every effort to fill this form out legibly in dark ink, using printed letters (no cursive). Explanatory notes should be made using complete, descriptive sentences.

Location: PLPI **Date and Time:** 12:00 29 FEB 2024 **Personnel Present:** Mitch S. and Chris F. **Site Visit Report:** PLPI10022429FEB24

Is this a routine station check or a "system down" service call? Routine

Do you have with you a typed hard copy of the previous Site Visit Service Ticket to place in the cabinet binder?

Problem Resolved or Purpose of Visit Achieved? Yes **Details in Notes at bottom of form:**

Have you verified that the Mini Mac PC date & time are set to Reykjavik? (Note A) Yes

Have you verified that Set Time Zone/Date and Time Automatically are disabled? (Note B) Yes

Is the RCVR Chassis Humidity reading verifiably less than 40% as preferred? (Note C) Yes **Actual:** 39

Is the FCC designated Call Sign properly set at this station? (Note D) Yes

Have you verified at least one call sign broadcast? (Note E) Yes

Does this station have acceptable GPS satellite coverage (5+)? (NoteF) Yes **No. Visible?** 5 Full/7 partial

Transmit Monitor Readings as indicated in the SeaSonde software: (Note G)

Active Transmission cycle FWD PWR observed: 20.1W **Active Transmission REV PWR observed:** 1.8W

5VDC Monitored Reading: 5.17VDC **24VDC Monitored Reading:** 25.14VDC

Chassis Temperature, C and F: 25/82 **Amplifier Temperature, C and F:** 26/83

Observe the Data Modem (RV50X) signal strength. Is it indicating at least Fair or Good as seen on the signal strength LED? (Note H) Yes, Fair

Prior to departure, have you performed due diligence to ensure that the DDB Enclosure cabinet interior is clean, that both chassis fan(s) are working and clear of obstruction, that the interior layout wiring is orderly?
Yes

Is there any evidence of corrosion, rust, or other humidity damage? No **If so, describe in Notes.**

Data Back Up Performed on this visit? No **(this is required ~ every six months)**

Are the Cabinet Locks functioning smoothly? Yes **Were they graphite treated during this visit?** Yes

Were the desiccant tub and hangar inside the enclosure replaced, and old ones disposed of properly? Yes

(as part of our ongoing effort to control cabinet humidity, this is sensibly done every visit)

What is the overall condition of the deck? List issues in Notes, if any: Good

Did you carefully wipe down the DDB Cabinet Enclosure with a cloth towel before departing? Yes

Have you verified that the DDB enclosure and cable GND Wires are both properly connected to their respective grounding rods? Were you able to verify with a Fluke MM that these grounding wire runs pass ohm tests with a value of 3.0 ohms or less? List measurements, if taken: (Note I) Yes, 0.4 ohm

Have you spot checked the Antenna base hinge bolts/nuts with wrenches and verified them to be firm? (Note J)
Yes
What is the overall Antenna Base Condition? List any issues in the Notes section: Good
Did you carefully walk the length of the conduit run(s) to check for damage or exposure?
Yes
Are there any signs of vandalism, theft, or interference with the Codar Station? No
Describe in Notes
Are there any specific issues that were observed but not resolved due to time/material/tool limitations that should be addressed at the next visit? Immediate action required or deferred? No **Describe in Notes**
Preferred, but not mandatory: Were pictures taken [to be included in the server folder] during this site visit? No
Upon departure, is this station fully operational or down for parts/repairs? Operational
Ideally, you have the Rates CODAR Mac laptop with you. If you do, were you able to connect the Mac laptop to the RV50X modem through a Cat5 cable and independently confirm station Sea Sonde broadcast through TeamViewer? Yes, verified
Duplicate this hand scribed ticket with a properly typed copy, then place both copies, the scanned original and word doc in an SV Report folder. Include any pictures or additional notes and/or pertinent documents that you might have. Expediently post your report on the server within 24-48 hours. Sign and include a scan of the original handwritten copy. As a courtesy, you should update the SV Report Log sheet on the server when you do this.

/// NOTES /// Affix an additional sheet to this ticket if you have more to add that cannot fit in the modest amount of space provided below. Summarize specific actions taken during this site visit that require further elucidation:
Everything Looks Good!

Exhibit B Intercomparison of Surface Current Produced by SCHISM Model and HF Radar in Galveston Bay and Sabine Lake Texas

Intercomparison of Surface Current Produced by SCHISM Model and HF Radar in Galveston Bay and Sabine Lake Texas

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Abstract:

This study provides a comprehensive inter-comparison of surface currents obtained in Galveston Bay and Sabine Lake, Texas, using High-Frequency (HF) radars and the SCHISM model. The SCHISM model was used to make surface currents simulations of Galveston Bay and Sabine Lake using input for the month of April 2023 and the HF radar data was extracted for the same month from the newly installed five HF radar network at Galveston Bay and Sabine Lake. Surface current data plays a pivotal role in elucidating nearshore physical processes, with wide-range applications, from marine traffic management to environmental monitoring. The methodology encompasses qualitative and quantitative analyses. Qualitative assessment focused on analyzing current vector directions, while quantitative analysis evaluated magnitudes and correlations of surface currents in the eastward and northward directions. Various statistical metrics were utilized to evaluate model performance. Results highlight robust predictive capabilities of both methods, exemplified by their strong correlations (up to 0.94), high index of agreement (up to 0.95) and low error metrics. Disparities in eastward and northward current measurements across dates underscore complex interplay between prevailing winds, bay-ocean interactions, and regional weather patterns. This study sheds light on the intricate dynamics of surface currents within Galveston Bay and Sabine Lake, underlying efficacy of both the HF radar and the SCHISM model in capturing current characteristics. Findings contribute to advancing the understanding of coastal dynamics and to determine strategies for environmental monitoring and management.

Key words: SCHISM, HF radar, Galveston Bay, Qualitative, Quantitative, Sabine Lake

1. Introduction

Surface current measurements provide invaluable insight into the state of ocean, seas, lakes, estuaries surfaces and physical processes taking place in these nearshore regions. Measurements of surface current fields are useful for applications in marine traffic information (Mantovani *et al*., 2020), oil spill monitoring and forecasting (Chiu *et al*., 2018), providing benchmark for numerical circulation models through intercomparison (Saviano *et al*., 2020; Barth *et al*., 2008; & Paduan and Shulman, 2004). High Frequency (HF) radars are highly deployed to provide invaluable real-time surface current data. The main product of the HF radar data - the surface currents - are primarily determined by first-order echo of wave from the ocean surface whose wavelength is half the transmitted wavelength (Saviano *et al*., 2023; Crombie, 1955). Similarly, as significant progresses have been made in the modeling of nearshore processes in recent years (Kirby, 2017), surface currents have been derived from computational approaches as well complimenting the efforts of observational instruments.

The state of Texas United States of America has several major estuaries along its coast including Galveston Bay and Sabine Lake. Generally, Galveston Bay (GB) and Sabine Lake (SL) are among seven major estuaries within the Texas Coast with the most intense marine activities and as result is most vulnerable to oil and other chemical spills. In addition, the bay and lake provide tremendous economic benefits to the state and are also of industrial importance to the country (see Table 1.1). The estuaries stand as pivotal shipping hubs within the United States, the bay housing the renowned Port of Houston, which ranks as the nation's largest port. It's worth noting that in terms of foreign tonnage, this estuary ranks sixth globally. The lake is home and share proximity to the navigation channel (Sabine-Neches Water Ways) of the largest commercial port of United States military, and, of the refineries that produce 60% of the nation's commercial jet fuel (Quian *et al*., 2023). The region surrounding the bay (GB) is home to over a third of the country's chemical production facilities and oil refineries, signifying its strategic importance in industrial operations. Moreover, the estuary contributes significantly to the economy, with one-third of commercial fishing income and half of sport fishing expenditures in Texas originating from this area (Salas-Monreal *et al*., 2018). On the other hand, Sabine Lake, the third largest waterway by tonnage in the US is the largest military offload port in the US and due to its proximity to petrochemical industries is usually saline. It is estimated to provide up to 100,000 jobs and a huge economic return to the nation. These have highlighted the need to improve operational monitoring of the bay and the lake with special interest in measuring the surface current field in the near real time thereby providing a prepared approach to face any future environmental degradation – oil and substance spill. Oil spill preparedness is needed for oil exploitation and shipping in general, and surface currents are the most important variable for an oil spill model for short time scales (Röhrs *et al*., 2021).

Traditionally, HF radars have become the most reliable source of real time surface current maps in operational oceanography. This permits proper monitoring of the estuaries, oceans because of their ability to cover extended areas (Röhrs *et al*., 2021); providing synoptic reconstruction of current fields over such with spatial and temporal resolution of 1km and 1h respectively (Kalampokis *et al*., 2016). The HF radar essentially measures the radial velocity which implies speed of movement of the surface gravity waves on the ocean or estuaries surface either away from or towards the radar. When these two directions are subtracted, we obtain the radial velocity field from a single radar. The combination of radial velocity from multiple radar sources is usually employed to fully deduce the east – west and north – south velocity components (mostly referred as totals) (Ohlmann *et al*., 2007) providing a detailed representation of total currents. The surface current representation usually arises from interplay of many processes including wind, waves, tides, density variation, so the total current is usually the cumulative measurement of all processes and their nonlinear (Roland *et al*., 2012) interactions. Many applications, including Panoply, enable the visualization to current vectors obtained from HF radars with typical hourly temporal scale (Ohlmann *et al*., 2007), facilitating qualitative comparisons with current vectors generated from numerical models operating at the same temporal scale.

Due to improvements in numerical methods (Azevedo, 2014), modeling of nearshore processes (Kirby, 2017) and advances in computers, model systems are becoming more useful in simulating the surface circulation in the ocean and estuaries. Typically, the modeling system consists of a hydrodynamic model, a transport model and other modules coupled together or as a system of many modules (SCHISM, 2021; Azevedo, 2014). Recently, a new robust 3-dimensional model known as semi-implicit cross-scale hydrodynamic integrated system model (SCHISM) was developed to simulate surface currents and water surface elevation (Zhang *et al*., 2016; Chiu *et al.*, 2018) and it is made up of a system of modules coupled to its hydrodynamic core (see Figure 1).Usually, the core part of the SCHISM modeling system is applied to produce current speeds and surface elevation. The current speed (total horizontal velocity) produced is usually in two dimensions – coupled together. Python - a free, open-source programming language has relevant libraries that can be used to extract the total current speeds in north-south direction and total current speeds in east-west direction. This will permit likewise quantitative intercomparison of magnitude of current produced by both HF radar and the SCHISM model.

Previous research has demonstrated that the SCHISM model is a valuable tool for predicting surface currents in oceans coast (Chiu *et al*., 2018), and other coastal regions including bays, with important implications for many numbers of applications such as oil spill response, and search and rescue operations, and assessment of numerical model performance. The robustness of the model in simulating hydrodynamics in coastal and estuarine environments is derived from its use of unstructured grids (Zhang *et al*., 2019) that can adapt to the complex geometry and topography of the coastline (Ye et *al.,* 2018), allowing for high-resolution simulations of flow dynamics.

Generally, model performance can be evaluated via model-observation (HF radar) comparisons of their horizontal velocity(currents) distributions (Li *et al*., 2021), either quantitatively or qualitatively or both. So, this work was motivated by the need to assess the performance of SCHISM model in generating the surface currents in Galveston Bay and need to provide full real-time environmental monitoring of the Bay due to its previously mentioned importance to the state of Texas. As a result, a network of three CODAR type HF radars were installed late 2022 at the Bay and January 2023 in the lake specifically to carry out this assessment. They have been measuring surface current data since early 2023 which are being archived at the National Center for Environmental Information (NCEI) website. The SCHISM model simulation using input parameters derived from the Texas coast was made to generate outputs corresponding to the month HF radar data is available in Galveston Bay and the lake. A special program was developed to analyze the complex hydrodynamic outputs from SCHISM to extract the surface current only for the bay and to hence which will be directly compared with the totals from the radar. Therefore, in this work we present our efforts in interpreting the HF radar current data and in running the schism model simulation to generate surface current derived as well as our effort in comparing the surface currents produced by the two methods at the bay and lake. Also, we present the remaining part of work under the following sections. Section 2 discusses the methods, section 3 presents the results, section 4 discusses the result, section 5 gives the conclusion.

Table 1.1: Describing the features of Galveston Bay and Sabine Lake

Bays/Estuary	Features
Sabine Lake (SL)	• Smallest major estuaries of Texas • Connect Sabine-Neches waterways to Ports of **Beaumont,** Port-**Arthur**, Orange County • Third largest waterway by tonnage in US • Largest military offload port in US, 2^{nd} in the world (Seabergh *et al*., 2010) • Surrounded by petrochemical industries and busy waterways. • Saline water because of increased shipping activities • Economic source ($10BN, 100,000 jobs)
Galveston Bay (GB)	• Seventh largest estuary in the U.S(Huang *et al*., 2021) • Largest estuary in Texas • Sixth largest by tonnage globally (Salas-Montreal *et al*., 2018) • Connect three ports: **Houston**, **Texas City, Galveston**.

- Oil spills frequent.
- Economic source ($2.3BN, 13,000 jobs)

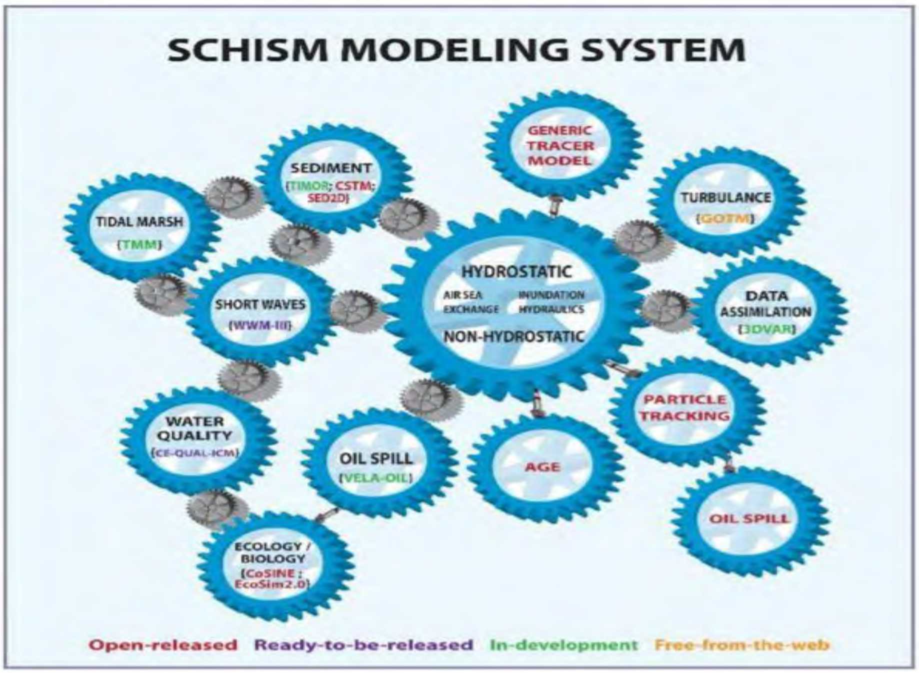


Figure 1: SCHISM modelling system (Chiu *et al*., 2018; SCHSIM ; http://ccrm.vims.edu/schismweb/).

2.0 Method

2.1 Study Area

2.1.1 Study Site Description

Galveston Bay is a wide and shallow estuary with an average depth of ~2 -3m and a total area of 1600 km^2(Salas-Monreal *et al*., 2018). Sabine Lake is a shallow lake as well of about 17miles(23km) long and 7miles(11km) i.e. area of 253$km^{2.}$ with an average depth of 3-6m. The Galveston Bay is connected to the open ocean by a deep channel (~14 m) and narrow (~200 m) channel (Houston Ship Channel) through Bolivar Roads Pass (see Figure 2.1) at the entrance of the bay (Huang *et al*., 2021). The bathymetry of Galveston Bay is relatively flat with a mean depth of 3 m, except in the northern entrance (Houston Ship Channel), where a 12 m deep channel is located (Salas-Monreal *et al*., 2018, Dupuis and Anis, 2013) while the average depth of Sabine Lake fluctuates between 3 to 6m depending on sedimentation, water levels and erosion. There are deeper channels within the lake especially along the Sabine – Neches Water Ways (SNWW) where depth averages 12m and efforts are underway to increase the depth from 12.2m to 14.6m by the U.S Corps of Army Engineer (USACE) (Qian *et al*., 2023). For an in-depth exploration of the topography, bathymetry, and other coastal dynamics of Galveston Bay, readers are referred to the following studies: Du, J., & Park, K., 2019b; Du et al., 2019a; and Du et al., 2020.

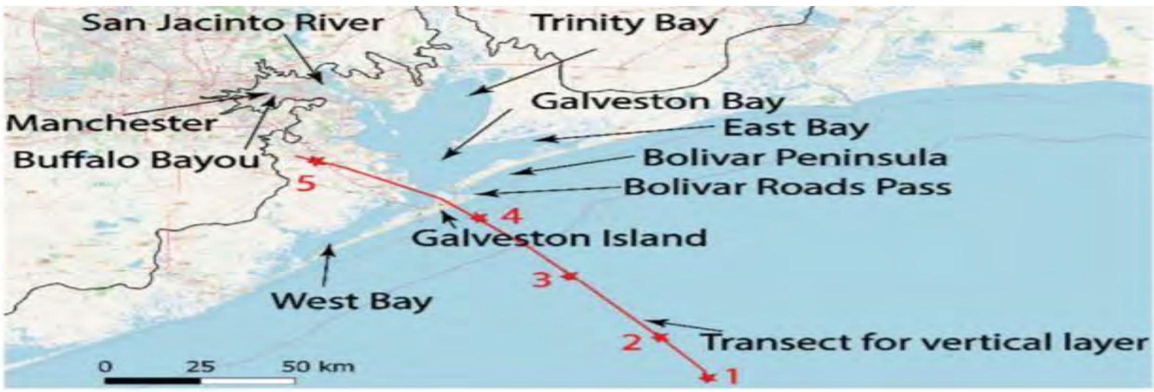


Figure 2.1: Geographic regions in Galveston Bay. The black lines are model land boundaries. (Huang *et al*., 2021).

2.1.2 Study Site Grid Description

The entire Texas coast was separated into two model grids Phase_1 and Phase_2 for computational convenience and efficiency (see Figure 2.2). Phase_1 encompasses the area extending from the Southern border to Freeport Texas while Phase_2 spans from Freeport to Sabine Lake. Galveston Bay and Sabine Lake are both situated within the boundaries of Phase 2. So, in the concept of this work, all mentions of the SCHISM simulation pertains specifically to Phase 2. A SCHISM model (version 5.8.0) simulation was conducted using Phase 2 inputs files encompassing the period of April 1st to April 30th, 2023. Phase 2 grid consists of coordinates extending from latitude 28.68°N to 30.11°N, longitude -93.6°E to -95.68°E. Following Ye *et al.* (2018), we determined that Phase_2 computational grid consists of 126474 nodes and 210510 elements. So, the computational grid defining Galveston Bay and Sabine Lake was derived from this Phase 2 computation grid (see Figures 2.3 and 2.4) using a special python program developed for this work.

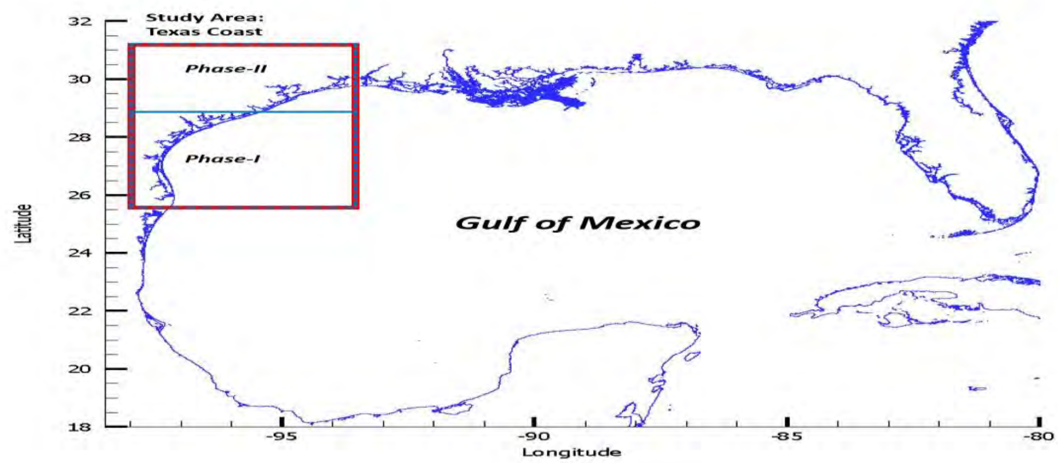


Figure 2.2: Showing the whole Texas Coast separated into Phase_1 and Phase_2.

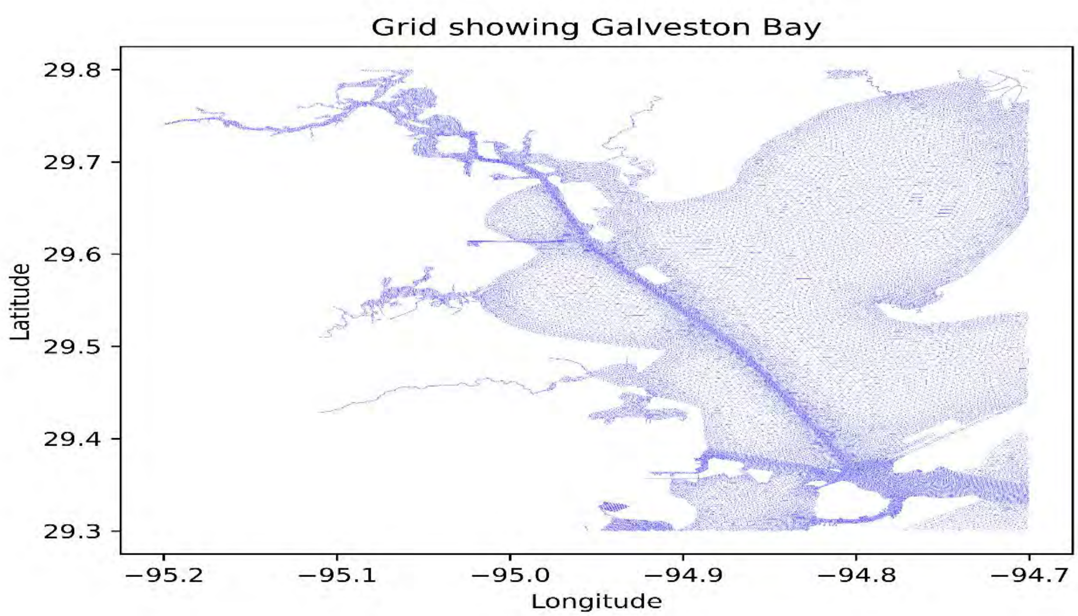


Figure 2.3: Showing computational grid delineating Galveston Bay derived from Phase 2.

