

## First HF Radar Observatory in the Kingdom of Saudi Arabia

Contributed by Drs. Lobitzune Solabarrieta & Burton Jones of KAUST



Red Sea view from KAUST campus in Thuwal, KSA.

Historically, the Red Sea has been one of the lesser-studied water bodies on our planet. It is, however, significant to the Kingdom of Saudi Arabia (KSA), as a major resource for transportation, desalination and discharge of wastewater, mining, fisheries, tourism, recreation, and ecological conservation.

Saudi Aramco and King Abdullah University of Science and Technology (KAUST) jointly established the Saudi Aramco-KAUST center for Marine Environmental Observations (SAKMEO) in 2013, led by Professor Burton Jones. SAKMEO is the first oceanic observatory capable of monitoring the eastern Red Sea by observing and understanding the baseline physical and biological aspects of this unique environment using gliders, drifters, floats and in-situ data from cruises.

In 2015, SAKMEO installed the first HF radar network in KSA, composed of two CODAR SeaSonde® HF radars, monitoring surface currents and waves in the central Red Sea. One SeaSonde is located at a KSA Coast Guard station in Rabigh pairing with the other set on the KAUST campus in Thuwal. The system has been set up by personnel of CODAR, Spanish engineering company Qualitas Remos and KAUST.

Both stations operate at a frequency of 16.14 MHz, providing hourly surface current measurements up to 100km with a spatial resolution of 3km. Resulting outputs feed into the advanced PORTUS Marine Information System to provide an easily accessible web display and management capability for all the surface current and wave data.

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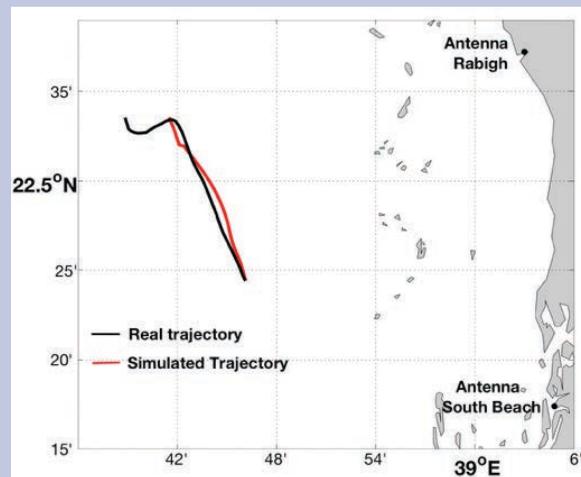
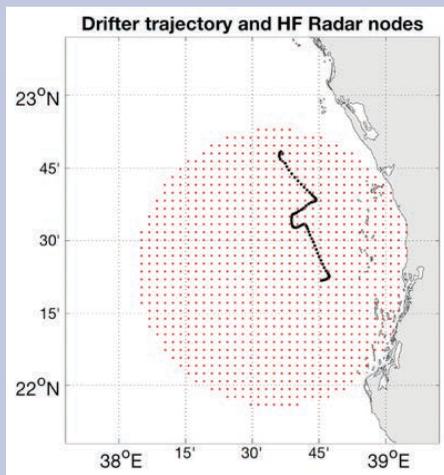
[www.codar.com](http://www.codar.com)

Story continued on next page

The new high spatio-temporal resolution dataset derived from the SeaSonde network will allow KAUST to study and understand different spatio-temporal scale circulation processes in the central Red Sea. Potential applications of these data and benefits for KSA include:

- Basic science, contributing to the Kingdom's fundamental understanding of ocean processes
- Tracking of marine pollutants
- Management of fisheries
- Marine protected areas design
- Improvement to safety of navigation in the area
- Assistance in search and rescue operations
- Assessment of the potential for ocean energy
- Future forecasting possibility once long-term time-series are established, including assessing impacts to coastal areas, improving weather forecasts and monitoring climate change.

Recently, during 8-11 June 2017, a Coastal Ocean Dynamics Experiment (CODE) drifter was deployed within the SeaSonde network coverage area, providing three days of in-situ surface currents data at 20 minute intervals. The drifter trajectory and the simulated trajectory produced from the HF radar measured currents via the PORTUS System are shown in the adjacent figures. The high similarity between both trajectories verifies the proper functioning of the new HF Radar system in KSA.



At left: Drifter trajectory visualized atop SeaSonde network footprint area. At right: Comparison plot between the real trajectory and PORTUS' simulated trajectory based on the SeaSonde outputs, showing excellent agreement, from June 9, 00:00 to June 10, 00:00 (24 hours).