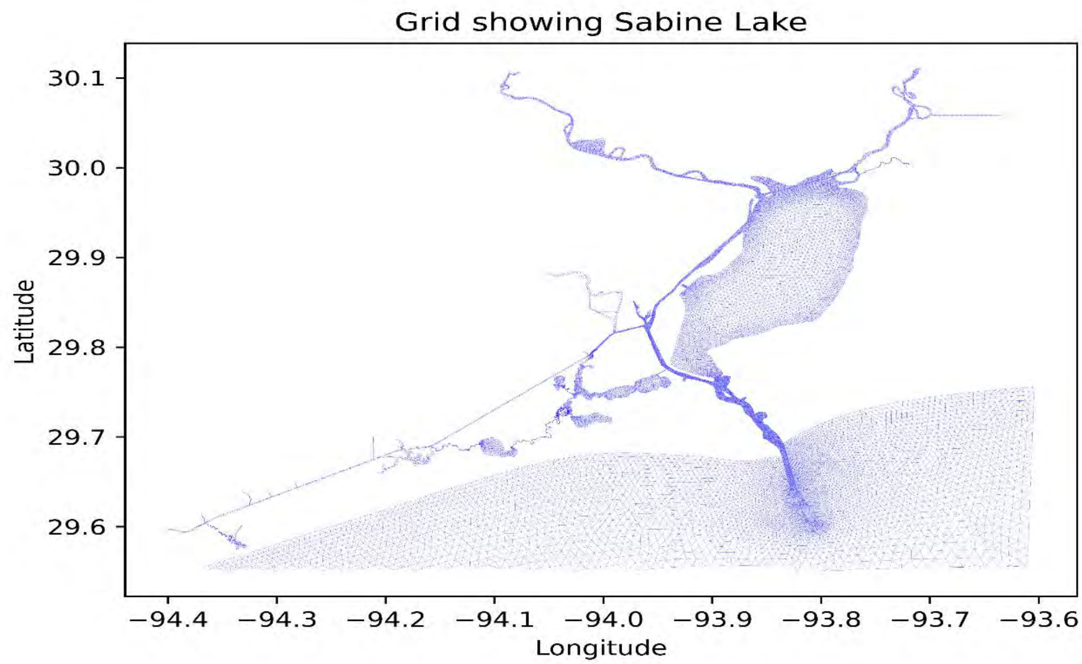


Figure 2.4: Showing computational grid delineating Sabine Lake derived from Phase 2

2.2 SCHISM Model

2.2.1 Description

The SCHISM model is made up of many components (modules) shown in Figure 1.1 above. A major part of the model involves the use of hydrodynamic core base to determine the water surface elevation and surface current (Chiu *et al*., 2018; Zhang *et al*., 2016). The uniqueness of SCHISM is derived from the new features that were implemented or added to the parent model Semi-implicit Eulerian-Lagrangian finite-element (SELFE) model. These new features include: (i) a highly flexible hybrid coordinate system in the vertical direction (ii) unstructured triangular-quadrangular grids in the horizontal direction and (iii) implicit advection scheme for transport (Chiu *et al.,* 2018, SCHISM, 2019). The applicability of SCHISM comes from its ability to simulate wider scale from creek to ocean scale (Zhang *et al*., 2016), its ability to delineate and resolve the complex topography especially in estuarine settings, accurate representation of key bathymetric features (Ye *et al*., 2018), superior performance. What really stands out from the SCHISM model is that unlike other unstructured grid (UG) and structured grid (SG) models, SCHISM utilizes high-resolution hybrid triangular-quadrangular unstructured grids in the horizontal dimension. It also makes use of implicit scheme which permits larger time steps and high resolution for efficiency. It utilizes a novel hybrid vertical grid (Localized Sigma

Coordinates for Shaved Cells) – this vertical grid permits seamless transverse of opposing scales such as from sub tributary to shelf. The model's reputed accurate representation of bathymetry is through the combination of vertical grid and triangular-quadrangular unstructured grid. When the SCHISM model is compiled and numerical simulation implemented, it solves the continuity equation and momentum equations derived from the Reynolds-Averaged Navier-Stokes (RANS) equations. Through this process, the model generates outputs such as free surface elevation (x, y, z) and velocity (currents) (u, v, w). For a comprehensive understanding of the underlying governing equations and implementation details, readers are directed to the comprehensive work by Zhang *et al*. (2021).

2.2.2 SCHISM Model Input

The unstructured grid in SCHISM enables the simulation of the entire Phase 2 Texas coast using the input data comprising boundary conditions files, the grid files, the time history files of relevant atmospheric and hydrodynamic variables. The parameters input file specifies how the SCHISM model will run the simulations. These input files to run SCHISM simulation were obtained from the Texas Water Development Board. They comprise of the mandatory input files and the optional inputs needed to make SCHISM simulation (see Table 2.1 below).

Mandatory inputs – These are required for all SCHISM simulations.

- Horizontal grid(**hgrid.gr3**)
- Vertical grid(**vgrid.in**)
- Parameter input(**param.nml**)
- Boundary condition and tidal inputs (**bctides.in**)
- Bottom friction input (**drag.gr3**, or **rough.gr3** or **manning.gr3**)

Table 2.1: Describing the mandatory Input used to run SCHISM simulation.

Inputs	**Description**	**Visualization**
***.gr3, hgrid.II**	Node centered spatial data and mesh connectivity	These files can be visualized using ACE/Xmgredit5
***.th**	Time history files in ASCII format	The ASCII files can be visualized using ACE/Xmgr5
***.ic (salt.ic, temp.ic)**	Initial condition files	Some of these files use .gr3 format, while others have simple ASCII format.

***.nc**	netcdf4inputs including time history (*. th.nc)	hotstart (hotstart.nc) and nudging inputs(*_nu.nc)
***.nml**	main parameter input	(param.nml)
***.in**	role-specific input files with individual formats	ASCII inputs include vertical grid(vgrid.in), B.C. input(bctides.in) and hydraulics.in (for hydraulics module)
Sflux/:	Atmospheric and heat flux files in netcdf format (CF convention)	These files can be visualized using standard tools like ncview, ferret.
Inputs from modules	.nml . inp	

2.2.3 Numerical Model Implementation

The SCHISM numerical model simulation was executed using input values corresponding to April 1st to April 30th, 2023. The simulation took place on the High-Performance Computing (HPC) facility cluster, jakar, at the University of Texas at El Paso (UTEP), in conjunction with the local workstation at the Atmospheric Physics Research laboratory in UTEP. Each day of the month yielded an output in the form of network common data format (NETCDF). These outputs were then analyzed using a specialized Python program developed for this study's purposes, enabling the extraction of hourly horizontal velocity (surface current) in northward and eastward directions for streamlined analysis alongside the HF radar vectors.

2.3 HF Radar

2.3.1 Site Description

To provide continuous measurement of estuarine surface currents at Galveston Bay and Sabine Lake as well as a source of data to intercompare with SCHISM model, three HF radars were installed at the bay in December 2022. The Bay has a dimension of 30km by 35km and the three-radars installed provide coverage to the important navigational channels in the bay including the Houston Ship Channel and Gulf Intracoastal Water Ways (Fuller et al., manuscript). The nominal operating frequency for each of the three radars is 25MHz and are determined to have range of 30km – 50km based on the inverse relation between range of HF radar coverage and frequency of radar. The locations of the three radars are MCPK- Mcollum Park, SMPT- Smith Point, and MOLA, Moses (see Figure 2.4). Table 2.2 summarizes the coordinates of the radar's antenna and distances away from the water:

Table 2.2: Summary of the coordinates of the radars' antenna and distance from the bay

Stations Name	Latitude	Longitude	Distance from bay
Mcollum Park, MCPK	29.744541°N	-94.828675°E	< 150m
Smith Point, SMPT	29.546765°N	-94.788082°E	<150m
Moses Lake Tide Gate, MOLA	29.445450°N	-94.917287°E	<150m

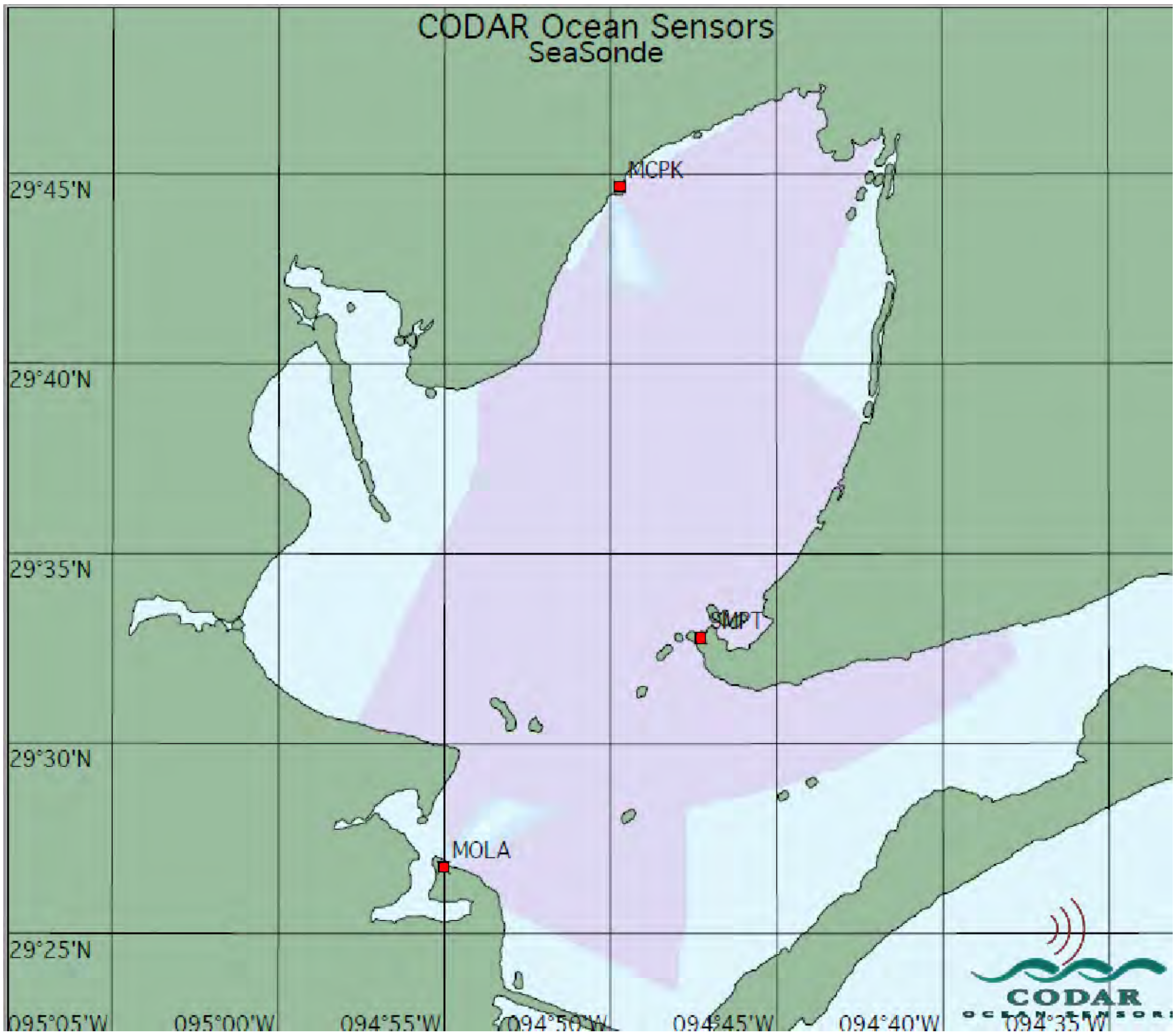


Figure 2.5: The locations of the three CODAR HF radar in Galveston Bay Texas at MCPK- Mcollum Park, SMPT- Smith Point, and MOLA, Moses.

Two key considerations that were usually considered before installing the radars' antenna include desire for the location of the antenna to be within 150 m of the shoreline and for the location of the antenna to be greater than one wavelength (i.e. 12 m) away from potentially interfering structures (Fuller *et al*., manuscript). All the three radars' antenna were all located within (less than) 150m of the bay and the radars at MCPK and SMPT are more than one wavelength aware from any conducting structure. There was a big conductive object within one wavelength of the antenna of the radar at MOLA (Fuller *et al*., manuscript).

Similarly, the Sabine Lake had the two-radars installed providing coverage to an area of 106km^2 and CODAR radars of shorter operational frequency of 45 – MHz (wavelength = 7m) was suitable enough to provide 10km coverage in the lake (Fuller et al., manuscript). Sabine Lake station at Pleasure Pier Blvd is in Port Arthur City Park. The environmental assessment of this location proved that radar of high operational frequency with the reduced range due to low salinity condition (which is routine observed) is appropriate in the lake. When such higher frequency shorter -range transmitters are deployed the need for maximum range is reduced and poor signal due to low transmission due to low surface conductivity becomes less of a factor in HF radar station performance. (Fuller *et al*., manuscript).

2.3.2 HF Radar Data Source and Analysis:

The National Centers for Environmental Information (NCEI) is part of the National Oceanic and Atmospheric Administration (NOAA) and is responsible for archiving, monitoring, and providing access to a wide range of environmental data. The National Data Buoy Center (NDBC) is one of the components of NCEI. It specifically focuses on the collection and dissemination of real-time and historical oceanographic and meteorological data from buoys and coastal stations. NDBC operates a network of buoys and coastal stations strategically placed in oceans and coastal areas to gather data on weather, sea conditions, and other environmental parameters. So, the radial currents from each of the HF radar networks at Galveston Bay and Sabine Lake were resolved into total vectors and incorporated into the NOAA NCEI/NDBC platform for public access.

The total velocities for eastward water velocities **u** and northward water velocities **v** from where plots of current vectors at Galveston Bay Texas and Sabine Lake were made in this work were accessed via the NOAA NCEI/NDBC Website https://www.ncei.noaa.gov/data/oceans/ndbc/. Panoply, a software tool developed by NASA for working with NETCDF data (https://www.giss.nasa.gov/tools/panoply/) , was employed to visualize the current vectors, whereas Python - a free and open-source programming language (https://www.python.org/) utilizing the dedicated 'netcdf4' library, facilitated other analyses. These approaches synergistically enabled the mapping of radar data tailored to a specific spatial location, exemplified in this scenario by Galveston Bay and Sabine Lake. The comparison was conducted utilizing HF radar data retrieved for the month of April 2023 from the provided link.

The summary of the parameters' describing the region where these dataset covers is shown on Table 2.3 below:

Table 2.3: Parameters of total vector velocities, derived from HF radar stations.

Parameters	Descriptions

Regional_description	**Unites States, East and Gulf Coast**
Data Source	https://www.ncei.noaa.gov/data/oceans/ndbc/hfradar/rtv/2023/202304/USEGC/
Date	**April-01-2023 to April-30-2023**
Geospatial_lat_min:	**21.73596**
Geospatial_lat_max:	**46.49442**
Geospatial_lon_min:	**-97.88385**
Geospatial_lon_max:	**-57.23121**
Grid Resolution:	**6km**
Lat. Direction	**Degrees North**
Lon. Direction	**Degrees East**

2.4 Overview of methods of comparison

We have established a methodology to compare the surface currents (horizontal velocities) generated by the SCHISM model with those produced by High-Frequency (HF) Radar. This comprehensive evaluation encompasses both quantitative and qualitative analyses.

2.4.1 Qualitative Comparison

For the qualitative assessment, we utilized current vector plots derived from SCHISM model outputs using the Matplotlib library in Python – a free and open-source programming language, alongside current vector plots obtained from HF radar data using Panoply, a software tool developed by NASA for working with NETCDF data. We conducted a thorough examination of the directions of the current vectors generated by both the model and the radar. To provide a clear visualization of the orientation (Eastward positive/negative, Northward positive/negative) of current vectors from the SCHISM simulation we created zoomed-out sections of the plots, facilitating a detailed comparison with corresponding HF Radar data. In our qualitative analysis, the focus primarily rests on the alignment of most vector directions from both the model and radar. To facilitate this comparative examination, we visualize the current vectors from the radar data during a selected hour of a specific day and contrast them with those generated by the SCHISM model, primarily focusing on the orientation of the current vectors. Three days were presented in the next section to provide the overall overview of the performance of both the model and the radar in generating surface currents at the bay.

2.4.2 Quantitative Comparison

In a parallel effort, the quantitative aspect of our comparison entails evaluating the magnitudes of the components of surface water currents in both the eastward and northward directions following Cosoli *et al*. (2005). Specifically, we examine the components of these velocities in their Eastward (U) and Northward (V) directions, denoted as surface eastward sea water velocity (**USCHISM**) and surface northward sea water velocity (**VSCHISM**) for the SCHISM model, and surface eastward sea water velocity (**U_HFR_6**) and surface northward sea water velocity (**V_HFR_6)** for the HF radar data. In our quantitative analysis, we utilize the average values of the hourly outputs for both model and radar velocities. This approach offers a more representative overview, considering that models and radar systems generate varying quantities of data points. Models usually can provide more data than in-situ, satellite (Li *et al*., 2021) and remote sensing instrument. For instance, on April 30, the model produced a total of 45,600 data values for both **Uschism** and **Vschism**, whereas there were on average only 5,000 data points for **U_HFR_6** and **V_HFR_6**. Commonly adopted evaluations metrics for these quantitative comparisons include correlation coefficient, mean square error, mean absolute error, coefficient of efficient, index of agreement (Li *et al*., 2021; Dye *et al*., 2019; Wilmot,1981; Allahdadi and Li, 2017). Chiu *et al*. (2018) used the correlation coefficient to verify the accuracy and show the relationship between the simulated surface currents obtained from SCHISM and monitoring data obtained from HF radar station. Allahdadi *et al*. (2017) used the Willmott index of agreement(d) for quantification of the model skill assessment of simulated current and water level from 3-D hydrodynamic model Mike3 FLOW MODEL-FM versus observation. For the SCHISM model, there is no consensus statistical validation metrics adopted majorly due to many module systems incorporated in SCHISM yield different output. However, many of the works have evaluated the performance of SCHISM using Root-Mean-Square-Error (RMSE) (Ye *et al*., 2018; Lavaud *et al*., 2020), correlation coefficient (Chiu *et al*., 2018), Willmott index of agreement(d) (Dye *et al*., 2019; Allahdadi *et al*., 2017), coefficient of determination (Dye *et al*., 2019),

Consequently, we adopted the correlation coefficient to compare the model and radar generation of currents at the same time of any day in visualizations represented in the next section. We further summarized the performance of the model and the radar in measuring the current using the evaluation metrics of correlation coefficient (corr), Mean-Square-Error (MSE), Root-Mean-Square-Error (RMSE), Mean Absolute Error (MAE) and Willmott index of agreement (IA).

3.0 Result

The following sections presents the results from our simulation and analysis on days where both northward and eastward currents are both significantly correlated in Galveston Bay (GB) as measured by both HF radar and SCHISM model, days with significantly correlated northward currents only at GB, and days with significantly correlated eastward currents only at GB as well. The results from the simulation covering Sabine Lake is also presented in section 3.5.

3.1.0 Days with Significantly Correlated Northward and Eastward Currents in GB

3.1.1 *Qualitative Comparison **April 8** at Galveston Bay*

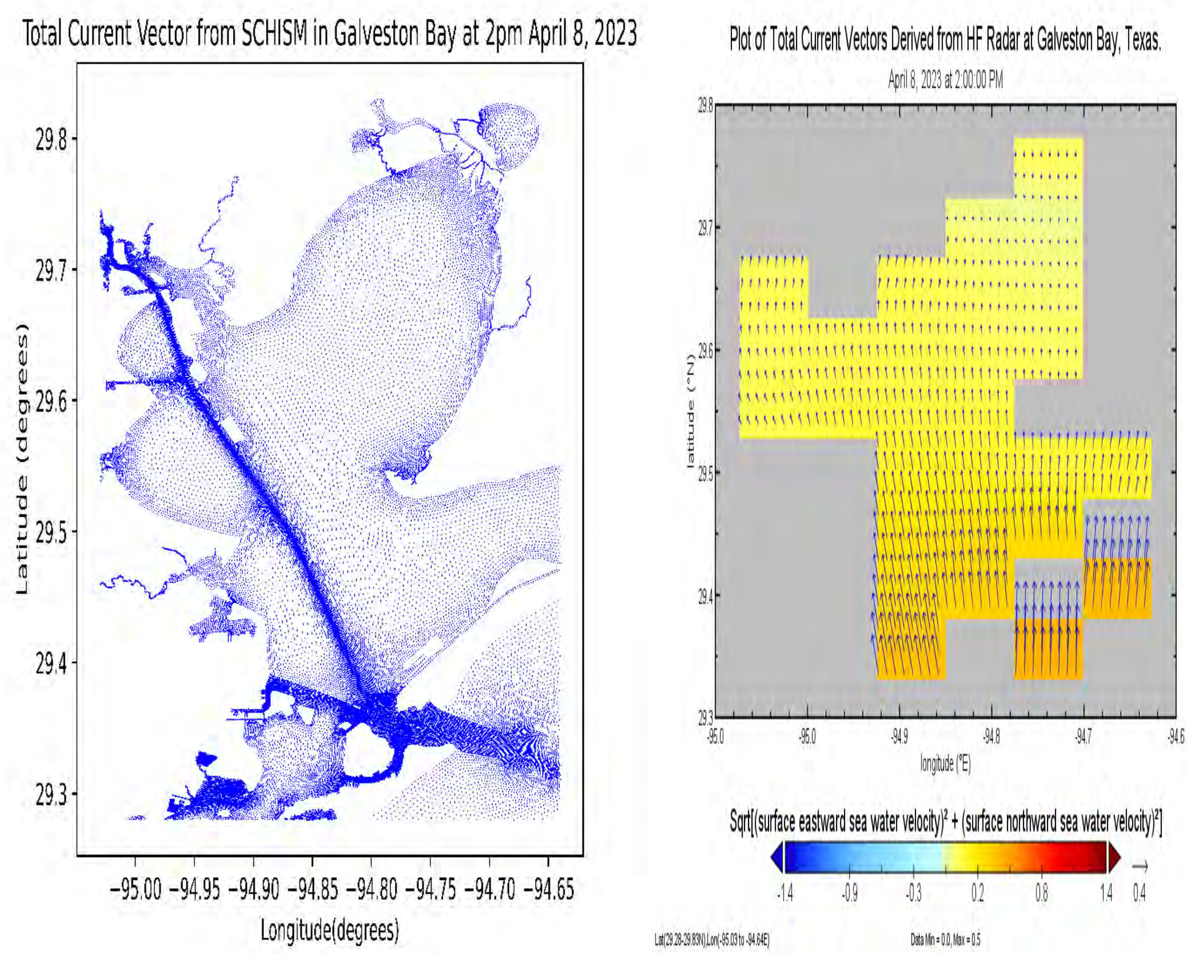
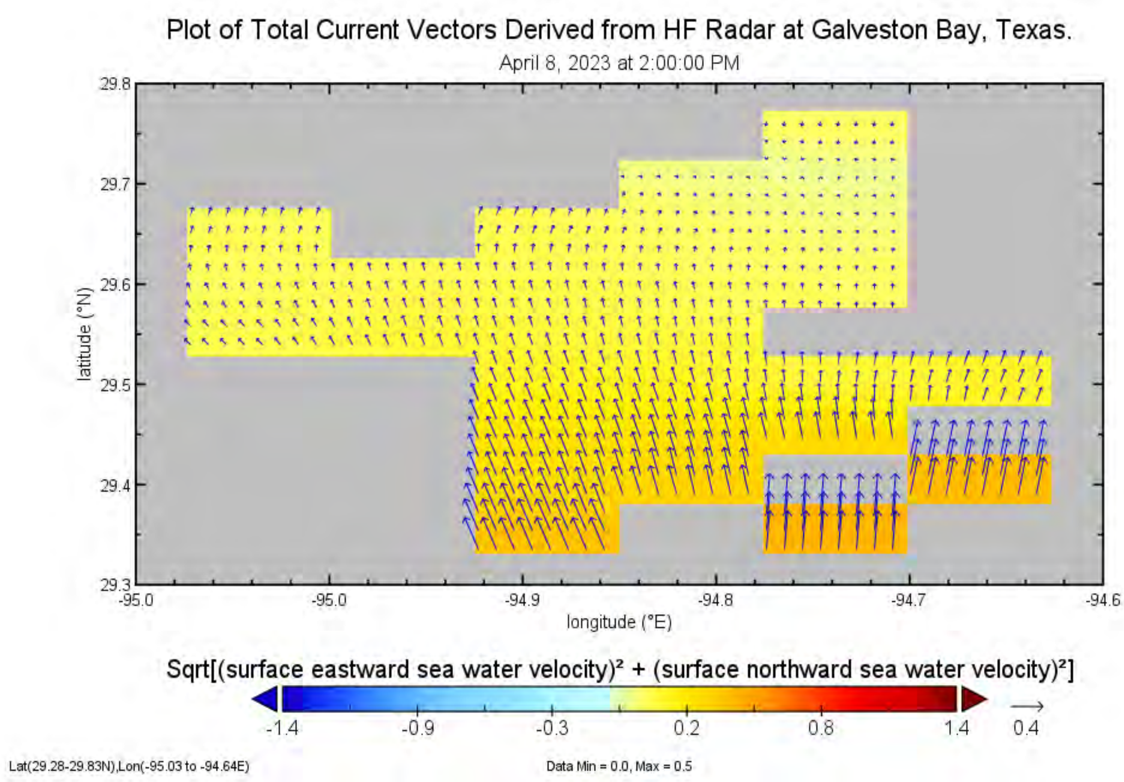


Figure 3.1.1: Plot of total current vectors produced by SCHISM and HF radar in GB at 2pm, April 8, 2023.



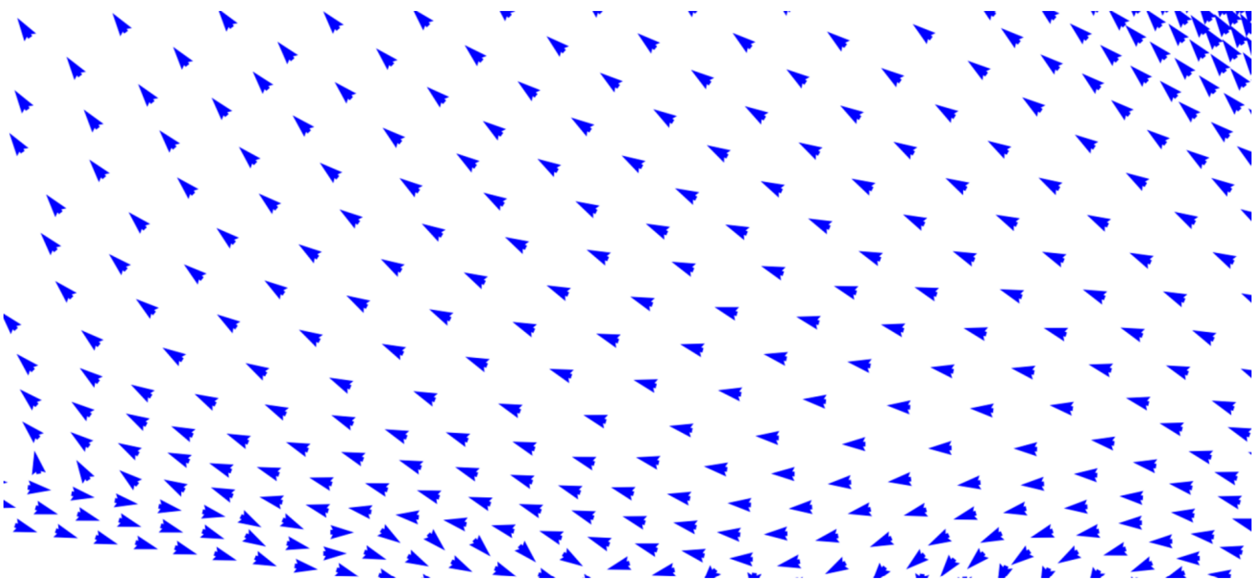


Figure 3.1.2: Zoomed-out portion of Total Current Vectors Derived from SCHISM Model at Galveston Bay April 8, 2023, at 2pm.

The initial examination of Figure 3.1.1 and Figure 3.1.2 shows that both the radar and the model effectively captured current vectors in various directions, encompassing both Northward and Eastward vectors. Most of the vectors indicate a shift in the current direction from eastward initially, transitioning to a northward trajectory. The provided visualizations from both the radar and the model depict the orientation of surface currents for a specific hour on April 8, 2023, out of the entire day.

3.2.0 *Quantitative Comparison* ***April 8*** *at Galveston Bay*

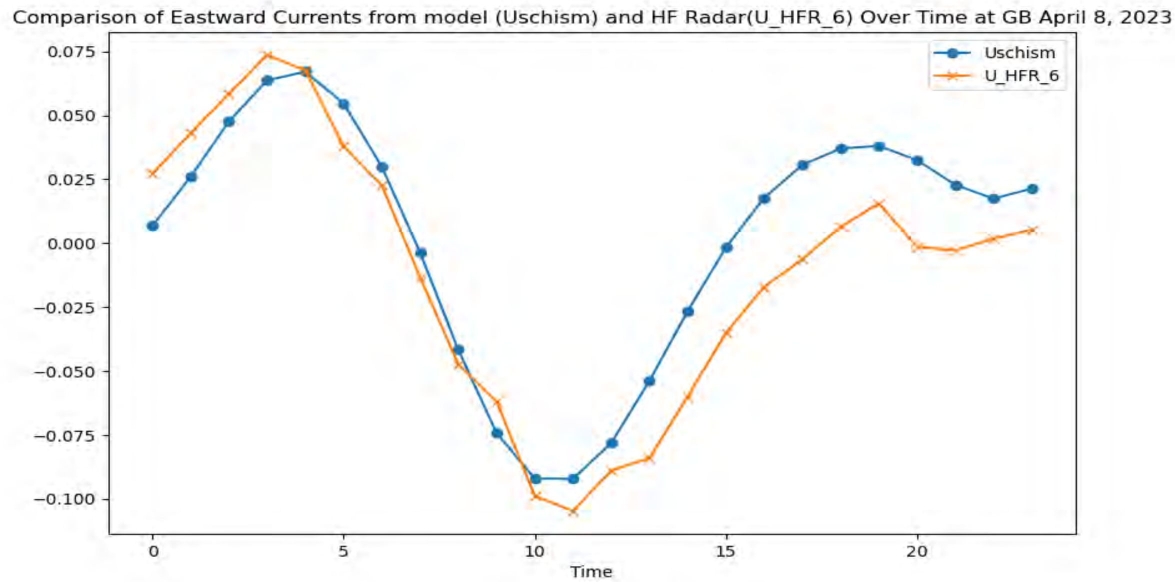


Figure 3.2.1: Plot showing comparison of Eastward currents from model (Uschism) and HF Radar(U_HFR_6) over time at GB April 8, 2023.

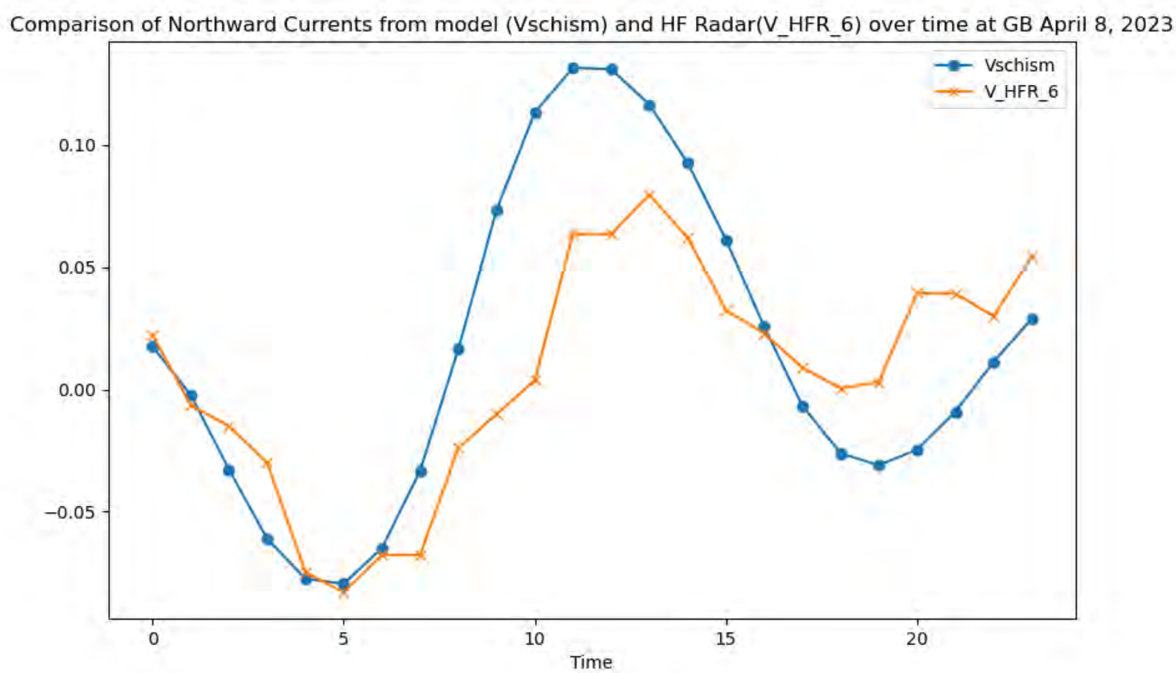


Figure 3.2.2: Plot showing comparison of Northward Currents from model (Vschism) and HF Radar(V_HFR_6) over time at GB April 8, 2023.

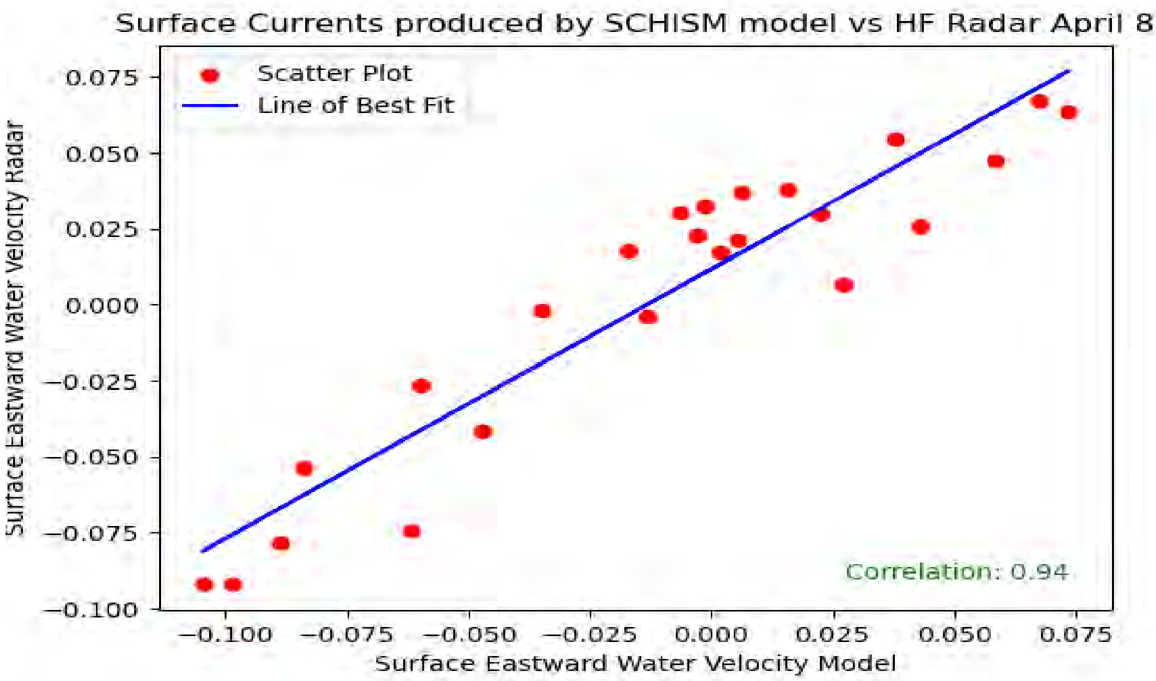


Figure 3.2.3: The plot showing the scatter plot and correlation between the hourly averages of **Eastward** currents as measured by the SCHISM model and the HF radar at GB for entire hours of April 8, 2023

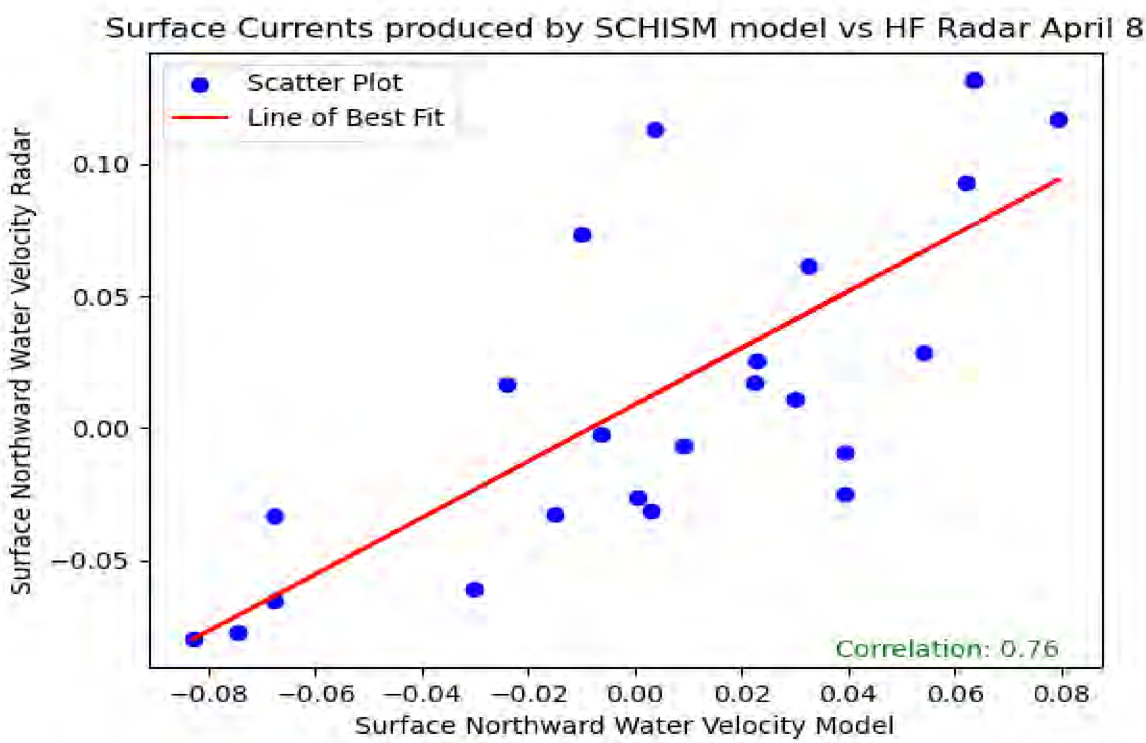


Figure 3.2.4: The plot showing the scatter plot and correlation between the hourly averages of **Northward** currents as measured by the SCHISM model and the HF radar at GB for entire hours of April 8, 2023.

Figures 3.2.1 to Figure 3.2.4 reveal a notable congruence between the SCHISM model and HF radar, portraying a comprehensive alignment in measuring the intensity and orientation of surface currents (water velocity) during April 8, 2023, in Galveston Bay, Texas. This suggests a persistent occurrence of both eastward and northward surface water velocities in the bay throughout the day. Particularly significant in Figures 3.2.1 is the close alignment in the phase diagram of the current produced by both methods in the eastward direction and Figure 3.2.3 is scatter, displaying a robust correlation coefficient of around 0.94 between the current generated by the model and radar. Furthermore, Figure 3.2.4 depicts the correlation coefficient between radar and model measurements in the northward direction is observed to be 0.76.

Upon thorough examination of the qualitative analysis presented in Figures 3.2.1 and Figure 3.2.2, it becomes evident that a predominant eastward direction characterizes most of the currents depicted by both the SCHISM model and HF radar. This observation aligns seamlessly with and reinforces the outcomes of the quantitative analysis presented above. The implications drawn from this observation are notably suggestive:

- The robust correlation coefficient of approximately 0.94 concerning eastward currents indicates a close tracking and measurement alignment between the SCHISM model and HF radar, showcasing their ability to measure similar values in eastward surface currents at Galveston Bay on April 8, 2023.
- The correlation coefficient of 0.76 in the northward direction between radar and model measurements signifies a significant level of agreement. Although marginally lower than the correlation for eastward currents, a coefficient of 0.76 still points to a robust positive relationship, illustrating that both the radar and model accurately captured similar trends and magnitudes in northward water velocities.

These elevated correlation coefficients strongly imply the reliability and consistency of the SCHISM model and HF radar in measuring surface current velocities, both eastward and northward, on April 8, 2023, in Galveston Bay, Texas.

3.3.0 DAYS WITH SIGNIFICANTLY CORRELATED NORTHWARD CURRENTS ONLY IN GB.

3.3.1 *QUALITATIVE ANALYSIS* ***APRIL 27*** *AT GALVESTON BAY*

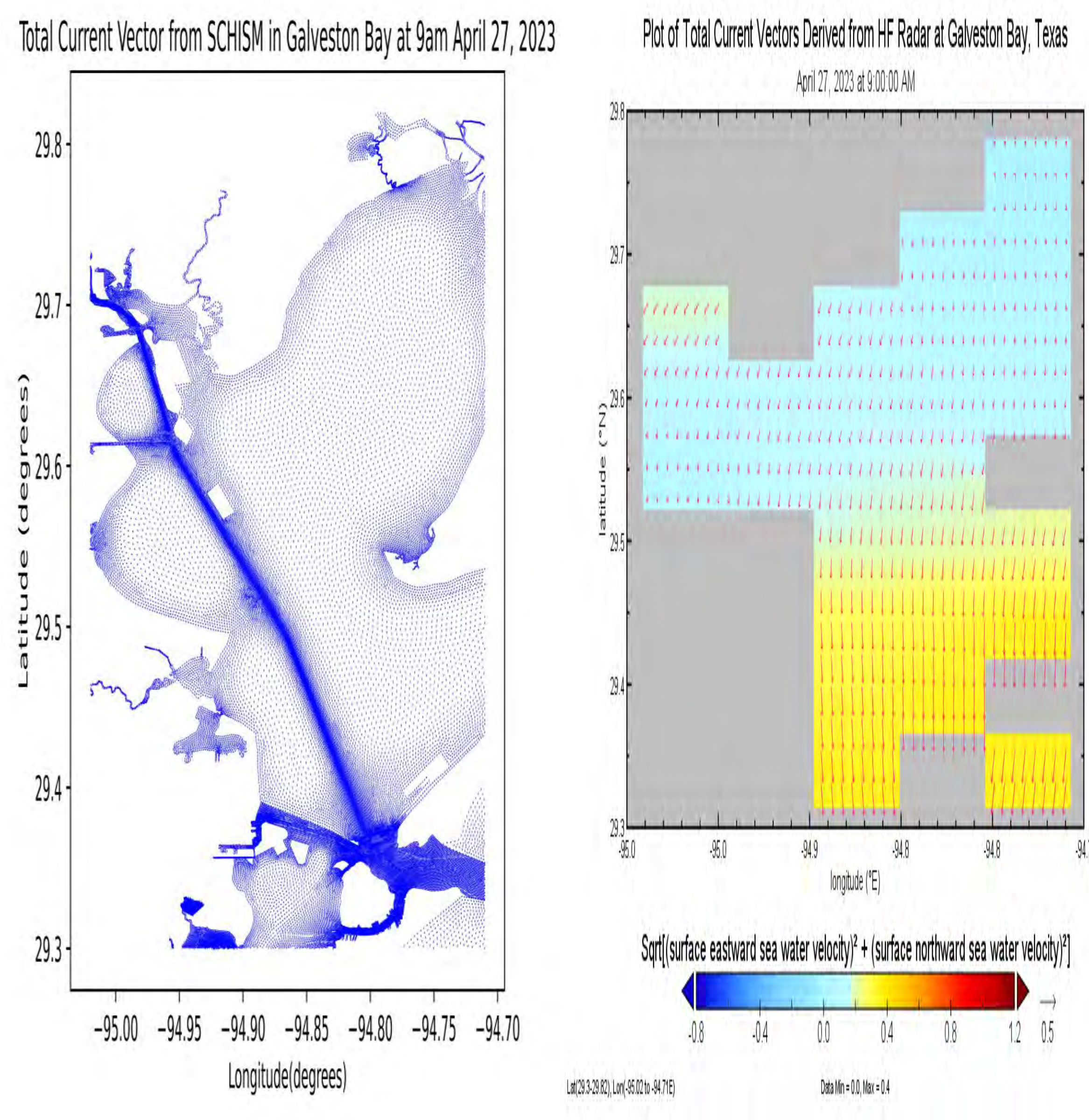
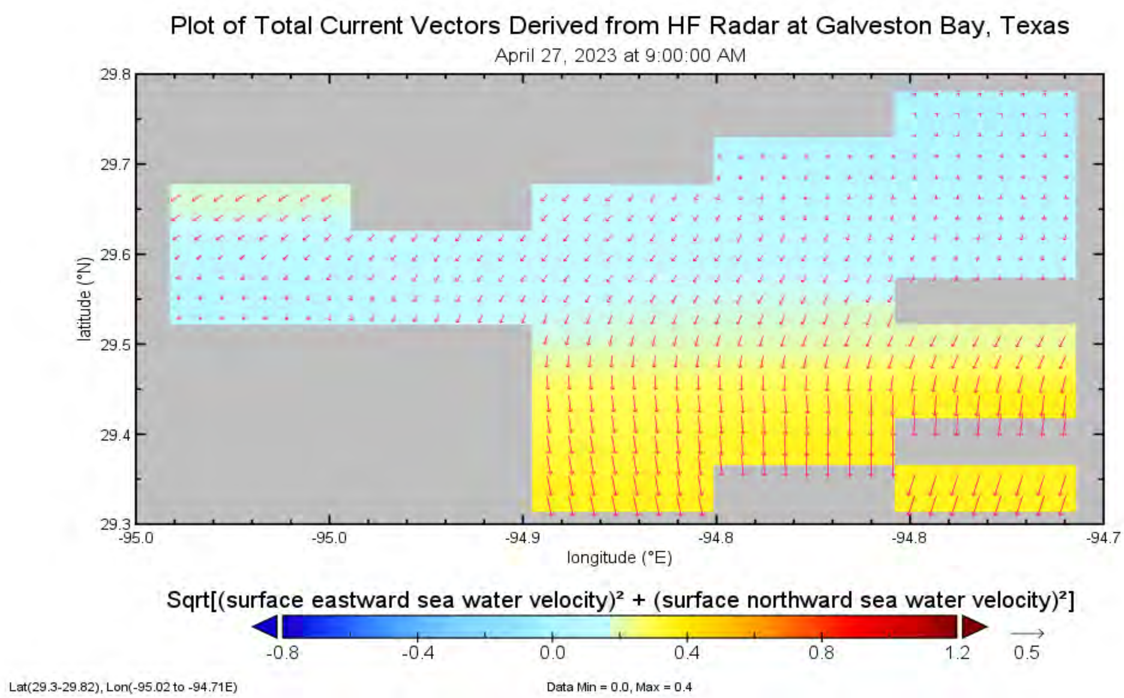


Figure 3.3.1: Plot of total current vectors produced by SCHISM and HF radar in GB at 9am, April 27, 2023.