The deployment of these first two CODAR HF radar units in the central Red Sea along the Saudi Arabian coast is the beginning of a more ambitious plan by SAKMEO to extend the network with additional stations along the northern and southern Red Sea coast. This future network will represent the most advanced and comprehensive HF radar network in the Middle East region.

More information about this project and other KAUST activities can be found at:

<https://iop.kaust.edu.sa/Pages/Home.aspx>

<https://rsrc.kaust.edu.sa/Pages/Home.aspx>



King Abdullah University  
of Science and Technology

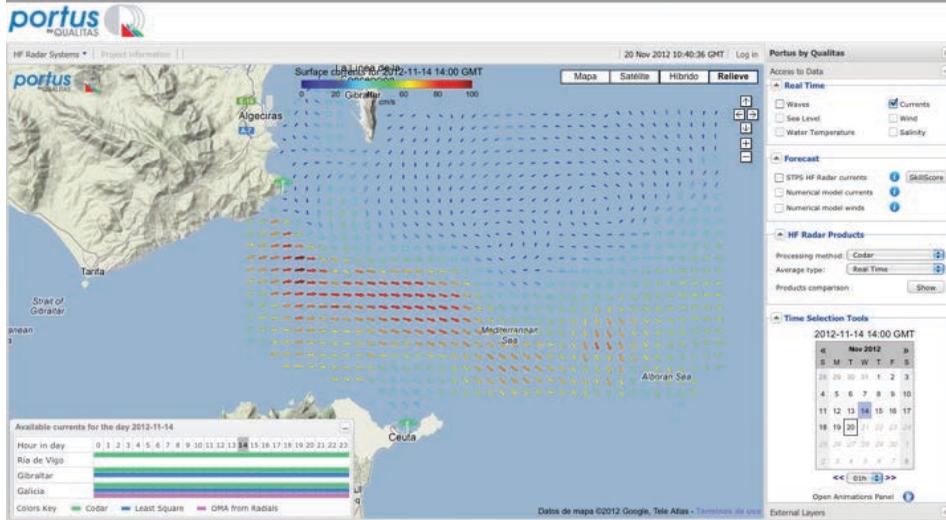
# PORTUS by Qualitas<sup>®</sup> Marine Information System

Integrates SeaSonde data outputs with other sensor & model data.

**P**ORTUS is a powerful multi-user, web-based Marine Information System that allows different users to display and manage SeaSonde data products with those from other sensors and models in an easy, intuitive environment. Initially developed in a cooperative effort between engineering firm Qualitas Remos and



Spain's Puertos del Estado for that government agency's use nearly a decade ago, Qualitas Remos has since created a commercial version that can be customized to meet specific needs of any program or organization. This is now being used within observing networks in Europe, North Africa and Middle East regions.



PORTUS user friendly web-based interface.

PORTUS features include:

- **User friendly web-based interface** to easily display and manage historic and real-time SeaSonde currents, wind and wave data using a mapping interface with zoom, pan and scroll features;
- **Open architecture to integrate comprehensive national observing systems** including ADCPs, buoys, tide gauges, met-stations, models and tailored derived products;
- **Flexible data sharing and export capabilities** to make data exchanges possible across different



Multi-language interface with Arabic selected.

multiple information systems (FTP, OPeNDAP) in different formats (ASCII, NetCDF, KML).

Additional system features include:

- **Multi-language support**, pull-down menu making it easy to switch between languages;
- **Fast access to information** using a calendar based component;
- **Individual surface currents vector values** are displayed just by clicking on any point of the surface currents 2D map;
- **Graphical time series** displayed for each surface currents velocity vector;
- **Wave time series information** displayed for each radar site;
- **Simple time series inter-comparison capability** for wave and current measurements by dropping time series sets on top of each other;
- **Movie making capability** to generate surface currents vector fields or other met-ocean data animation over any period of time for which data are observed;
- A tool to run, display and export **particle trajectory simulations** (both foreword and backwards) using the SeaSonde 2D currents fields as forcing;
- **Wind forecasts from NOAA's Global Forecasting System** can also be displayed in a standard way through PORTUS web viewer;
- Access to the web viewer and all other PORTUS functionalities are **login/password protected** and can be set to levels tailored for each authorized party. Contact CODAR or Qualitas Remos for more details.



MyOcean numerical forecast currents vs. CODAR measured currents: RMSE U and RMSE V comparison plots generated from the PORTUS.