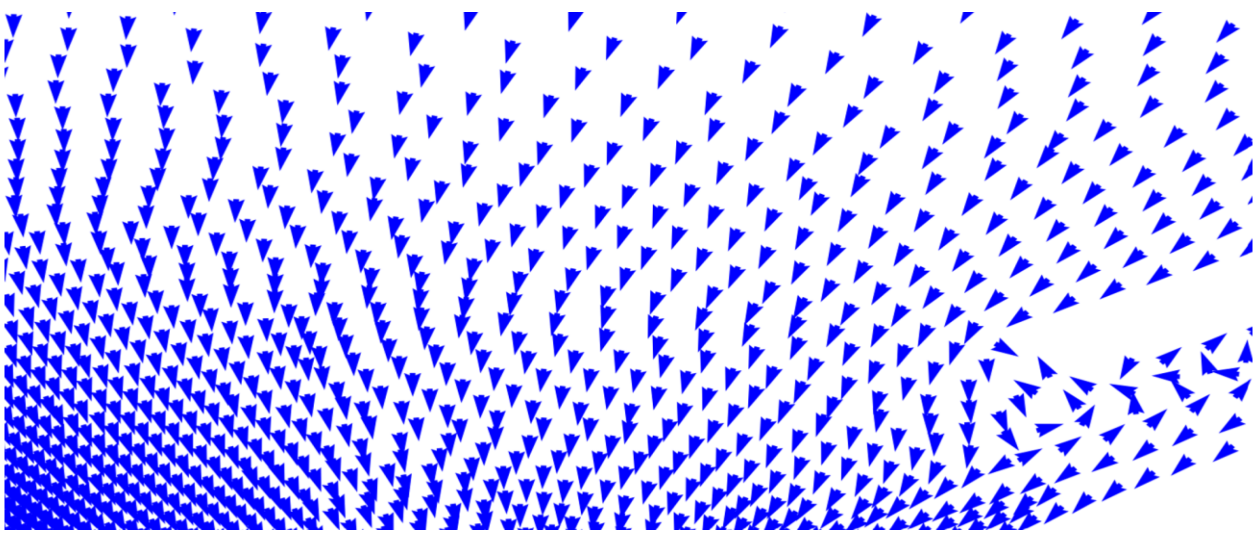


Figure 3.3.2: Zoomed-out portion of Total Current Vectors Derived from SCHISM Model at Galveston Bay April 27, 2023, at 9am.

Examination of Figures 3.3.1 and Figure 3.3.2 unveils a pronounced prevalence of surface northward currents in Galveston Bay at 9 am on April 27, 2023. Notably, minimal eastward current vectors were shown during this specific time in the bay. Most of the northward currents (both from model and radar) were oriented in the negative northward direction, essentially toward the south. This observation implies that, during the specified period (at 9 am on April 27, 2023), the primary water movement in Galveston Bay was directed northward. The scarcity of eastward currents suggests a prevalent northward flow, influenced by diverse environmental factors such as tides, wind patterns, or coastal geography. Discerning the predominant current direction holds significance for activities like navigation, environmental monitoring, and coastal management.

3.3.2 *QUANTITATIVE ANALYSIS **APRIL 27** AT GALVESTON BAY*

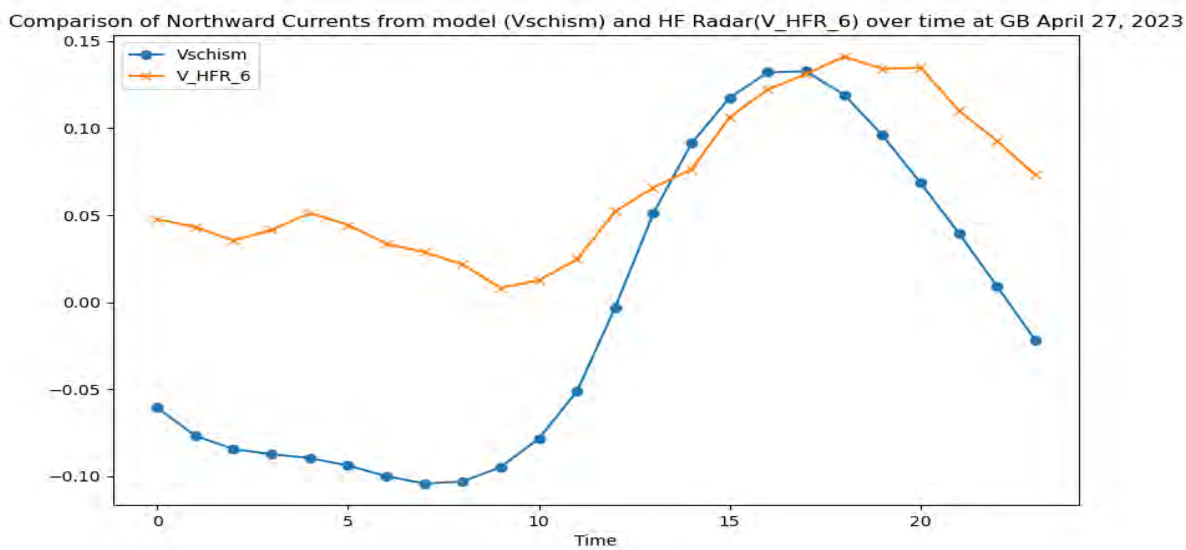


Figure 3.3.3: Plot showing comparison of Northward Currents from SCHISM Model (Vschism) and HF Radar(V_HFR_6) over time at GB April 27, 2023.

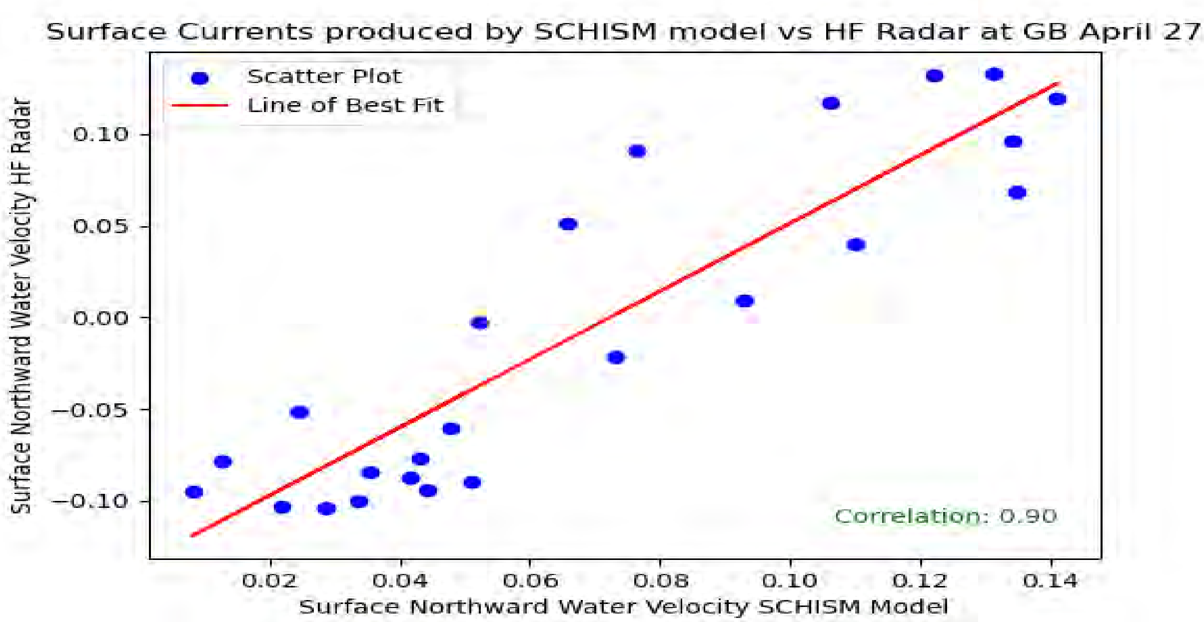


Figure 3.3.4: The plot showing the scatter plot and correlation between the hourly averages of **Northward** currents as measured by the SCHISM model and the HF radar at GB for entire hours of April 27, 2023.

The correlation coefficient of 0.90, as depicted in Figure 3.3.4 between the magnitudes of northward surface currents (water velocity) from both the Model and HF Radar throughout April 27, supports the earlier qualitative comparison at 9 am, confirming a persistent northward water movement in Galveston Bay. This consistency suggests that the prevailing northward flow endured throughout the entire day. Days characterized by substantial correlation exclusively in the northward direction, such as on April 27 indicate that the primary water flow on those days consistently trended northward.

The prevalence northward flow observed in Galveston Bay this day signifies a stable directional pattern in water movement, adeptly captured by both the SCHISM model and HF radar. The robust correlation analysis enhances the reliability of identifying and characterizing these prevailing flow patterns, providing valuable insights into the bay's consistent hydrodynamic behavior as measured by both the model and radar.

3.4 DAYS WITH SIGNIFICANTLY CORRELATED EASTWARD CURRENTS ONLY AT GB

3.4.1 *QUALITATIVE ANALYSIS* ***APRIL 6*** *AT GALVESTON BAY*

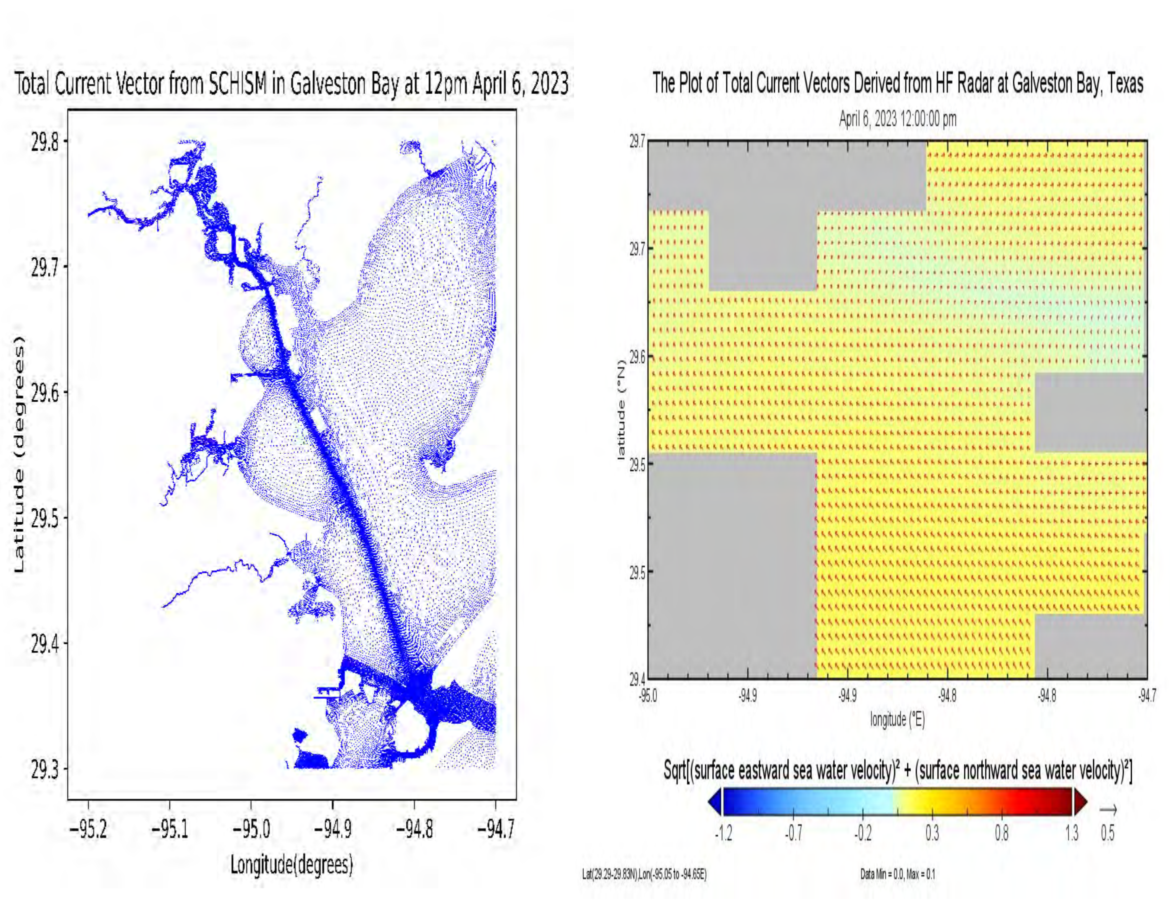
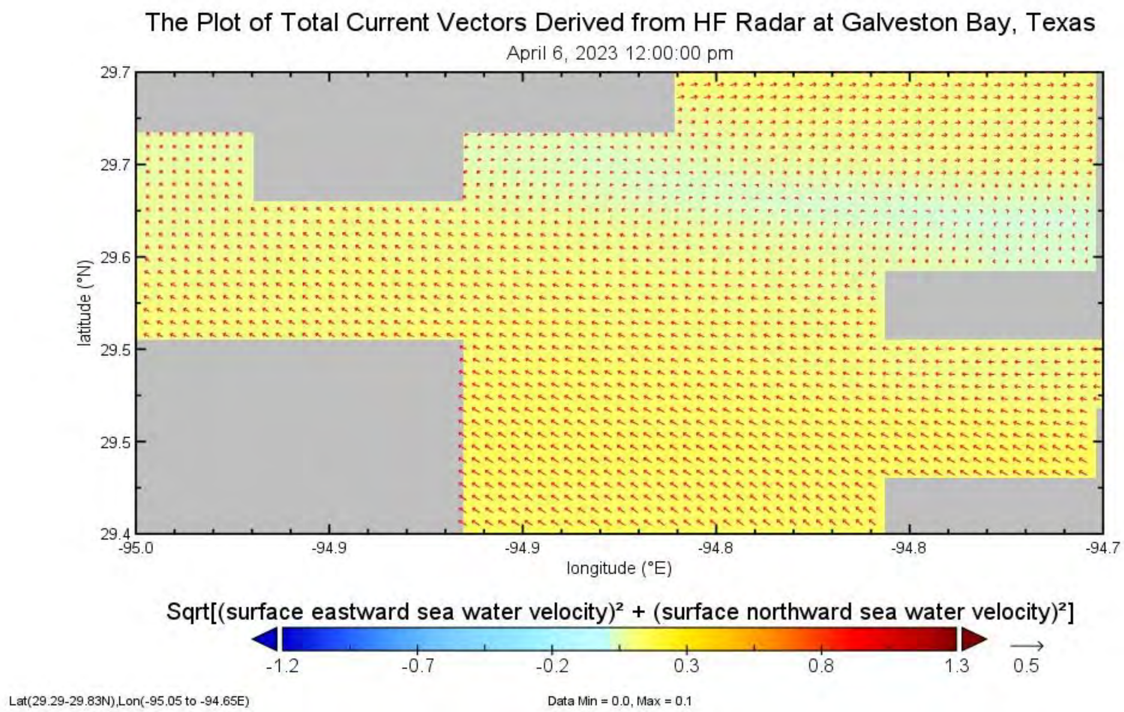


Figure 3.4.1: Plot of total current vectors produced by SCHISM and HF radar in GB at 12pm, April 6, 2023.



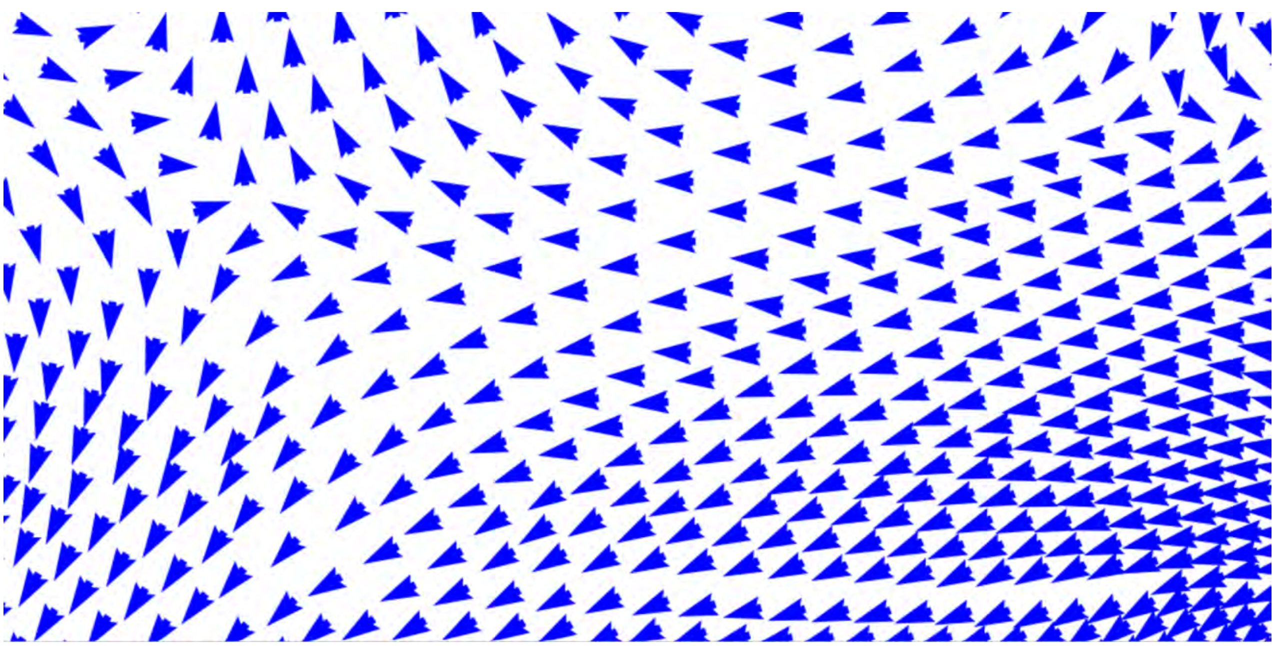


Figure 3.4.2: Zoomed-out portion of Total Current Vectors Derived from SCHISM Model at Galveston Bay April 6, 2023, at 12pm

Through qualitative analysis of current vectors as portrayed in Figure 3.4.1 and Figure 3.4.2, it is obvious that the eastward currents dominate, particularly in the negative east direction. The synchronous depiction of current directions by both the SCHISM model and HF radar signifies a compelling agreement, thereby bolstering the credibility of these two methodologies in faithfully measuring the predominant flow patterns within the bay.

3.4.*2 QUANTITATIVE ANALYSIS* ***APRIL 6*** *AT GALVESTON BAY*

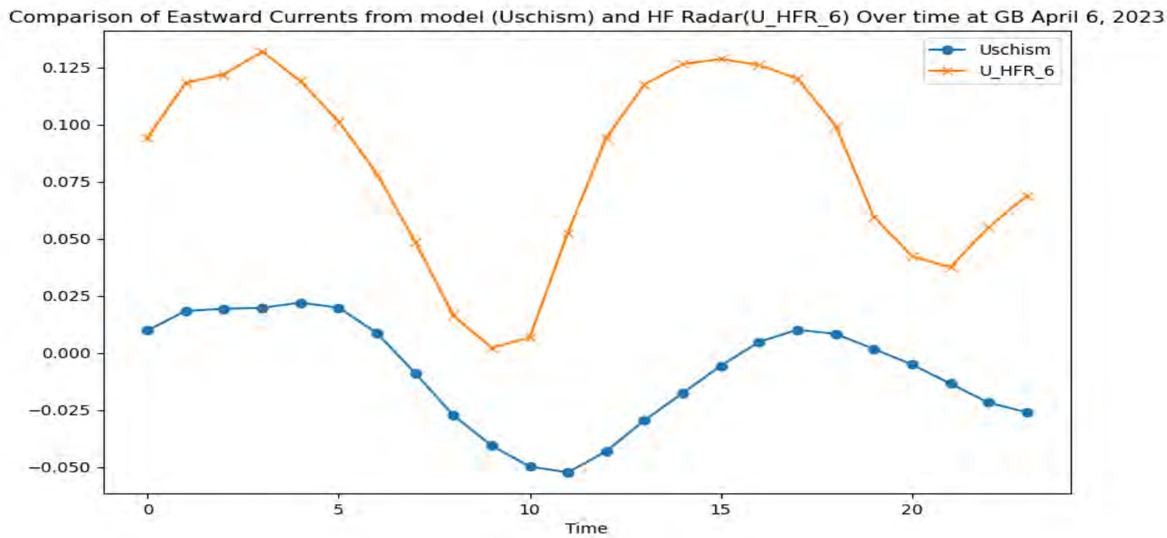


Figure 3.4.3: Plot showing comparison of Eastward Currents from SCHISM Model (Uschism) and HF Radar(U_HFR_6) over time at GB April 6, 2023.