# Combine Suite Release 8 Coming Soon

*Learn about new tools and features in the upcoming software release*

**C**ombine Suite Release 8 (CSR8), CODAR's latest version of the software driving the SeaSonde Central Management / Data Combining Station, will become available in the second half of 2017. CSR8 contains new features that will make your Central Management / Data Combining Station more secure, enable quicker combine processing and simplify the task of network monitoring, saving both time and money. Whether you are a data scientist, a network technician or project manager, there is something new in CSR8 for you.

## **Better Security**

Keeping with the latest security features in macOS 10.12, CODAR software is now classified as "100% code-signed" meaning CODAR is a registered developer whose software meets the latest industry security standards.

## **Easier Radar Network Management**

The tool that will make the biggest splash with those SeaSonde technicians monitoring their networks on a daily basis is the new Combine Suite Web Server. Its interface will be familiar to those who use the CSR7 and CSR8 radial site web interface to easily monitor data and diagnostics. What the Combine Suite Web Server interface uniquely gives you, though, in addition to the usual visualization of the 2D currents, is a network-at-a-glance overview of your radar unit diagnostics and warnings, to easily identify whether anything is operating out of acceptable bounds or that data is not available. This is a very useful timesaving feature.

Another CSR8 feature to ease the burden on network techs is the new smart archiving. While archiving is not the first thing one might think of for their SeaSonde network, data management is key to keeping things running smoothly. When the hard drive on your Central Management / Data Combining Station nears capacity, the new Archivist tool begins removing the oldest data in a way that allows the user to set priority their way. It's one less thing to worry about.

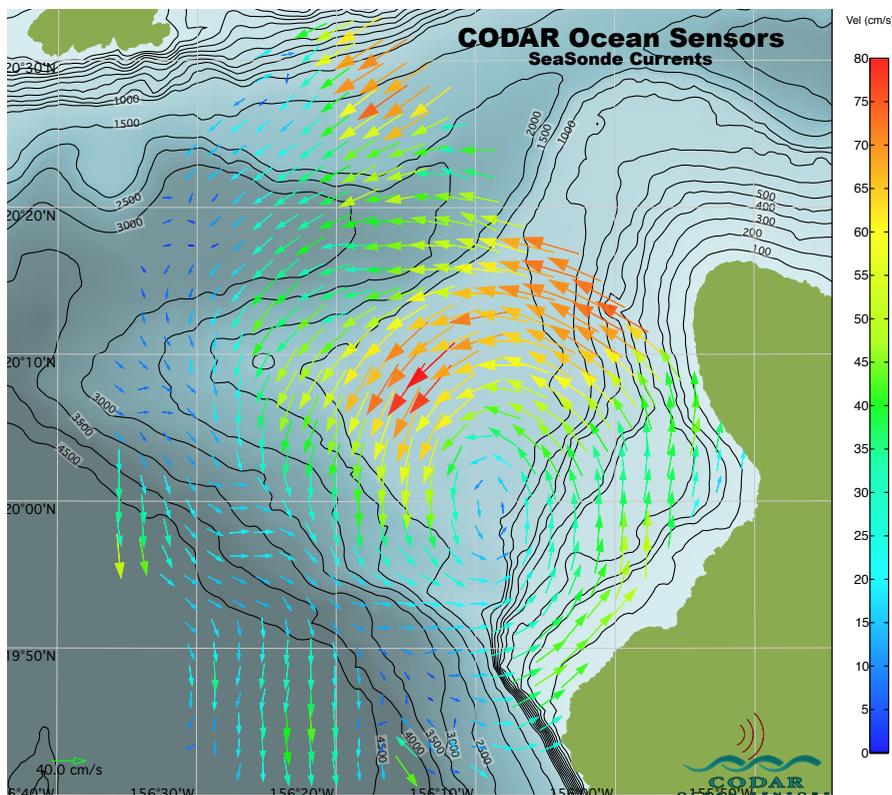
## **New and Improved Software Tools**

Many tools and applications have been redesigned including a more streamlined, easy-to-use software installer. The completely rewritten SeaDisplay 8 draws maps using vector graphics and Portable Document Format (PDF) output. SeaDisplay 8 contains many new features like bathymetry, coverage plots, map creation, map editing, site editing, and much more, all of which are available in a single, intuitive user interface.