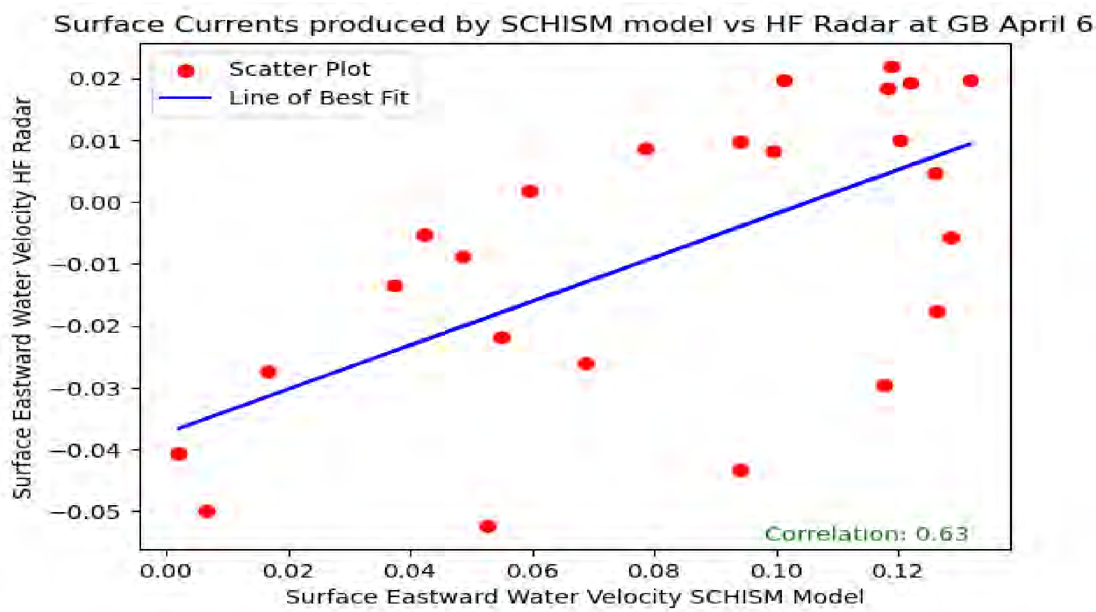


Figure 3.4.4: The plot showing the scatter plot and correlation coefficient between the hourly averages of **Eastward** currents as measured by the SCHISM model and the HF radar at **GB** for entire hours of April 6, 2023.

A pronounced prevalence of eastward currents evident in the qualitative analysis above is further confirmed by the moderate yet significant correlation coefficient in Figure 3.4.4 which is the quantitative metric used evaluate the level of agreement between the measurements of surface currents at the bay by SCHISM model and the HF Radar. In Figure 3.4.3, it becomes apparent that both the model and radar-generated currents follow a congruent trajectory, as depicted in their phase diagram. This suggests a notable capability of both methodologies to apprehend the parallel trends in water movement across the bay throughout the day. However, it's noteworthy that the numerical values recorded by the model are substantially smaller in magnitude than those measured by the radar. Consequently, this stark difference accounts for the observed moderate correlation of 0.63 in Figure 3.4.4.

3.5 DAYS WITH SIGNIFICANTLY CORRELATED NORTHWARD CURRENTS ONLY AT SL.

3.5.1 *Qualitative Analysis* ***April 27*** *at Sabine Lake*

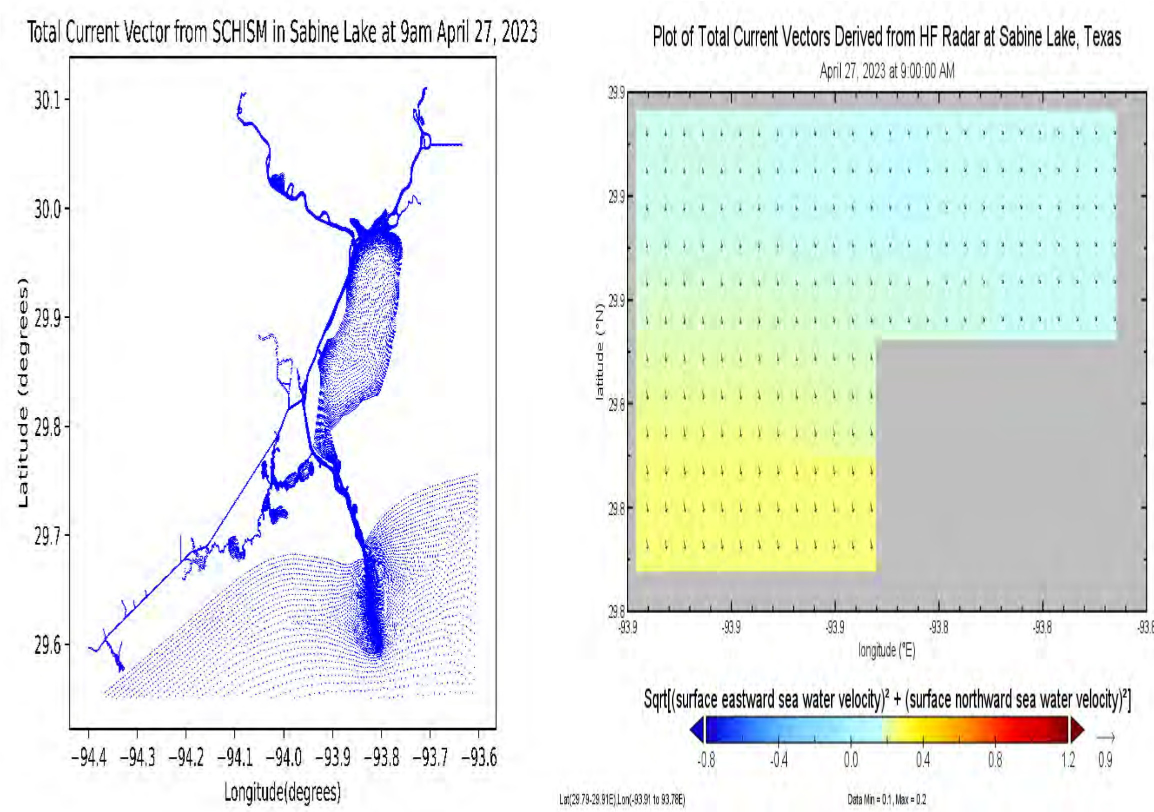
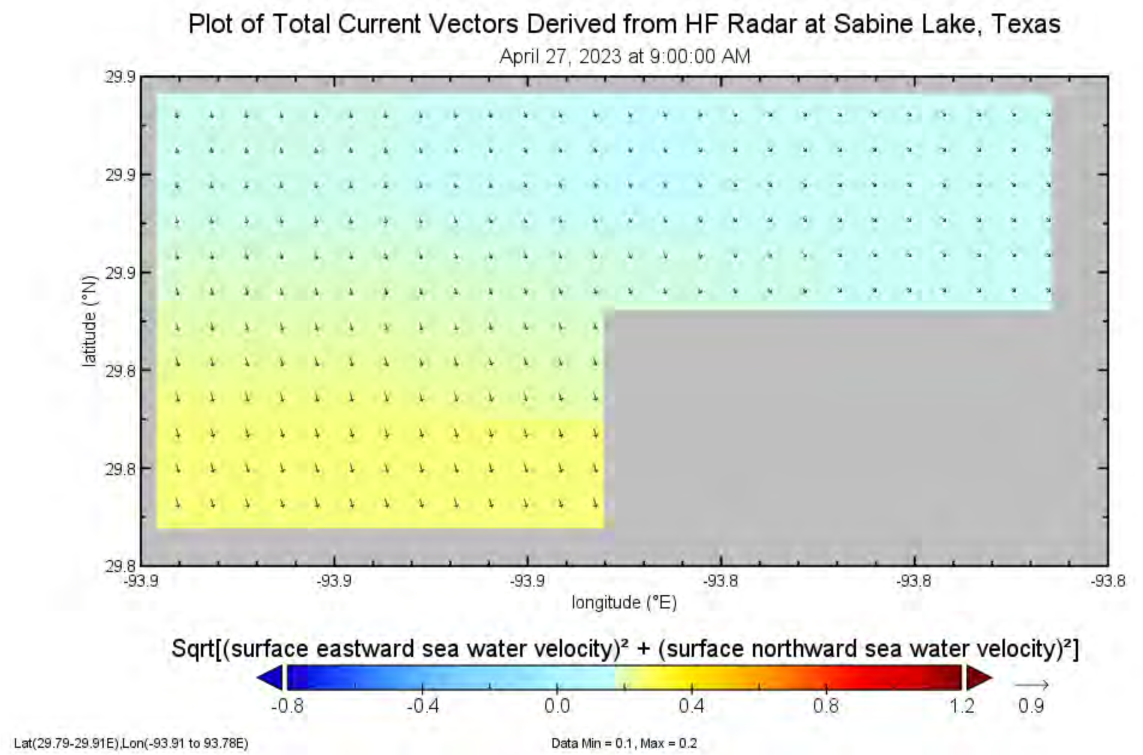


Figure 3.5.1: Plot of total current vectors produced by SCHISM and HF radar in SL at 9am, April 27, 2023.



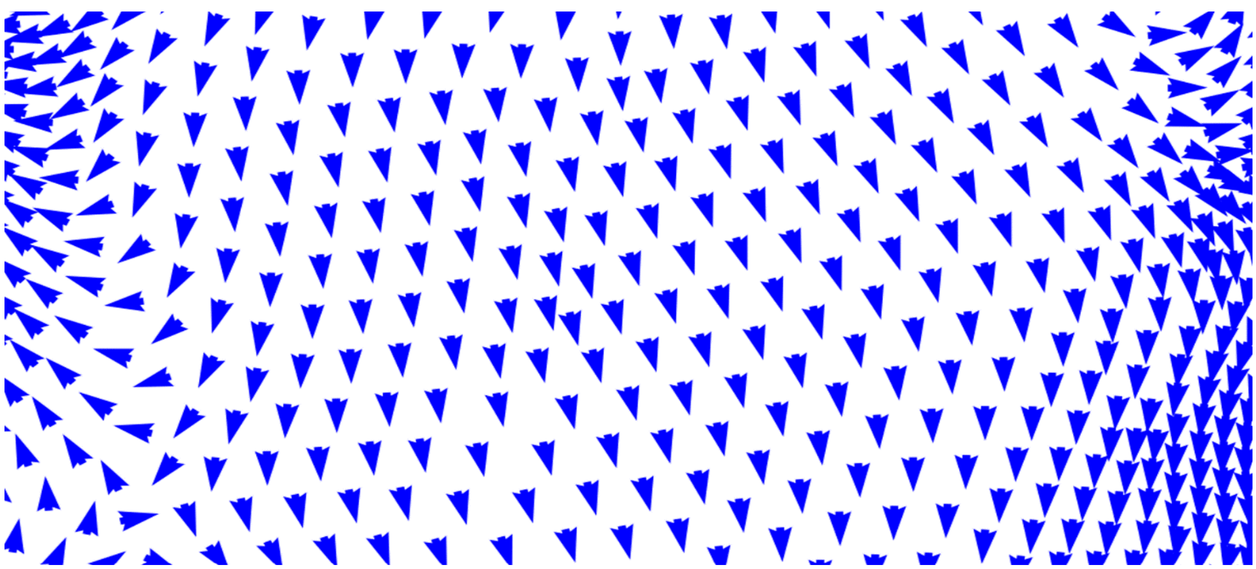


Figure 3.5.2: Zoomed-out portion of Total Current Vectors Derived from SCHISM Model at Sabine Lake April 27, 2023, at 9am.

Observations from the qualitative comparison highlight a prevailing northward current in Sabine Lake at 9 am on April 27, evident in both Figure 3.5.1 and 3.5.2. Current vectors from both HF radar and the SCHISM model illustrate this trend. The consistent depiction of predominantly northward currents by both methodologies at this specific time bolsters the coherence in their observations.

*3.5.2 QUANTITATIVE ANALYSIS **APRIL 27** AT SABINE LAKE*

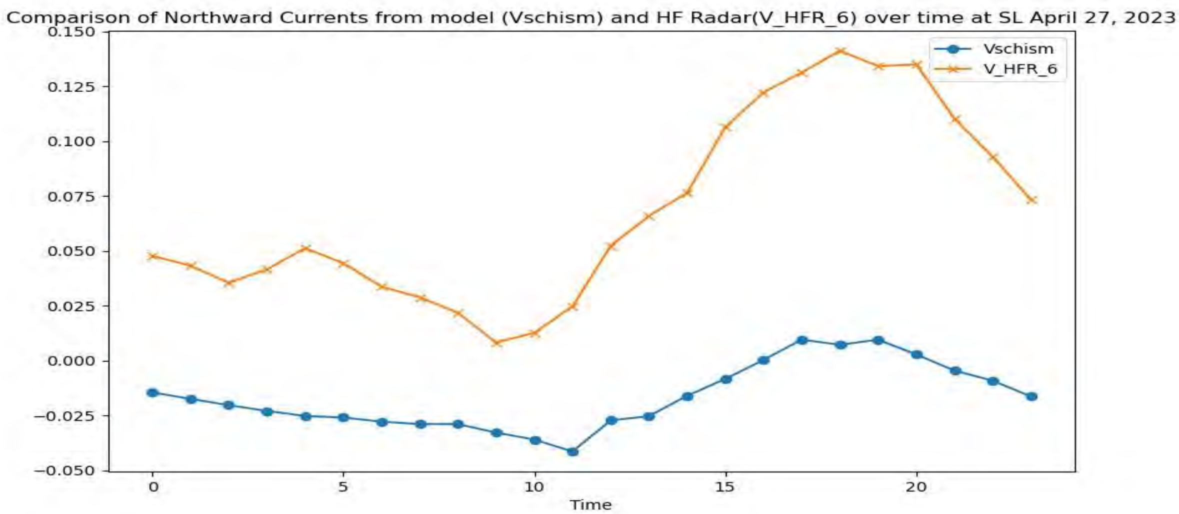
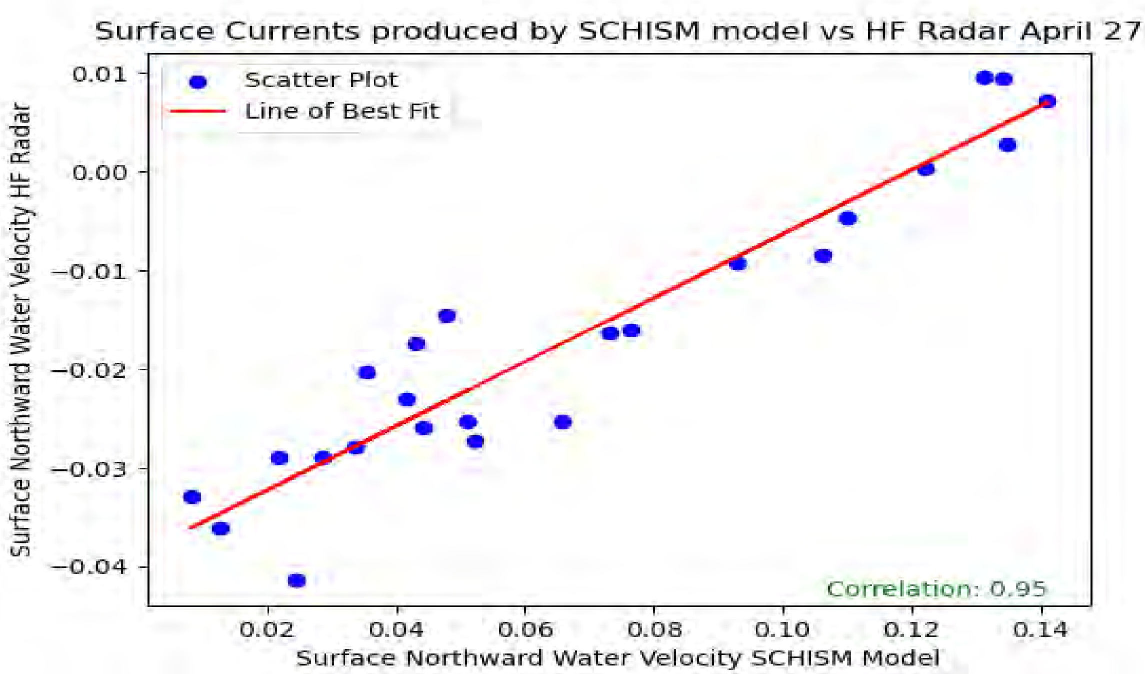


Figure 3.5.3: Plot showing comparison of Northward Currents from SCHISM Model (Vschism) and HF Radar(V_HFR_6) over time at SL April 27, 2023.



3.5.4: The plot shows the scatter plot and correlation between the hourly averages of **Northward** currents as measured by the SCHISM model and the HF radar at **SL** for entire hours of April 27, 2023.

The quantitative comparison presented in section 3.5.2 reveals very remarkable insights in the performance of both the HF radar and SCHISM model in generating surface currents in the lake. Specifically, figures 3.5.3 and 3.5.4 depict the noteworthy significant correlation coefficient of 0.95 for the magnitude of surface currents produced by the two methodologies on April 27 in Sabine Lake, Texas. This quantitative observation is in perfect agreement with the observation of dominant northward currents in the qualitative analysis in 3.5.1. Besides, this correlation coefficient of 0.95 stands out as the most significant observation throughout April 2023 in both the bay and the lake, emphasizing the consistent and robust agreement in the observed northward flow as measured by the radar and the model. Figure 3.5.3 shows clearly that the current as captured by the two methodologies have the same phase diagram.

Furthermore, the implications of these findings, discussed in Section 3.5.2, underscore the reliability of both the SCHISM model and HF Radar measurements in capturing and characterizing the prevailing northward flow patterns in Sabine Lake on this day to almost a perfect degree. The consistent identification of significant correlation in the northward direction on specific days further enhances our understanding of the dominant flow patterns within the lake – and the ability of either of the two methodologies to give accurate quantitative measurements.

4.0 Discussion

Table 4.1: Summary Statistics for model and radar performance in each of the components in GB

Date	Statistical Metrics	U-component	V-component
April 8	corr.	0.94	0.76
	MSE	0.00047	0.00188
	RMSE	0.02172	0.04332
	MAE	0.01890	0.03343
	Index of Agreement	0.95174	0.83445
April 27	corr.		0.90
	MSE		0.008446
	RMSE		0.091904
	MAE		0.079163
	Index of Agreement		0.617231
April 6	corr.	0.63	
	MSE	0.009166	
	RMSE	0.095739	
	MAE	0.090277	
	Index of Agreement	0.465083	

Table 4.1 provides a concise and detailed overview of the HF radar and SCHISM model performance in capturing the surface current characteristics for different dates in Galveston Bay, April 2023. Figures 4.1, 4.2, and 4.3 added more visualizations to understand the statistics used to evaluate the performance of the two methodologies. In terms of the U-component on April 8, both the model and radar exhibit a strong correlation (corr.) of 0.94, indicating a high level of agreement in predicting eastward water velocities. The Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Index of Agreement (IA) further support the efficacy of both methods, with low error values in these metrics suggesting accurate predictions (see Figure 4.1).

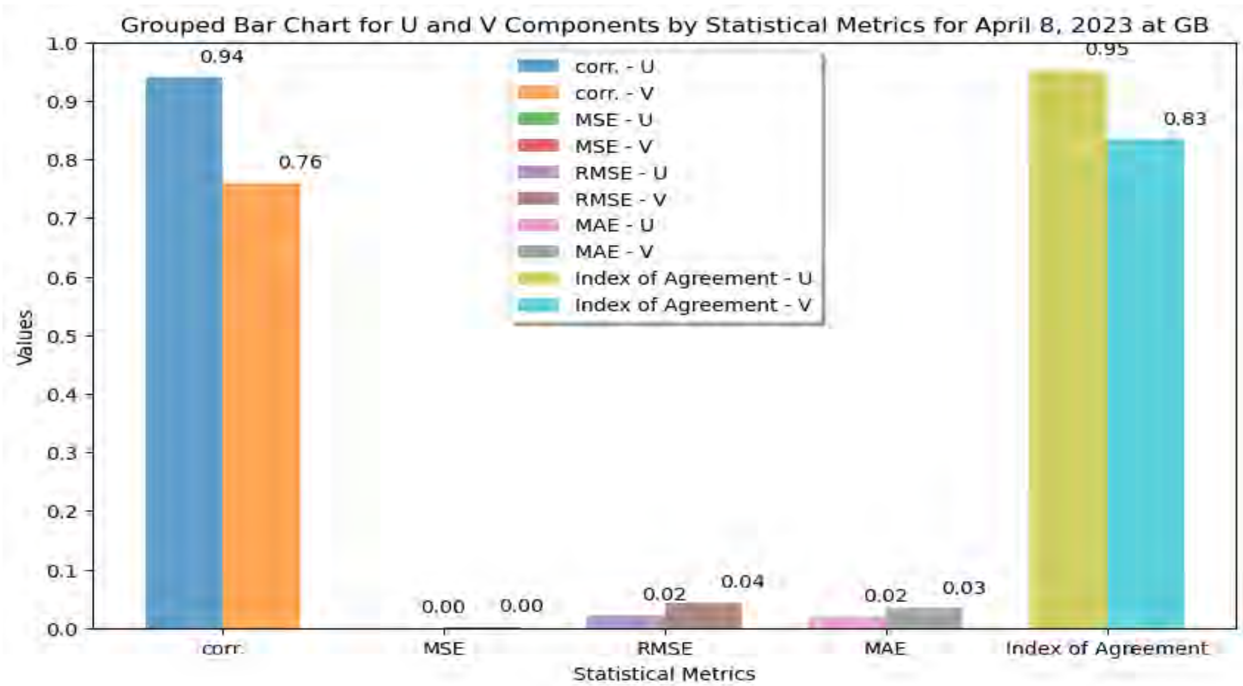


Figure 4.1: Plot of statistical metrics used to evaluate radar and model performance in predicting surface current in both Eastward(U) and Northward(V) components in Galveston Bay, April 8, 2023.

On April 27, 2023, at the bay, both the model and radar captured quite precisely the northward water movement (see Figure 4.2). The V-component correlation coefficient was substantial at 0.9 , suggesting a reliability of the two methodologies in measuring the surface current on this day. The error metrics for this date also indicate precise predictions. On the other hand, April 6 exhibits a lower correlation (0.63) in the U-component, indicating a relatively weaker agreement between the model and radar predictions (see Figure 4.3). The associated error metrics for this date is higher, implying some discrepancy in predicting eastward water velocities.

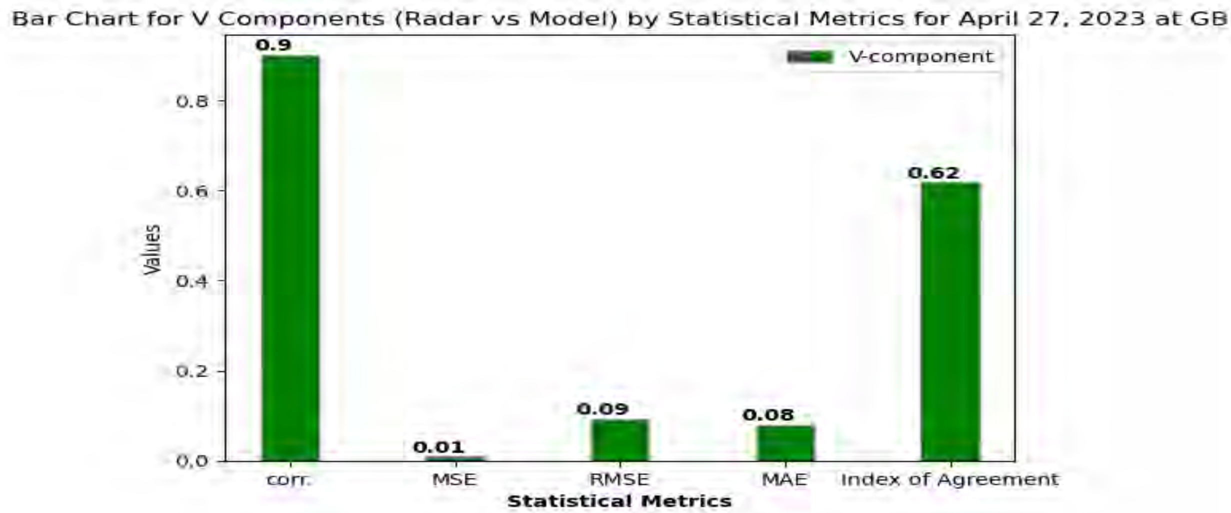


Figure 4.2: Plot of statistical metrics used to evaluate radar and model performance in predicting surface current in Northward (V) components in Galveston Bay, April 27, 2023.