Users of CSR8 will enjoy more than just a new SeaDisplay, though, as SpectraPlotterMap, DiagDisplay, and WaveDisplay have all been rewritten for ease of use, greatly enhanced graphics, and PDF output for crisp vectorized graphics. And for the Google Earth users out there, CODAR KML tools (LLUVtoKML, PattToKML, and TRAKtoKML) have been rewritten and enable easy generation of Keyhole Markup Language (KML) files. The software tool updates you'll find in CSR8 will make report and presentation prep a whole lot easier.

Combine processing is much faster even if producing multiple 2D vector output grids with minimal load on the processing computer. The new SeaSondeCombineOptions application offers real-time combine processing status. File exchange setup has been simplified along with new file transfer scripts.

In addition to these improvements, there are a host of others, including multiple baseline interpolation, compressed LLUV file support, and others. For a full feature list or to inquire about upgrading your SeaSonde Combine Suite existing software license to Release 8, please contact CODAR company or your local authorized CODAR dealer.

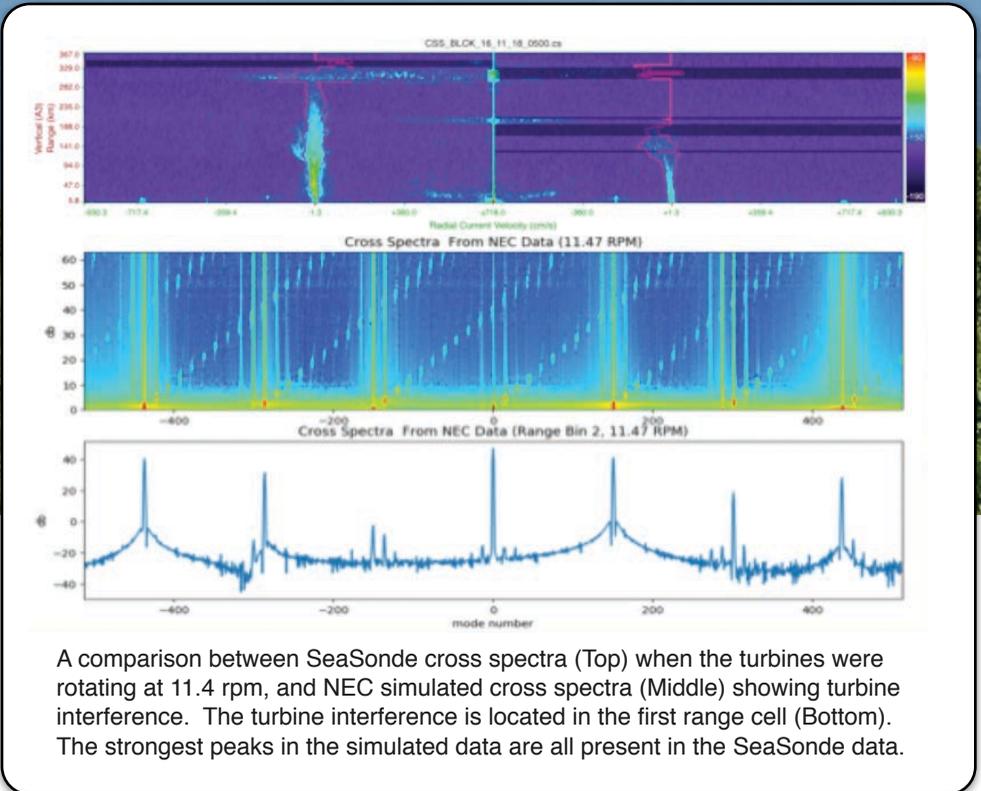


# Mitigating Offshore Wind Turbine Interference in HF Radar Networks

The reflection of the HF radar signal from the spinning blades of an offshore wind turbine has been observed to have an impact on HF radar systems in Europe. With the first U.S. offshore wind turbine facility going operational in 2016 in the monitoring area of the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) SeaSonde network, the proximity of radars and turbines prompted a study to better understand the potential effects on the U.S. National HF Radar Network. Construction of several more offshore wind turbines is planned to begin in the coming years, begging the question: what can be done to minimize the impact on the U.S. National HF Radar Network?



SeaSonde at Block Island looking out towards offshore wind turbines



A comparison between SeaSonde cross spectra (Top) when the turbines were rotating at 11.4 rpm, and NEC simulated cross spectra (Middle) showing turbine interference. The turbine interference is located in the first range cell (Bottom). The strongest peaks in the simulated data are all present in the SeaSonde data.

Unlike fixed objects, the periodic change in radar cross-section (RCS) of a turbine creates a signal spike in the Doppler cross spectra, and since the turbine blades are longer than a wavelength, those peaks appear in more than one range/Doppler bin and will vary in range and Doppler as the turbine rotation rates change.

This presents a challenge for processing software. CODAR is now almost half way into a two-year study funded by the Bureau of Ocean Energy Management (BOEM) to assess, classify, and mitigate the turbine-induced interference. With six radar sites, including both 25 MHz and 5MHz systems on Block Island, this first offshore wind farm is proving to be an excellent testbed.

Due to the complex nature of the interference, the initial turbine study relies on the comparison between numerical simulations and radar data. For simulations, we use the Numerical Electro Magnetic Code (NEC), developed at Lawrence Livermore National Laboratory, to simulate the RCS of the turbines with their fan blades in different positions. The RCSs are then put into a time series corresponding with a given rotation rate. A simulated cross spectra of expected interference is then produced by running the time series through CODAR's dual FFT FMCW processing. By using this process with the fan blades spinning at different RPM, we can see the expected location of the turbine interference in the SeaSonde cross spectra. Ultimately, this helps us distinguish the difference between peaks in SeaSonde cross spectra from vessels and turbine interference as well as if the turbine contamination falls in the Bragg region. By comparing the simulated data to radar data, we can also estimate the rotation rates of the turbines and use this information to design noise mitigation techniques. Now that we have been able to classify the structure of the interference we are moving forward with our efforts into removal methods.

Study funding was provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, D.C, under Contract Number M16PC00017.

# Development of Combined Transmit-Receive Antenna for Long-Range SeaSonde

*SBIR-funded technology development program will bring valuable siting flexibility for Long-Range systems*

Long-Range (LR) SeaSonde systems transmitting in the 4-5.5 MHz band, with nominal offshore ranges of 160-220 km and range resolutions of 3 – 6 km, account for approximately one-third of the stations in the U.S. National HF Radar Network, part of the U.S. Integrated Ocean Observing System (IOOS). LR SeaSondes are a crucial component as they provide the largest coverage area and farthest offshore range for applications like search and rescue, spill response, among others. In analyzing data collected during both hurricanes Irene (2011) and Sandy (2012), researchers at Rutgers University were able to show that the two-dimensional surface current data from their LR SeaSonde network can be a key observation tool, along with subsurface gliders and satellite data, that can help better predict the intensity of approaching hurricanes and their associated storm surge before they make landfall [Glenn, et al, 2016].



SeaSonde antenna damaged by Hurricane Sandy storm surge. Photo provided by Rutgers University.



Sadly, Hurricane Sandy's storm surge, which devastated entire communities along the Northern New Jersey and New York coasts, also damaged many of the HF radar stations installed in the most vulnerable positions along low-lying areas [Malakoff, 2012]. When rebuilding in the Mid-Atlantic region an additional hardening of the HF radar installations was performed [Roarty, 2013] to try and mitigate damages in future storm events and is an important planning consideration in many operational networks.

LR SeaSondes presently require separate transmit and receive antennas spaced approximately 60 m apart, which precludes mounting them on most structures and platforms leaving only ground-mounted solutions. Although SeaSonde antennas are designed to withstand hurricane force winds, when mounted on the ground, they can be vulnerable to damage from intense storm surges and erosion in low-lying areas as they were during Sandy. By redesigning the LR SeaSonde antenna as a co-located single-mast solution, like the present configuration for SeaSonde antennas above 11 MHz, they can be placed in areas better protected from severe storm surges, providing valuable data on approaching storms.

Earlier this year, CODAR applied for, and was awarded, a FY2017 Phase I Small Business Innovative Research (SBIR) Grant to design a single-mast LR SeaSonde antenna system for placement on hardened, fixed structures like concrete buildings and parking structures or on existing hurricane-resilient stations like NOAA Sentinels. Sentinels are water level observing stations, designed by The Center for Operational Oceanographic Products and Services (CO-OPS), part of NOAA's National Ocean Service (NOS), that have been strengthened to deliver real-time storm tide data during severe coastal events. These stations, one of which is shown in the adjacent photo, are single-pile structures designed to withstand category 4 hurricanes. CODAR is partnering with the Texas General Land Office (TGLO) to utilize their Sentinel stations in the design and testing process. The Phase I program runs 6 months and is structured like a feasibility study in which concepts and designs are investigated. Following the phase I program, CODAR will be applying for FY2018 phase II funding in which a prototype will be built and tested.