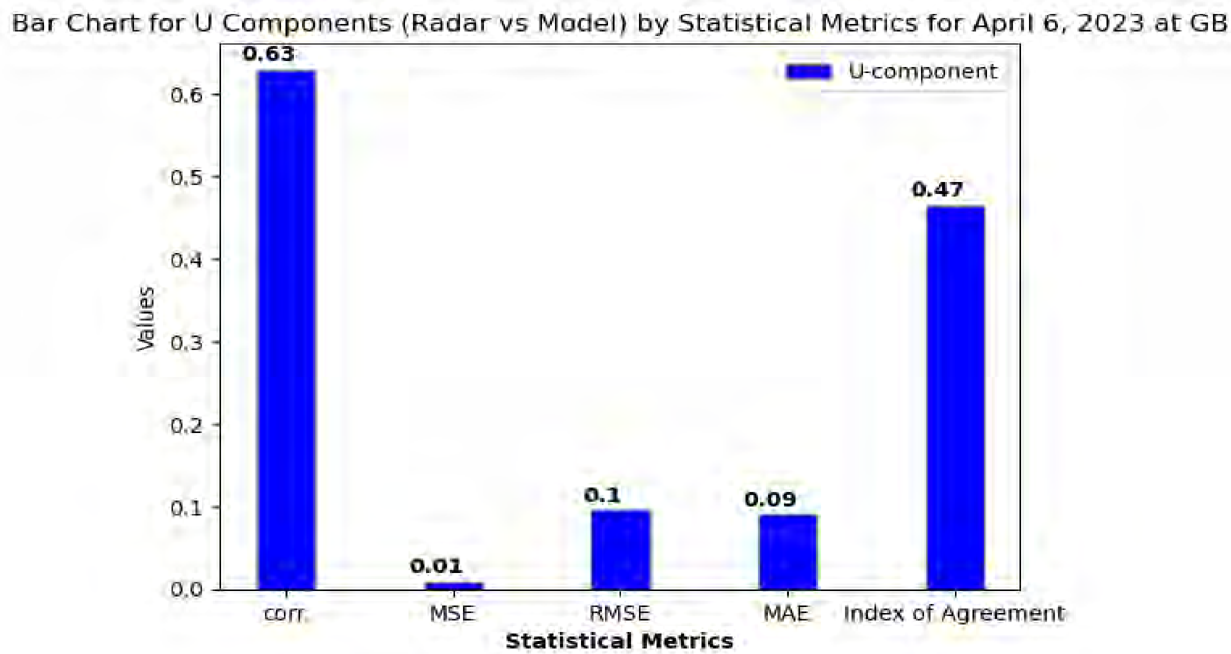


Figure 4.3: Plot of statistical metrics used to evaluate radar and model performance in predicting surface current in Eastward (U) components in Galveston Bay, April 6, 2023.

The observed disparity in the precise measurements of currents by the two methodologies, particularly in the eastward and northward directions, could be attributed to a combination of factors including wind dynamics within the bay, seasonal weather patterns prevalent in the month of April in the bay, influence by its proximity to the Gulf of Mexico. Park *et al.* (2001) observed that the dominant winds in the bay are the southeasterly winds and the bay - ocean interactions is usually influenced through the North-Eastern direction. Salas-Monreal *et al.* (2018) inferred from their work that southerly winds dominate the bay from October to April while northerly winds are more pronounced in the bay from May to September. Thus, the month of April is usually characterized by variable wind patterns in the bay, primarily driven by prevailing winds from the east or southeast. These findings support the outcomes depicted in Figures 4.1 and 4.3 for April 8 and April 6, respectively. Moreover, the anticipated shift towards northerly winds dominating the bay on April 27 aligns with the radar and model measurements capturing Northward currents, reflected in a correlation coefficient of 0.9.

Table 4.2: Summary Statistics for model and radar performance in each of the components in SL

Date	Statistical Metrics	U-component	V-component
April 27	corr.		0.95
	MSE		0.008008
	RMSE		0.089489
	MAE		0.084740
	Index of Agreement		0.762368

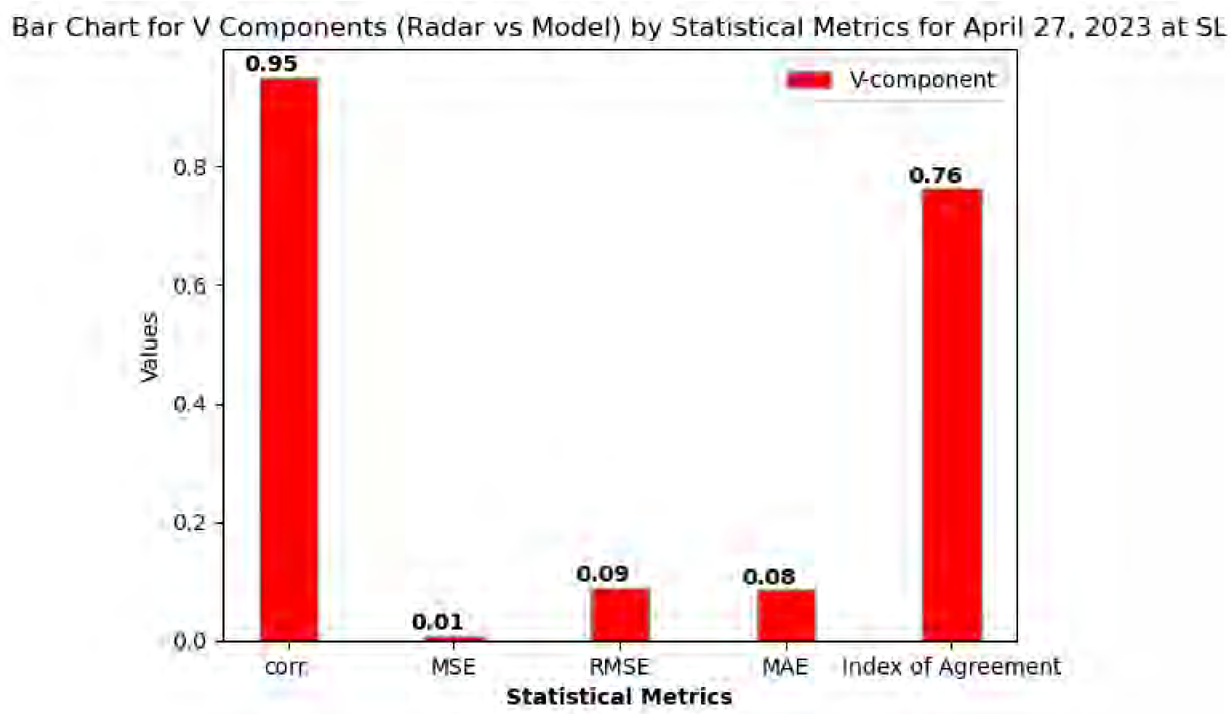


Figure 4.4: Plot of statistical metrics used to evaluate radar and model performance in predicting surface current in Northward(V) components in Sabine Lake, April 27, 2023.

According to Table 4.2 and Figure 4.4, the significant correlation coefficient of 0.95 indicates that there is similar agreement in predicting Northward water velocities on this day at the lake by both the radar and the model. Notably also are the low error values (MSE, RMSE and MAE) and substantial Willmott's index of agreement value (76%), which further suggest reliable measurement. The implication of these results is that the SCHISM model is accurate and reliable in capturing the behavior of surface currents in the lake as well based on the result of this day. These findings affirm the model's ability to accurately capture surface current behavior, crucial for diverse environmental and scientific endeavors.

5.0 Conclusion

This study has shed more light on the intricate dynamics of surface current measurement within Galveston Bay and Sabine Lake, during the month of April 2023. By carrying out a meticulous analysis of HF radar and SCHISM model performance, we discern a pattern of robust predictive capabilities, notably exemplified by strong correlations and low error metrics on April 8 and 27. These findings underscore the efficacy of both methodologies in accurately capturing surface current characteristics.

Even the nuanced variations observed, particularly on April 6, hint at the influence of environmental factors such as wind dynamics and seasonal weather patterns. The disparities in eastward and northward current measurements across dates underscore the complex interplay between prevailing winds, bay-ocean interactions, and regional weather patterns. Insights gleaned from previous research on the bay by Park *et al.* (2001) and Salas-Monreal *et al*. (2018) further elucidate the role of wind patterns in shaping surface current behavior at Galveston Bay.

Regarding the qualitative comparison and its relationship to the result of the quantitative analysis, it was observed that days characterized by predominant northward currents exhibited significant correlation coefficients exclusively in the northward direction in the bay and lake. Similarly, during days dominated by eastward currents, the correlation coefficients for currents measured by both the model and radar were significant only in the eastward direction for the bay. Notably, the SCHISM model and HF radar also effectively captured the trend and magnitude of surface currents on days with both eastward and northward currents in the bay.

This research findings emphasize the importance of considering environmental variables in surface current predictions using hydrodynamic models like SCHISM and HF radar especially in regions influenced by coastal dynamics like Galveston Bay. The SCHISM model exhibited commendable comparable performance in accurately simulating surface currents, aligning closely with the established methodology of HF radar. This suggests the potential extension of the SCHISM model's applicability to study various environmental phenomena such as coastal flooding and storm surge along the Texas coast. Very importantly, this study contributes valuable insights into the intricate relationship between wind dynamics and surface current behavior, advancing our understanding of coastal dynamics and informing strategies for environmental monitoring and management.

Finally, it is important to point out that this paper presents a particular case study at Galveston Bay and Sabine Lake, Texas, USA. The data used for this study are unique to the Texas coast and specific to Galveston Bay and Sabine Lake. It is our believed that the methodologies established, and modeling techniques described in this study may be applicable to intercompare surface currents produced by High Frequency Radar and SCHISM model at other estuaries within the Texas coast or elsewhere if the similar data can be sourced there.

Funding

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37.

Exhibit C Assessment of Possible HF Radar Data Integration within CE-QUAL-W2

Title: Assessment of Possible HF Radar Data Integration within CE-QUAL-W2

Introduction

This review explores the possibility of integration of High Frequency (HF) radar data within the CE-QUAL-W2 model. CE-QUAL-W2, is a two-dimensional, laterally averaged, hydrodynamic, and water-quality model originally developed by the U.S. Army Corps of Engineers (USACE) (Cole and Wells, 2006; Smith *et al*., 2014). This integration usually aims to enhance the accuracy and efficiency of water quality assessments – water quality models – in aquatic systems including estuaries. HF radar technology provides real -time monitoring of surface currents, providing valuable information into water movement patterns, ocean surface circulation patterns, which importantly influence water quality dynamics. One of the key prospects of this integration of HF radar data into CE-QUAL-W2 model is an opportunity of improving the model's predictive capabilities as such integration permits incorporating more current and precise information. So, this assessment outlines key considerations, challenges, and benefits associated with integrating HF radar data into CE-QUAL-W2 model.

Key Considerations and Challenges

The integration of observational data especially from remote -sensed HF radar data into water quality models like CE-QUAL-W2 holds promise for advancing the understanding of aquatic ecosystems. This stems from the fact that researchers can leverage such technology to obtain high -resolution surface current information, sea heights and other variables to better characterize the hydrodynamic processes. In addition, integrating such observational data into CE-QUAL-W2 model has the potential to refine the model outputs and enhance the accuracy of water quality predictions. However, there are key considerations that must be examined to ensure successful integration and utilization of HF radar data within the CE-QUAL-W2 model framework.

One of the key considerations associated with that integration is data consistency and data compatibility. In terms of data compatibility, HF radar may have different spatial and temporal resolutions than the CE-QUAL-W2 model grids, thus requiring the interpolation or downscaling techniques to align the datasets appropriately. Similarly, to ensure data consistency, it is important to perform data preprocessing steps like quality control and calibration to guarantee the precision and dependability of HF radar -derived currents before integrating them with CE-QUAL-W2. Additionally, another important aspect thing to consider is that the integration of HF radar data introduces computational complexities, as the CE-QUAL-W2 model must accommodate additional input variables and processing routines.

Benefits

Despite the aforementioned challenges, the integration of HF radar data into the CE-QUAL-W2 model offers potential numerous advantages for water quality management and assessment. By incorporating the real-time surface current data information, the CE-QUAL-W2 model can sufficiently capture the dispersion and transport of nutrients, pollutants, spilled substances, and other contaminants in aquatic systems. The overarching benefits of this is enhanced predictive ability of the model which will enable informed decision-making regarding water resource management, pollution mitigation strategies, and ecosystem conservation efforts. Additionally, the integration of the HF radar data into the CE-QUAL-W2 model also promotes model validation and calibration, giving more credence to the suitability of the model for simulations, and improving its reliability and robustness as well.

Comparison

To better understand the importance of integration we consider some important similarities and differences between CE-QUAL-W2 model data and HF Radar data.

- The CE-QUAL-W2 model provides spatially and temporally continuous simulation of water quality, temperature and other parameters within a water body or water system. The HF radar offers spatially distributed data on the surface currents across a larger area, providing insight into dynamic circulation patterns.
- The CE-QUAL-W2 model can vary in spatial and temporal resolution, they often operate at a very finer scale than HF radar measurement, permitting detailed representations of processes within the water body. The HF radar measurement on the other hand covers larger spatial scales but may have lower resolution compared to the model outputs, providing broader coverage of surface currents.
- The accuracy of CE-QUAL-W2 model output depends on the accuracy of input parameters, boundary conditions and model's representation of physical processes while the HF radar measurements directly capture surface currents and can provide valuable validation data for model simulations.
- CE-QUAL-W2 model and HF radar offer complementary information for understanding water body dynamics. The CE-QUAL-W2 model can provide insight into internal processes such as temperature stratification and pollution transport while radar measurements focus on surface currents and circulation patterns. Integration model simulations with radar data allow for a more comprehensive understanding of hydrodynamic processes, including the interaction between internal dynamics of water body and surface currents.
- The CE-QUAL-W2 model and HF radar both produce several modeling outputs that provide insights into hydrodynamics, water quality and ecological conditions within a water body. CE-QUAL-W2 model produces hydrodynamic variables including water velocities throughout the water column including surface currents, subsurface currents, and vertical velocities. The model also produces water surface elevation -used for model calibration sometimes (Buccola *et al*., 2013), and water quality products including temperature, dissolved oxygen, nutrients, algal biomass, water quality profiles (Cole and Wells, 2006). However, the HF radar products provide information about the ocean

surface in the form of surface current vectors (water current speed and direction), and surface wave parameters including ocean surface wave height, period and direction.

Conclusion

In summary, incorporating HF radar data into the CE-QUAL-W2 model shows promise for improving water quality assessment and modeling capabilities. While there are challenges related to data compatibility, preprocessing, and computational complexity, the advantages of integrating high-resolution observational data outweigh these obstacles. By addressing these challenges and leveraging HF radar technology, researchers can enhance the precision, dependability, and usefulness of CE-QUAL-W2 for analyzing and managing aquatic ecosystems.

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Exhibit D Fitting Normal Modes to HF Radial and Total Surface Current Vector Data Over Enclosed Bays and Estuaries

Fitting Normal Modes to HF Radial and Total Surface Current Vector Data Over Enclosed Bays and Estuaries

This work is a summary of a project performed in the Corpus Christy Bay by Mr Hector Aguilar and Rosa M. Fitzgerald, which awarded Mr Aguilar a Master degree in Physics.

The Bay of Corpus Christy was selected because of its natural enclosure, with only one inlet, Aransas pass, making it ideal to be used with Normal Modes Analysis.

Contents

Introduction

- The analysis of oceanic surface currents has been an important area of research for the past four decades, with applications in navigation, oceanic biology, and oceanography.
- Various methods have been used by oceanographers in an attempt to map out and understand the dynamics of the coastal surface currents, from Langrangian drifters to huge phased radar antenna arrays, to compact high frequency (HF) antenna units referred to as CODARs (Coastal Ocean Dynamics Acquisition Radar).
- This research used the data obtained with the CODAR units set up at Corpus Christi bay and owned at the time by Dr Jim Bonner, from the Conrad Blucher Institute.

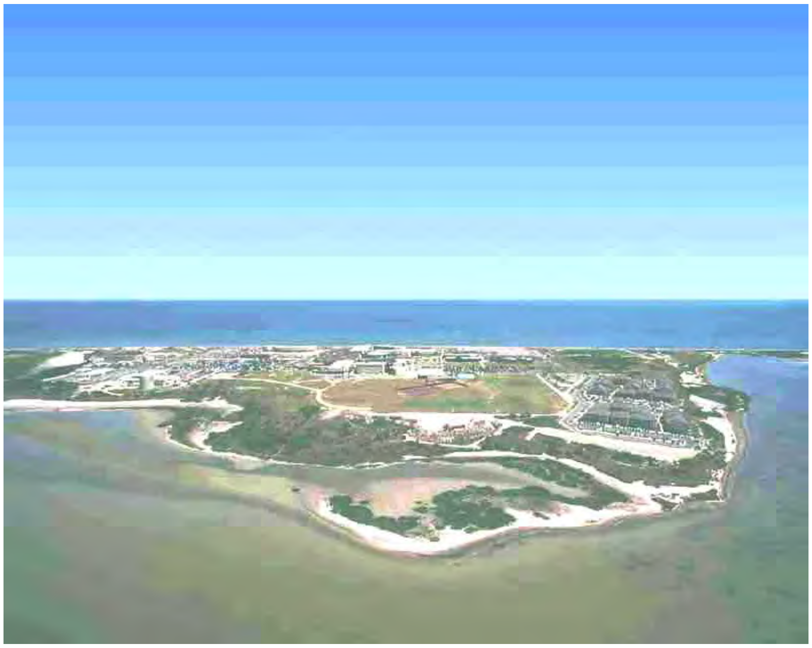
HF Radar

- High Frequency (HF) Radar spans the 3-30 MHz band with wavelengths between 10 and 100 meters.
- When an HF Radar signal is directed toward the ocean surface containing waves that are 3-50 meters long it scatters in many different directions.
- The radar signal that the CODAR looks for is the one that is scattered directly back towards its source. The only radar signals that do this are those that scatter off a water wave that is exactly one half the transmitted signal wavelength.

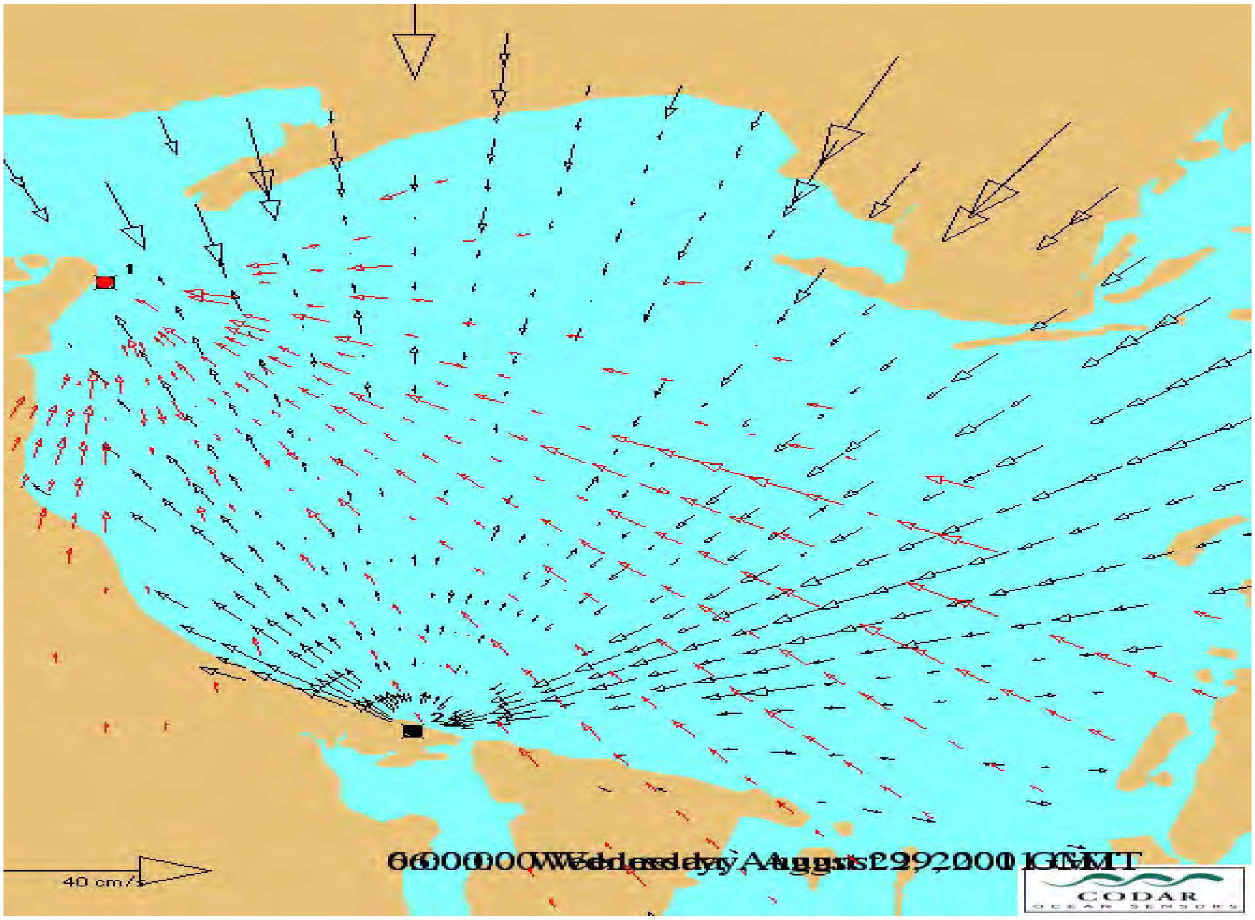
Transmission Frequency	Transmission Wavelength	Ocean Wave
25 MHz transmission	12 meter EM wave	6 meter ocean wave
12 MHz transmission	25 meter EM wave	12.5 m ocean wave
5 MHz transmission	60 meter EM wave	30 meter ocean wave

Corpus Christy Bay

A pair of SeaSonde HF coastal radars had been recording and archiving hourly surface-current map data over Corpus Christi Bay. These units were originally owned by Dr Jim Bonner from the Conrad Blucher Institute. The 15 km x 25 km bay is shallow and nearly completely enclosed. The dominant circulation is wind driven, with a weak tidal co-oscillatory response forced by flow through the inlet.