## References:

1. Glenn, S. M. et al. Stratified coastal ocean interactions with tropical cyclones. *Nat. Commun.* 7:10887 doi: 10.1038/ncomms10887 (2016).
2. Malakoff, D. Scientists Assess Damage From Sandy's Deadly Punch. *Science*, vol. 338, pp. 728-729 (2012).
3. Roarty, H. Repair and Hardening of Mid Atlantic Ocean Observing Assets After Hurricane Sandy. NOAA Cooperative Agreement Proposal (2013).



# Recommended Reading

*Notable publications from CODAR user community*

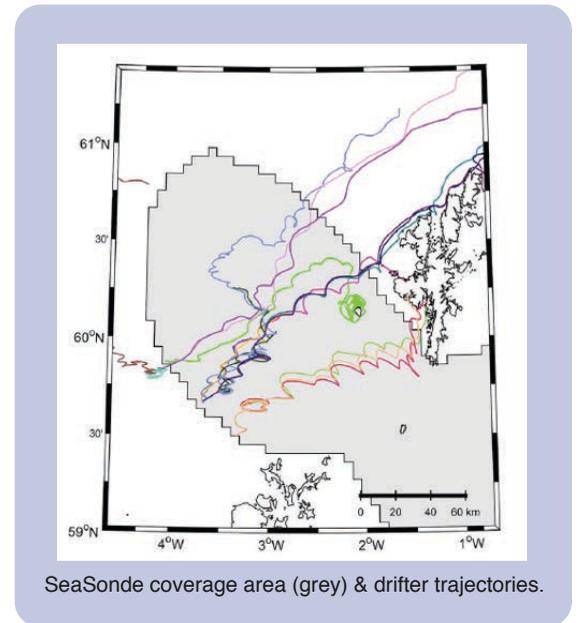
## Operational Oil Spill Trajectory Modeling Using HF Radar Currents

The broad spatial and temporal scale of SeaSonde surface current data represents an untapped resource for oil spill mitigation and is especially valuable when combined with oil spill detection solutions such as satellite imagery. Recognizing this potential, IH Cantabria and Marine Scotland approached the challenge strategically, addressing data gaps with Open Modal Analysis (OMA), assimilating a short term predictive system (STPS) for 12 hours of forecast currents, and implementing the TESEO oil spill transport and fate model. The resulting real-time oil spill trajectory system was integrated into the PORTUS Marine Information System, allowing web-based or private Internet access.

This publication details the multi-layered work effort and a successful test case in the Fair Isle Gap, a channel separated by two island chains in the northwest European shelf sea. The oil spill trajectory forecast model was validated with 18 drifter deployments. On average, OMA-enhanced, STPS currents reduced error in the simulated trajectory by approximately 40% compared to hydrodynamic model output.

SeaSonde currents prove useful in hindcast mode - for detection of the origin of pollution and debris in the sea - and in forecast mode, to inform real-time response efforts. PORTUS takes the operational system one step further with its integration of environmental data, cohesive visualization, and flexible data output options.

Abascal, A.J., Sanchez, J., Chiri, H., Ferrer, M.I., Cárdenas, M., Gallego, A., Castanedo, S., Medina, R., Alonso-Martirena, A., Berx, B., Turrell, W.R., Hughes, S.L. "Operational Oil Spill Trajectory Modelling Using HF Radar Currents: A Northwest European Continental Shelf Case Study." *Marine Pollution Bulletin*, Vol. 119, No. 1, 336-350 (2017).



SeaSonde coverage area (grey) & drifter trajectories.

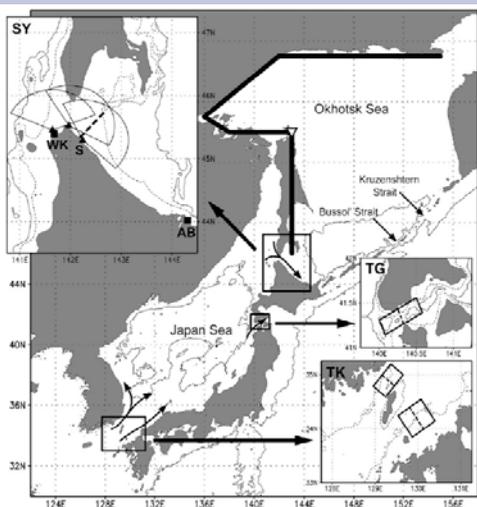
## Soya Strait SeaSonde Current Data Fills Japan Sea Throughway Knowledge Gap

Twelve years of SeaSonde current data served as a crucial long term dataset in Soya Strait, an outlet of the complex Japan Sea Throughflow, which provides passage for a portion of the Kuroshio Current. While transport through two of the three straits is well studied, Soya Strait has not been investigated with long term records until now. Fishing activity, the national border, and winter sea ice have hindered access, however, continuous monitoring from three standard range SeaSondes provided 95% coverage along the study transect line from August 2003 to August 2015.

The extensive record of surface currents provided a key component of volumetric flow rate, or flux, calculations through Soya Strait. Annual flux values were used to quantify the distribution of flow, heat, and salt through the Japan Sea Throughflow, closing these budgets for the first time. Monthly means reflected a seasonal peak in flux during summer/fall and a minimum in winter/spring. Wind stress along the east coast of Sakhalin was identified as a significant transport mechanism, setting up greater differences in sea level between the Japan Sea and the Sea of Okhotsk during the summer/fall.

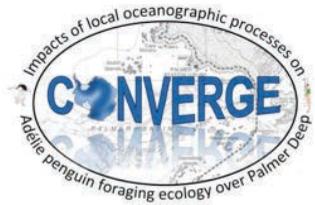
The discoveries in this article have implications for the role of the Japan Sea Throughflow in atmospheric cooling. In addition, potential sources of regional oceanic waters are identified. We recommend exploring the details.

Ohshima, K.I., D. Simizu, N. Ebuchi, S. Morishima, and H. Kashiwase. "Volume, Heat, and Salt Transports through the Soya Strait and Their Seasonal and Interannual Variations." *Journal of Physical Oceanography*, Vol. 47, No. 5, 999-1019 (2017).



Study area. SY, TG, TK represent Soya Strait, Tsugaru Strait, Tsushima-Korea Strait, respectively. Study transect is dashed line above S. Triangles represent SeaSondes.

# Successful Project CONVERGE in Antarctica



## SeaSonde helps reveal processes that may be affecting Adélie penguin population

**A**délie penguin populations near Palmer Deep Canyon in Antarctica have been in serious decline since the 1970's. According to Principal investigator Dr. Josh Kohut of Rutgers University, the project CONVERGE multi-year mission, sponsored by the U.S. National Science Foundation (NSF), aims to “investigate the impact of local coastal physical processes (e.g. tides, currents, upwelling events) on Adélie penguin foraging ecology in the vicinity of the Palmer Deep submarine canyon, off Anvers Island on the Western Antarctic Peninsula (WAP). Guided by real-time maps of surface convergent features derived from the SeaSonde HF radar network, a multidisciplinary research team adaptively sampled the distribution of phytoplankton and zooplankton, which influence Adélie penguin foraging ecology, to understand how local oceanographic processes structure the ecosystem.”



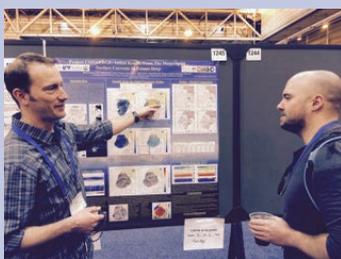
SeaSonde installation in Antarctica



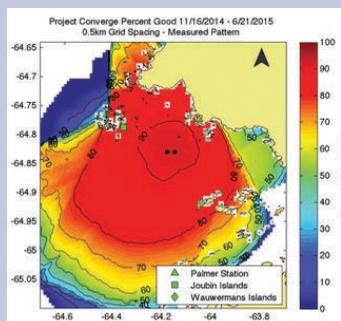
Adélie penguins

This part of the world's ocean is highly under-sampled and even general ideas of current velocities, wave conditions and variabilities on spatial and temporal scales of the canyon were not known prior to start of this project. The first season HF radar deployments in early 2014 served to determine the optimal system operating parameters for this region via a series of field tests. In the next summer season of 2015 three SeaSonde radars were redeployed using optimal configurations and settings having been pre-determined inside the initial season, with data outputs guiding adaptive biological sampling. Two sites were deployed on remote islands beyond the reach of any existing power and communication. At these locations, the team from the University of Alaska, Fairbanks designed and deployed a remote power and communication system based on solar and wind energy. These remote systems worked flawlessly throughout the summer penguin foraging season needed to address the proposed science. Despite the remote locale, this SeaSonde network performed reliably through sampling season. The field campaign was a success and subsequent analysis of the data collected has proved it invaluable.