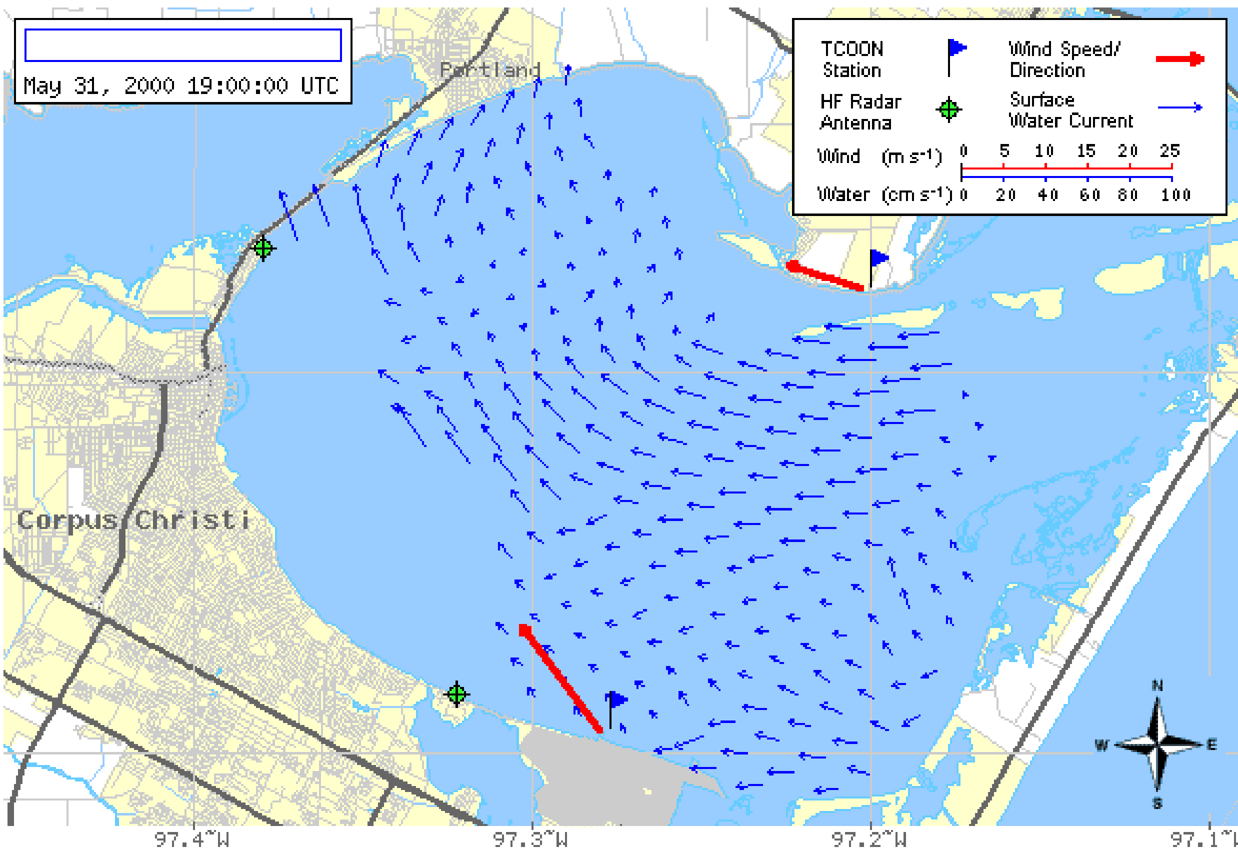


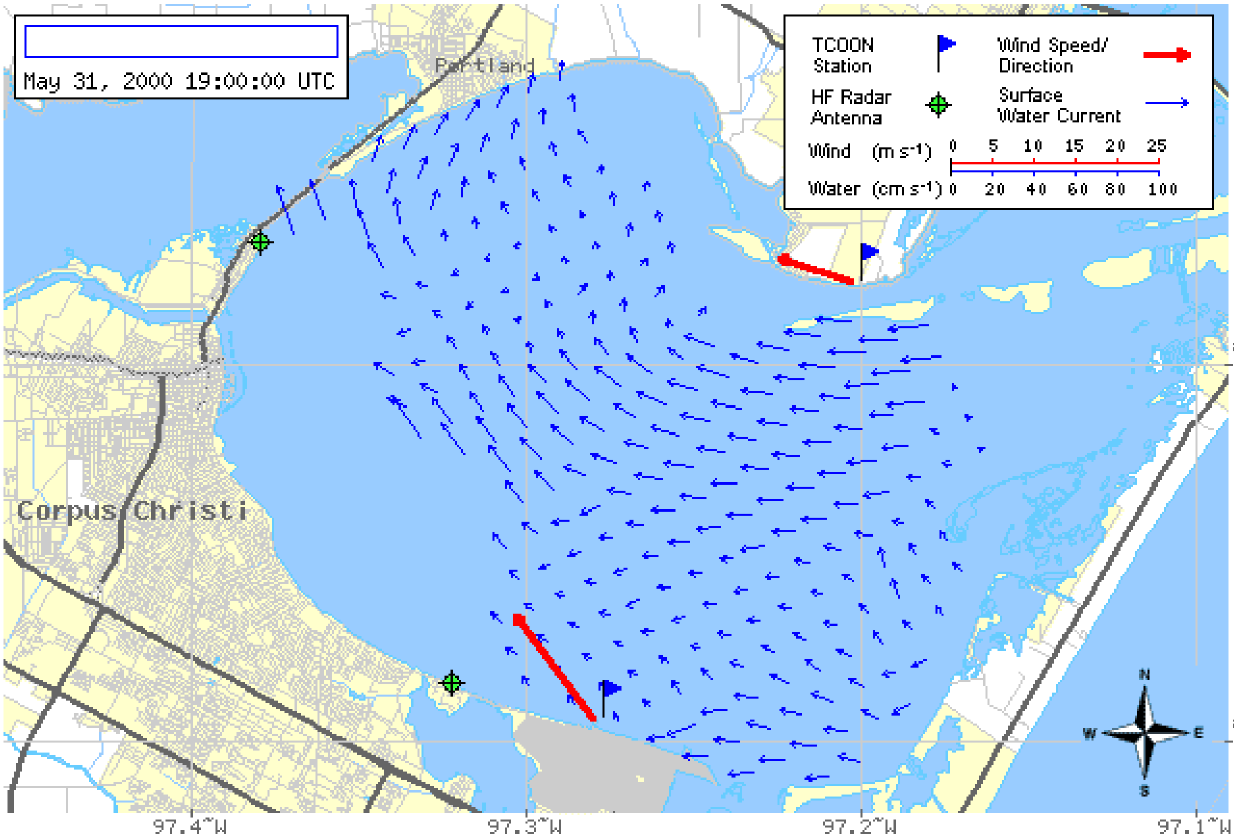
SeaSonde radial data for the two radar positions on Corpus Christy Bay.



Total vector coverage by the SeaSonde pair spans on average half of the bay surface, with gaps caused by:

- Environmental variations (noise, wave conditions, etc.)
- Regions seen only by one radar but not the other.
- Zones along the baseline between the two sites where total vectors cannot be produced because both observe the same velocity component.





Observed Limitations

- A single coastal radar produces only one dimensional vectors in the radial sense.
- Total vector fields are produced only where two or more coverages overlap.
- Gaps in the coverage in bays is produced by land occlusion.
- High frequency noise in vector data obscures main features.

Goals

- Fill in gaps in the total vector maps by using Normal Mode Analysis (NMA) to make total surface current maps using the radial maps from CODAR units.
- Create total vector maps by using the radial data from only one radar unit.

Fitting of Normal Modes

Hypothesis: fitting NMA (Normal Mode Analysis), hydrodynamic basis functions directly to the one-dimensional radial vector maps produced by each radar separately. Thus, a velocity field of 1-dimensional scalar components is being used to define a 2-dimensional flow pattern inherent in the coastline-conforming NMA mode functions.

- From the total vector representation of the Normal Modes calculate the radar-directed scalar component of the velocities.
- Match the scalar radial SeaSonde data by interpolation to the radar-directed components of the mode functions.
- Express the model as a series of the radar-directed Normal Mode velocity functions times unknown coefficients.
- Solving this over-determined linear system of equations using the method of least-squares.
- Applying the model solution to cover the entire Corpus Christi bay in order to determine total vectors of the bay's surface currents even where radar coverage is limited.

Theoretical Background

The approach that we applyed was first developed by *Zel'dovich et al.* where a three-dimensional incompressible velocity field can be represented in terms of two scalar potentials

$$\vec{v} = \nabla \times \left[\hat{k}(\Psi) + \nabla \times \left(\hat{k}\Phi \right) \right]$$

where k is the unit vector representing the vertical direction, that is the direction orthogonal to the surface of the coastal zone in my study, Ψ and Φ represent the set of Dirichlet and Neumann functions to be used as basis functions to describe the velocity field.

- The velocity field within the given boundaries is then represented as an expansion of eigenfunctions.
- The surface velocity field is partitioned into two parts.
- A homogeneous solution where the normal velocity is held to be zero at the boundaries determined in the model by the shape of the bay with the assumption that there are no inlets.
- An inhomogeneous solution where the surface velocity is dependent on the specified normal flow through the bay inlets located in the bay area being considered.

The Dirichlet eigenfunctions ψ (containing the vorticity) satisfy an eigenvalue equation on a Cartesian system and obey a Dirichlet boundary condition:

$$\nabla^2\psi_n + \lambda_n\psi_n = 0, \quad \psi_n\big|_{boundary} = 0$$

By taking the gradients of the ψ functions with respect to the plane that is being considered the velocity components of the Dirichlet functions can be established:

$$\left(u_n^D, v_n^D\right) = \left(\frac{\partial\psi_n}{\partial y}, \frac{\partial\psi_n}{\partial x}\right)$$

The eigenfunctions ϕ that satisfy the Neumann boundary conditions also satisfy the following eigenvalue equation and obey a Neumann boundary condition

$$\nabla^2\phi_n + \mu_n\phi_m = 0, \quad \left(\hat{k}\cdot\nabla\phi_m\right)\Big|_{boundary} = 0$$

The velocity components for the Neumann functions are thus:

$$\left(u_m^N, v_m^N\right) = \left(\frac{\partial\phi_n}{\partial y}, \frac{\partial\phi_n}{\partial x}\right)$$

Subsequently the case of open boundary is considered with water inlets.

For Corpus Christi bay there is only one main inlet from the Gulf of Mexico, located to the Northeast near Aransas Pass. For this case normal flow, as well as tangential flow is found to exist at the inlet. The normal component of the flow through the open boundary at the main inlet into the Corpus Christi is obtained.

$$\nabla^2\Theta(x, y, 0, t) = S_\Theta(t),$$
$$\left(\hat{n}\cdot\nabla\Theta\right)\Big|_{boundary} = \left(\hat{n}\cdot\vec{u}_{\mathrm{mod}el}\right)\Big|_{boundary}$$

This is the inhomogeneous equation in which **n** is the unit vector pointing out from the normal of the open boundary and **u** is the surface velocity, S being the source term that accounts for the net flow into the domain through its open boundaries, and obtained as *Lipphardt et al*:

$$S_\Theta(t) = \frac{\oint \hat{n}\cdot\vec{u}_{\mathrm{mod}el}\,dl}{\iint dxdy}$$

For the case of the tangential component of the flow at the inlet a boundary stream function γ can be calculated to the solution:

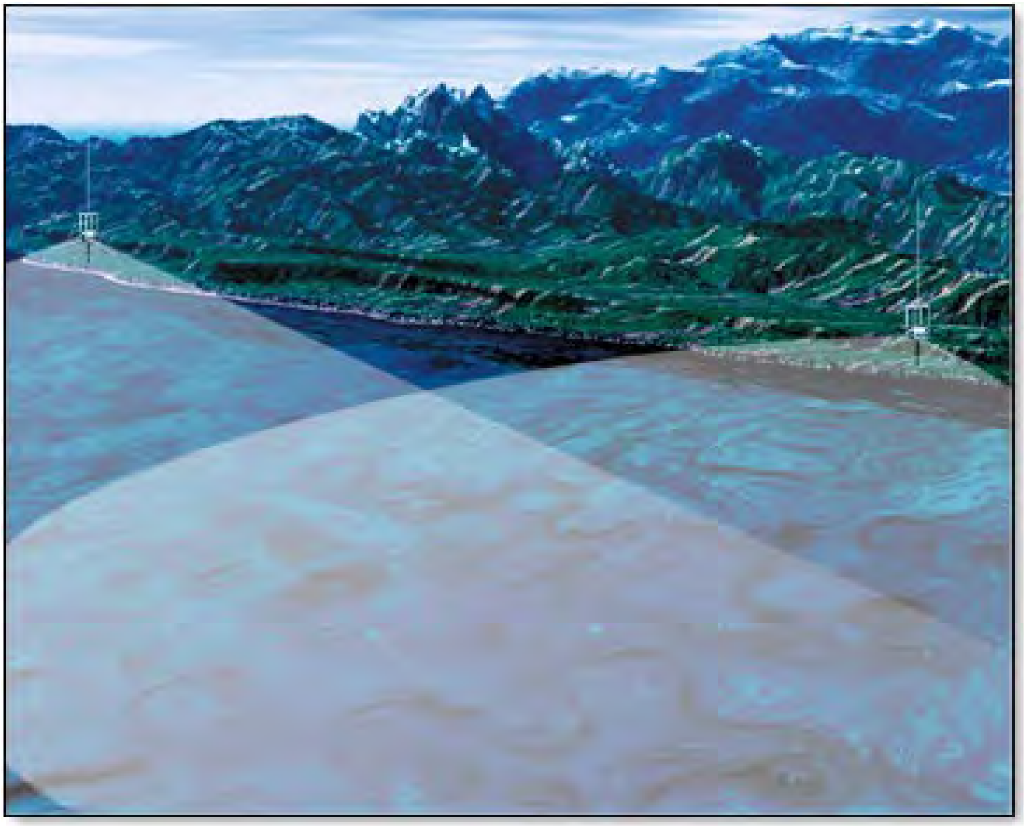
$$\nabla^2 \gamma(x, y, 0, t) = S_\gamma(t),$$
$$(\hat{n} \cdot \nabla \gamma)\big|_{boundary} = (\hat{n} \cdot \vec{u}_{\mathrm{mod}\,el})\big|_{boundary}$$

Here t is the unit tangent vector on the boundary and S is the source term that accounts for the net circulation on the domain boundary, S being defined as:

$$S_\gamma(t) = \frac{\oint \hat{t} \cdot \vec{u}_{\mathrm{mod}\,el} dl}{\iint dxdy}$$

All these constitutes the Normal Mode Analysis technique. The solutions of these equations using the Corpus Christy boundary shape were obtained using the PDE2D software, which uses a Finite Element Method.

Normally most of the radial data is discarded when creating total vector maps of a bay since the total vectors of surface currents are created in areas of a bay where the scans of two or more SeaSondes overlap.



Fitting Normal Modes to Corpus Christi Bay

We used all the recorded data from one or more SeaSondes to fit "Normal Modes Analysis (NMA) functions" calculated for the bay to fill in the gaps in the SeaSonde total vector maps for the surface currents.

- Using the PDE2D software we were able to determine the lowest modes for Corpus Christi Bay, a total of 16 normal modes, 8 modes obeying Dirichlet boundary conditions, 8 modes obeying Neumann boundary conditions were used.
- From the two SeaSondes we have the radial data files giving radial velocity, range, and bearing from Corpus Christi Bay out to 31 kilometers in range.

This represented all the information necessary to fit the NMA functions to the experimental data from the CODAR units

Experimental Data

- Take the SeaSonde data from a given radar position
- Express the polar coordinates in terms of the Cartesian system used by the PDE2D model
- Find the 4 nearest neighbor data points from the radar data for each model data point

- Find the average radial velocity of these nearest points
- Use these averaged points to find the fit of the model data points using least squares method

PDE2D Simulation Data

PDE2D returns two sets of 2-dimensional basis functions, one of which satisfies the Dirichlet boundary conditions and the other satisfying the Neumann boundary conditions at the coastline.

In order to obtain a good fit of the modes given, the following steps are followed to assure a correct comparison with the given SeaSonde radial data:

- Multiply the u and v components of the two dimensional flow vector given by each mode by the radial unit vector of each given radar position upon the Cartesian system in order to obtain the radial component of the mode value.
- Repeat this process for each radar position and mode.
- We use 16 sets of mode values to create a matrix that will be used to solve the over-determined system of equations.

Least Squares

Given an over-determined linear system of equations, use of Least Squares minimization will lead into a completely determined system with an invertible square matrix.

The system of equations can be expressed as the matrix equation:

$$[b_n] = [a_{n,k}][x_k]$$

- Where b_n denote the radial velocity measurements from the SeaSonde as an (N x 1) matrix.
- a_n represent M radial velocity-directed normal modes at each of the N grid points where there are radial velocities, expressed as a (N x M) matrix.

  X_k denotes the unknown mode coefficients for all the M desired modes. We used 8 velocity-potential functions and 8 stream functions.

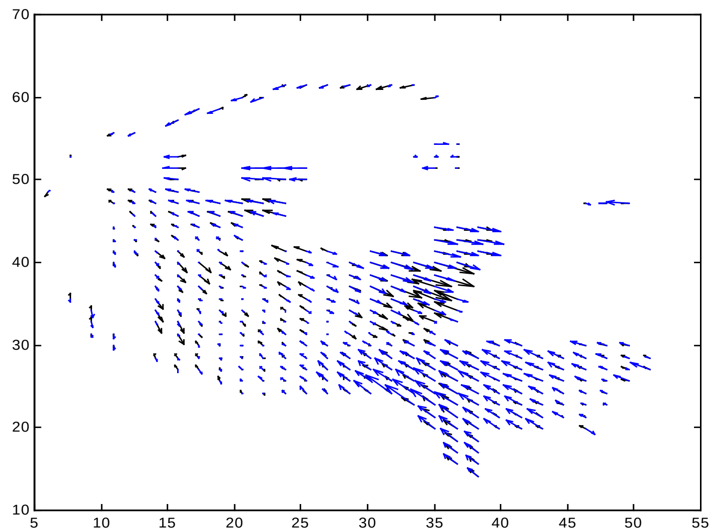
Results of the Least Squares Approach

- The averaged radial velocity amplitudes for Radar 1, Radar 2, and the combined case where the modes for both radars are used were recovered as will be seen in the following pages.
- Converting the summed modes to two dimensional vector maps we see that both cases reproduce the total vector data with greater accuracy depending on the number of points used.
- Space -time gaps are filled.
- Flow estimates are extended to all regions of Corpus Christi Bay.

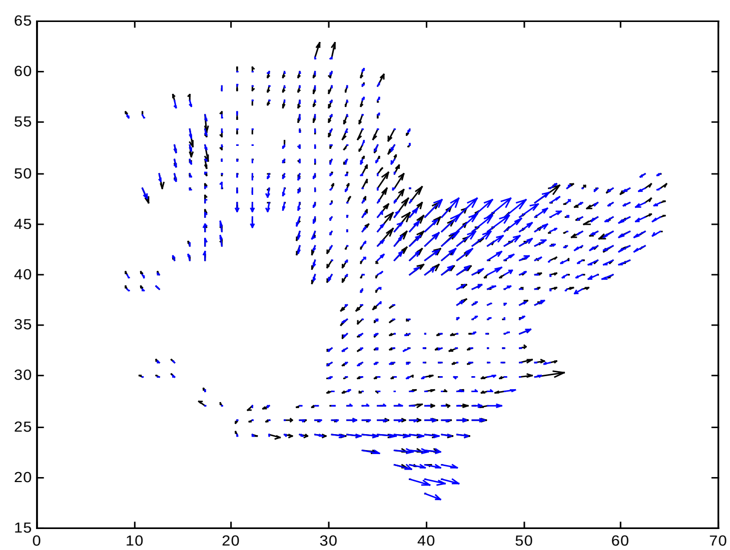
- Total vector flow maps can be constructed with only radial currents available.

On the following pages we present representative results we obtained utilizing this technique.

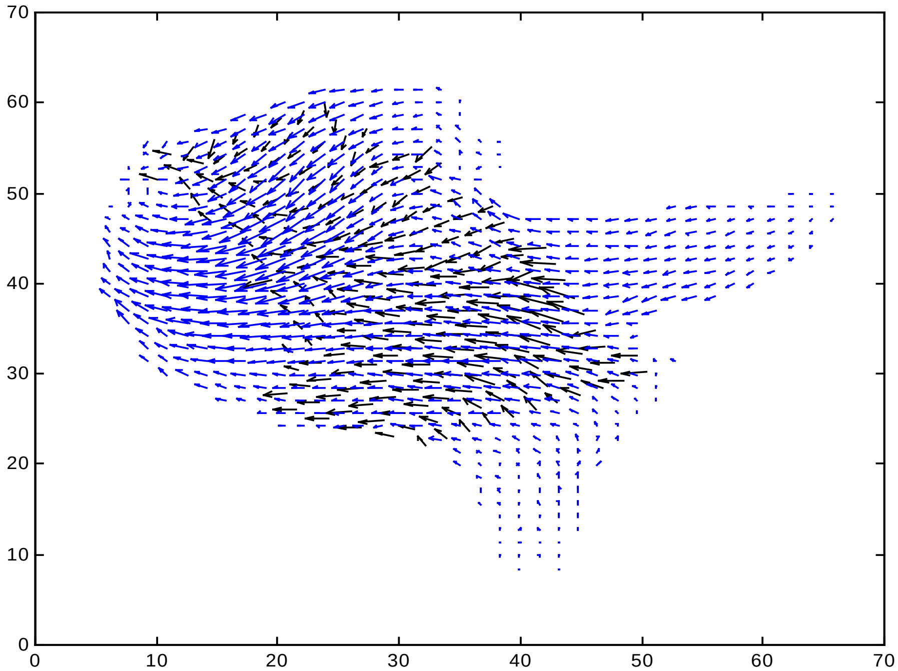
Comparison of Radar 1 averaged radials with fitted values for 0700 hrs Aug 29 2001

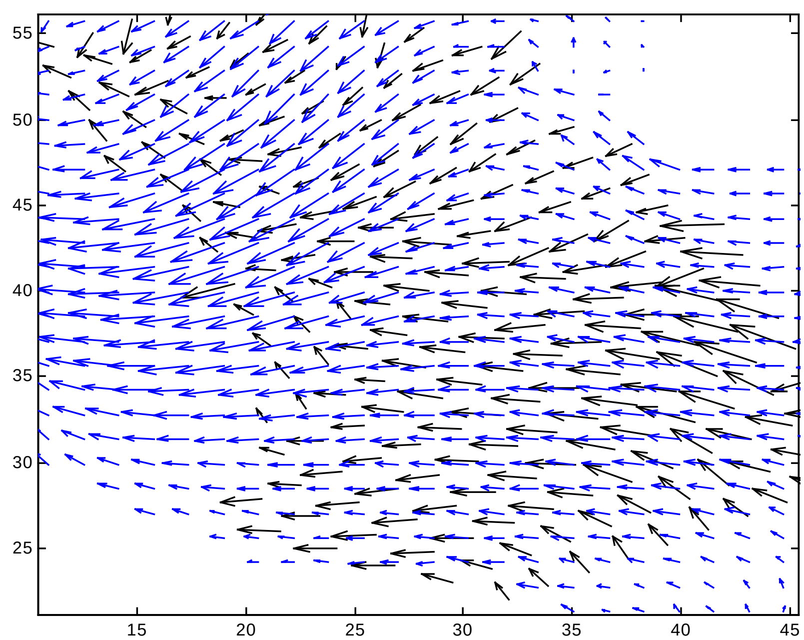


Comparison of Radar 2 averaged radials with fitted values for 0700 hrs Aug 29 2001

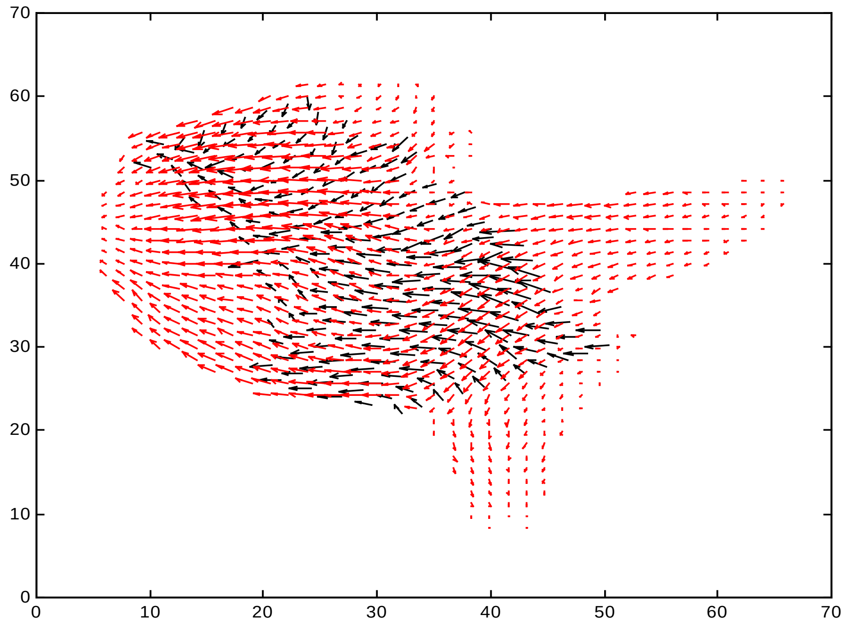


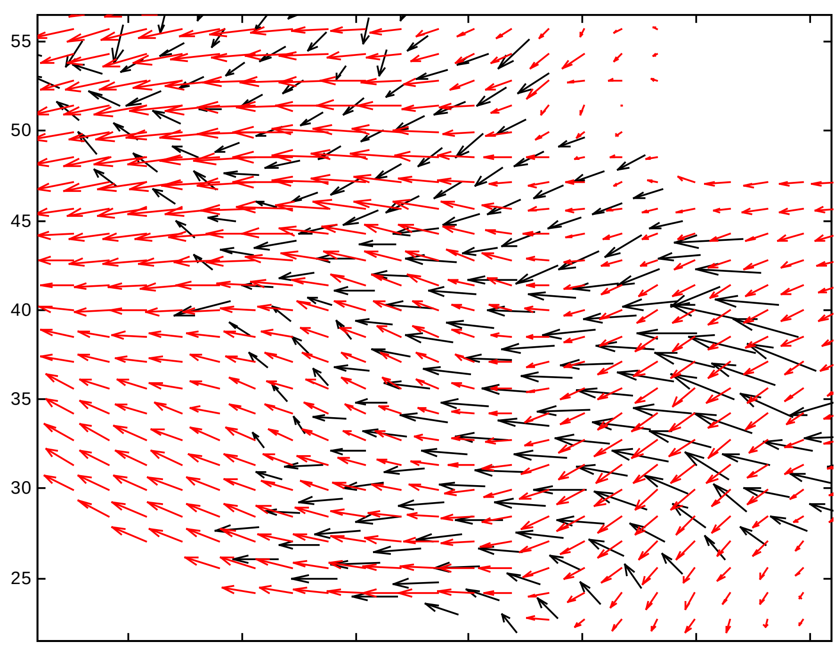
Radar 1 fitted data versus total vector data from SeaSonde 0700 hrs Aug 29 2001



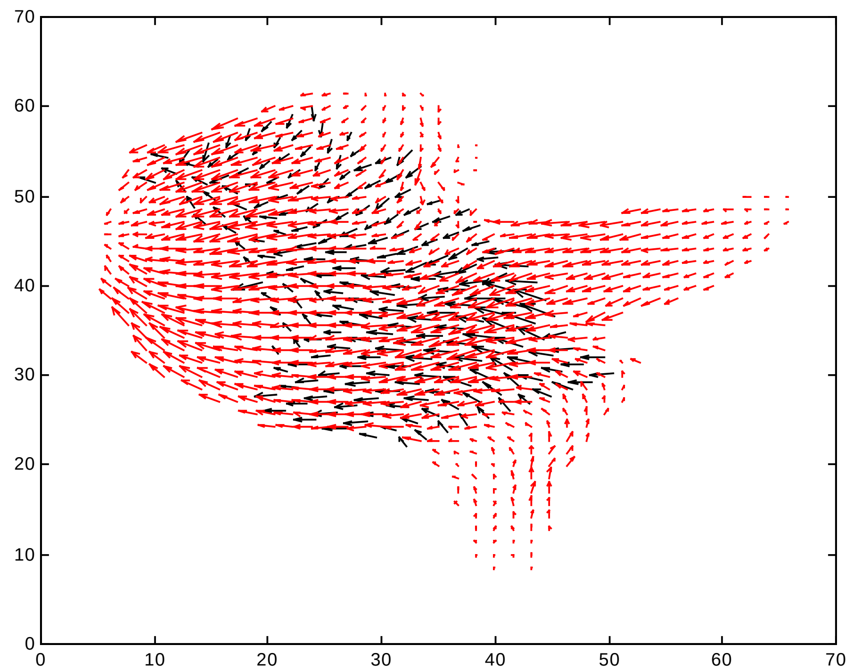


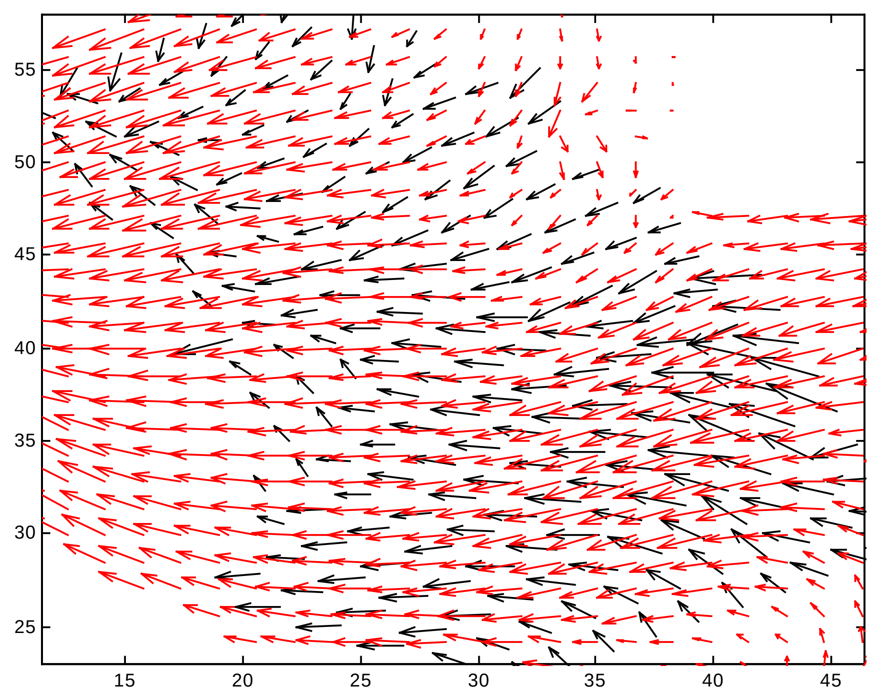
Radar 2 fitted data versus total vector data from SeaSonde 0700 hrs Aug 29 2001



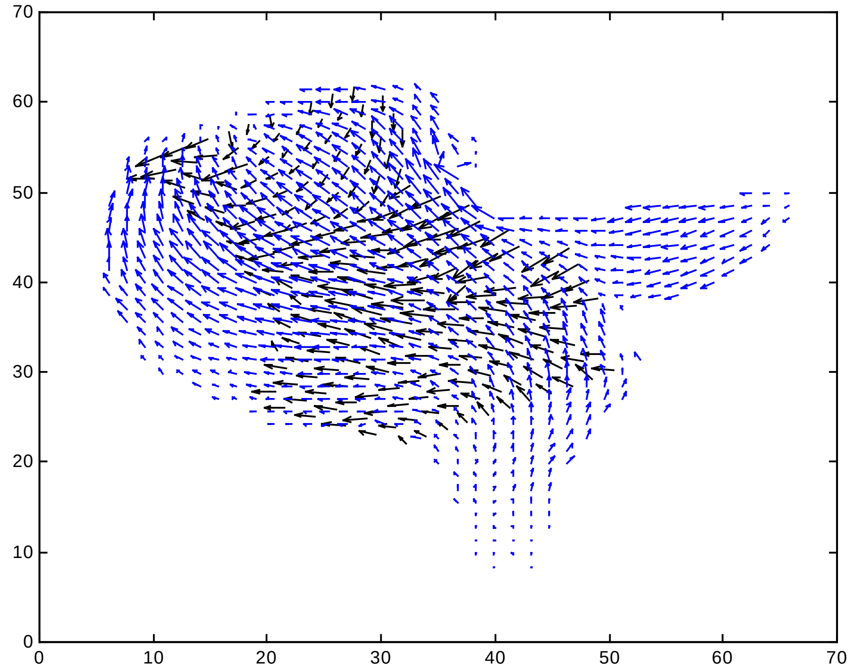


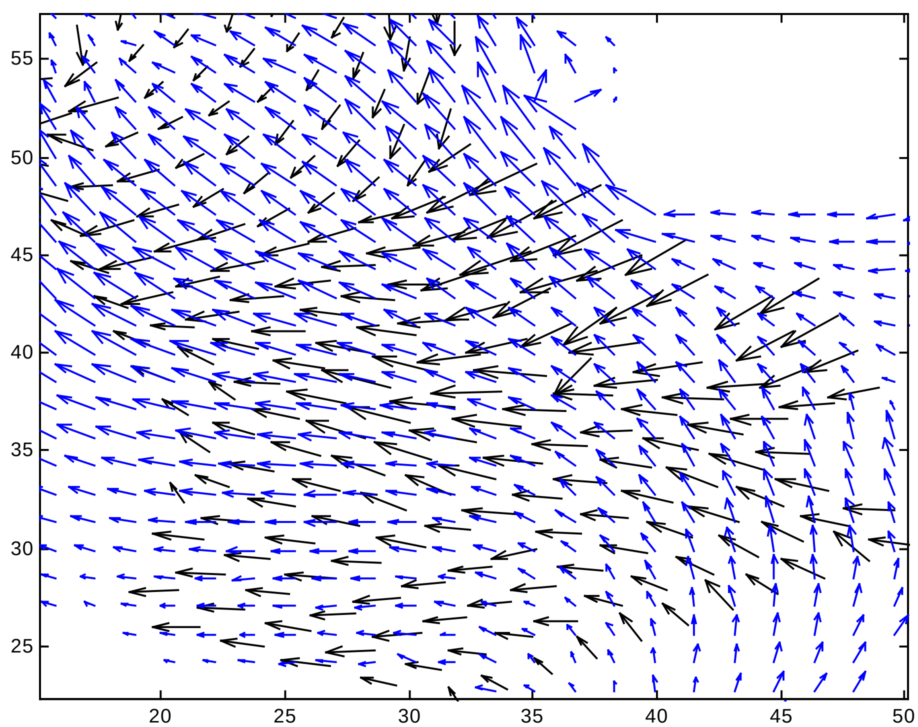
Combined fitted data versus total vector data from SeaSonde for 0700 hrs Aug 29 2001



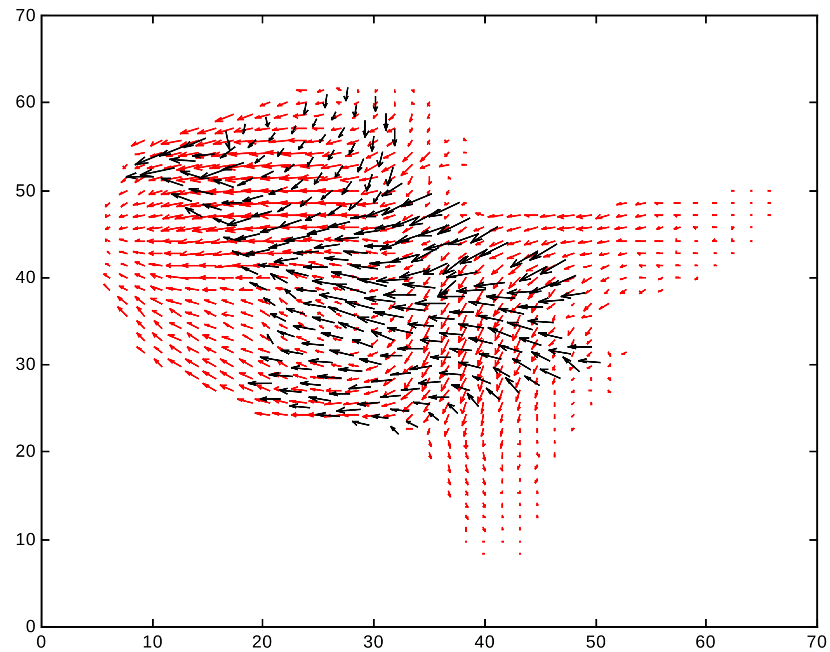


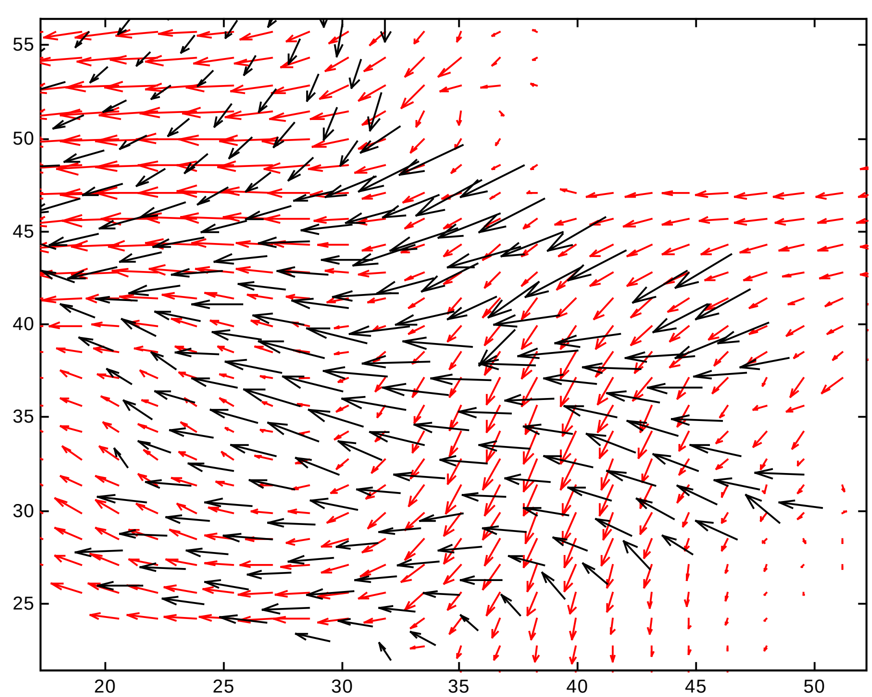
Radar 1 fitted data versus total vector data from SeaSonde 0800 hrs Aug 29 2001



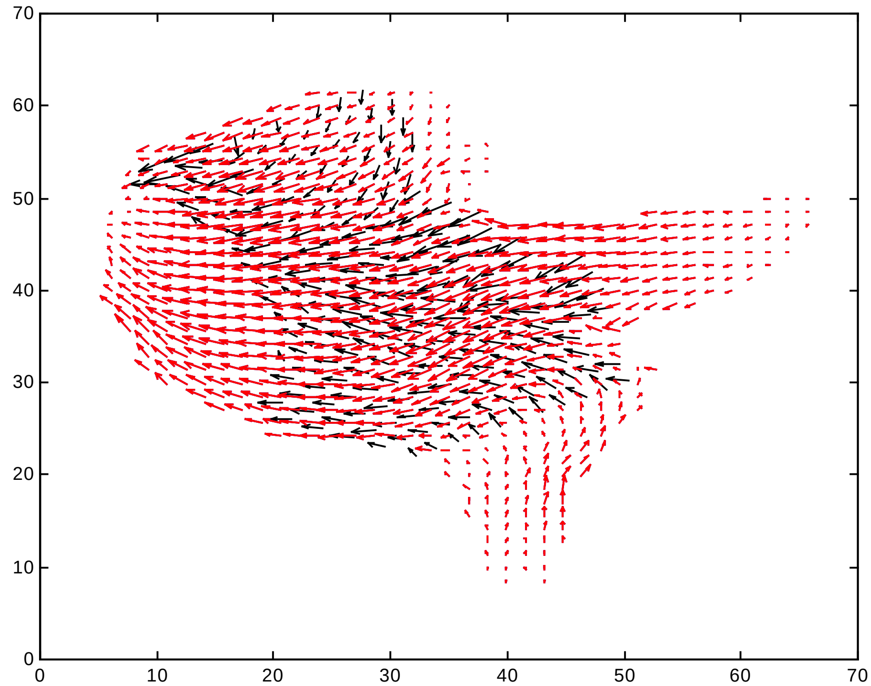


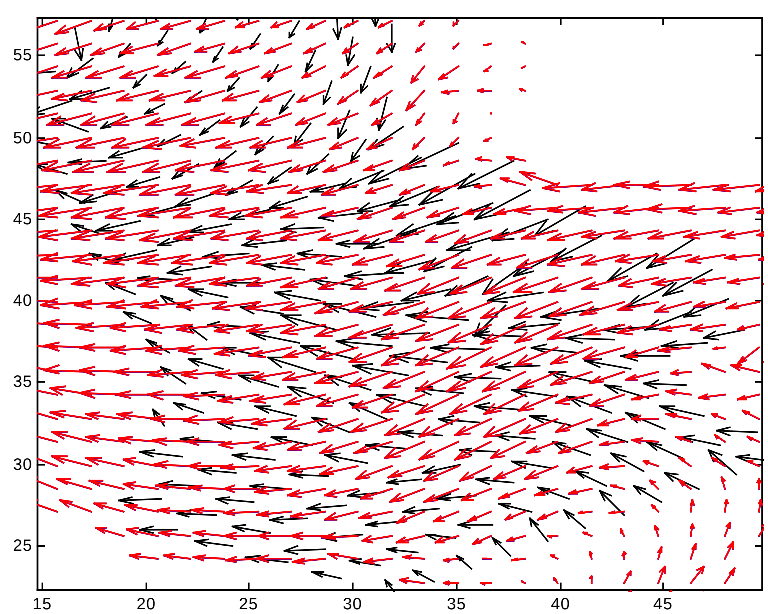
Radar 2 fitted data versus total vector data from SeaSonde for 0800 hrs Aug 29 2001





Combined fitted data versus total vector data from SeaSonde for 0800 hrs Aug 29 2001





Conclusions.

- We started with the radial vector data from individual SeaSondes.
- We calculated the radial projections of the total vectors from the PDE2D model toward each radar separately.
- Using over-determined linear Least Squares we recovered the given radial velocities.
- We were able to construct total vector maps using fitted data from each individual SeaSonde and the combined case.
- The position of the SeaSonde when considering total surface current maps from data of an individual Radar is important.
- The Normal Mode Analysis technique was successfully applied using HFRadar units.

Exhibit E GOMESA Performance Measures

CMP GOMESA Projects of Special Merit Performance Measures

For more information, please contact Julie McEntire at
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Fax: (512) 475-0680
Email: Julie.McEntire@glo.texas.gov
CMP website: https://glo.texas.gov/coast/grant-projects/funding/index.html

This form must be completed and submitted to the Texas Coastal Management Program as described in the contract.
The GLO must approve the completed form prior to issuance of the final grant payment.

Instructions

Please fill out each highlighted box in each of the following sections: Personal Info, Land Acquisition, Habitat Restoration, Water Quality, and Planning

Project Name:	High Frequency Radar for Texas Bays and Ports
GLO Contract Number:	21-155-002-C874
Contract Period:	04/01/21-03/31/24
Organization Name:	University of Texas at El Paso
Project Manager:	Dr. Rosa Fitzgerald
Address:	500 W. University Ave. El Paso, TX
Phone:	909-241-0105
Email:	rfitzgerald@utep.edu
County(ies) where project is located:	Galveston, Chanbers, Jefferson

Land Acquisition

If a question does not apply to your project, please leave it blank

		Notes
Coordinates		Not Applicable
Acquisition method (fee simple, conservations easement)		Not Applicable
Number of acres protected:		Not Applicable
Number of public access sites created		Not Applicable
Number of public access sites enhanced		Not Applicable
Texas Coastal Resiliency Master Plan project implemented (Y/N)		Not Applicable

Habitat Restoration

If a question does not apply to your project, please leave it blank

Number of miles or acres restored		Not Applicable
Number of public access sites created		Not Applicable
Number of public access sites enhanced		Not Applicable
Amount of sand/sediment placed (cubic yards)		Not Applicable
Texas Coastal Resiliency Plan project implemented (Y/N)		Not Applicable
Restoration of a coastal natural resource area (Y/N)		Not Applicable
Amount of marine debris removed (tons)		Not Applicable
Number of CZMA Section 6217 Best Management Practices employed		Not Applicable

Water Quality

If a question does not apply to your project, please leave it blank

Number of stakeholders engaged	76	
Number of technical workshops	3	
Number of peer-reviewed publications published/in-prep	3	
Number of students/technicians trained	12	4-_UTEP, 4- RATES, 4-Lamar
Number of water quality samples obtained		Not Applicable
Number of plans/ordinances under development/revision:		Not Applicable

Estimated pounds/amounts of pollutants removed as result of projects:		Not Applicable
Estimated pounds/amounts of pollutants abated (not generated) as result of projects:		Not Applicable
Texas Coastal Resiliency Plan project implemented (Y/N)	4	1) R0-7-State Flood Risk and Flood Management; 2) R0-08 Texas Coastal Non-Point Solution Program; 3) R0-09 Sediment Management Plan; r0-13 Lon-Term Hydrologic Monitoring Program
Number of CZMA Section 6217 Best Management Practices employed		Not Applicable

Planning

If a question does not apply to your project, please leave it blank

Number of state-level plans created		Not Applicable
Number of local-level plans created		Not Applicable
Number of ordinances created		Not Applicable
Number of projects completed at the local-level		Not Applicable
Number of projects completed at the state-level		Not Applicable
Number of stakeholders engaged		Not Applicable
Number of peer-reviewed publications published/in-prep		Not Applicable
Number of students/technicians trained		Not Applicable
Number of technical workshops		Not Applicable
Texas Coastal Resiliency Plan project implemented (Y/N)		Not Applicable
Money leveraged from other sources because of project		Not Applicable