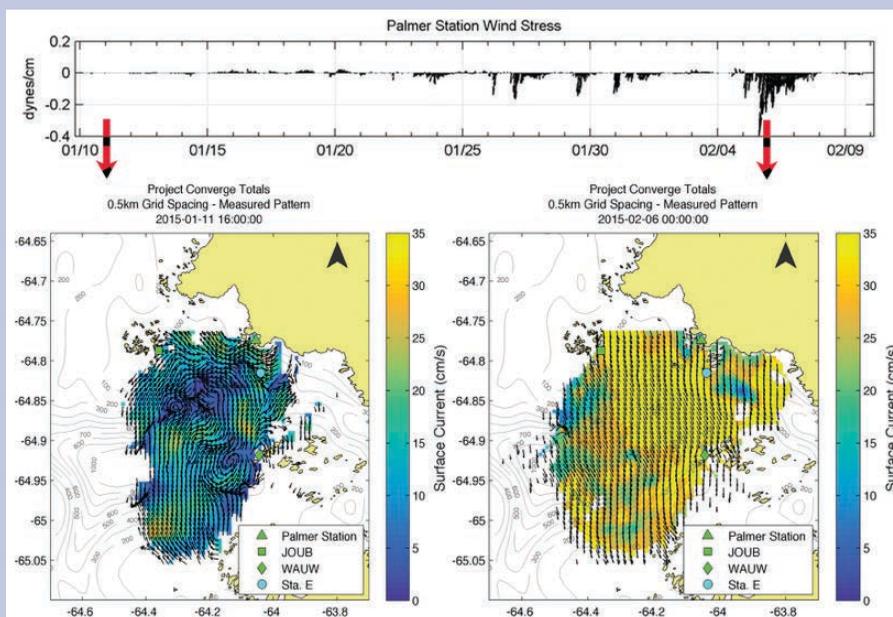
Details about the study, with specific focus on the HF radar network aspect, were presented by Hank Statscewich of University of Alaska Fairbanks and other project collaborators in 2016 at the AGU Ocean Sciences meeting in New Orleans, Louisiana. We thank Hank and the rest of the Project CONVERGE team for allowing us to re-post a few of their findings here:



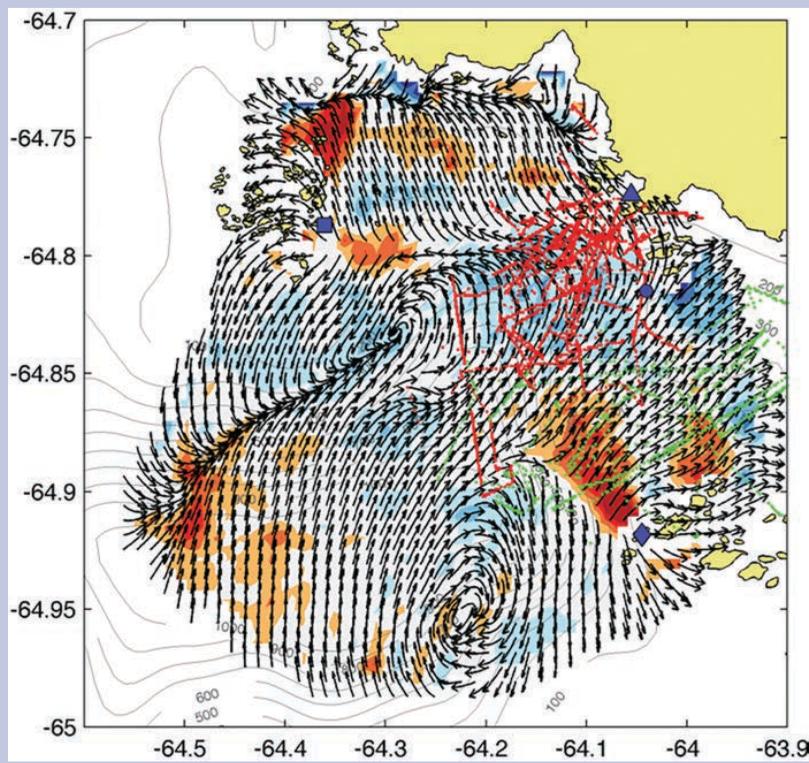
Project team member Hank Statscewich at AGU Ocean Sciences 2016.



Percentage coverage from the 3-radar network during intensive sampling period.



Above Top: Time series of water levels at Palmer Station during the intensive field sampling period in January 2015. Above Left: An example map of raw surface currents during a period of calm winds reveals complex circulation features such as coastal jets, multiple small scale vortices and topographically steered flow. In contrast to (Above Right): Circulation captured by the HFR, during a period of storm winds show the surface currents in Palmer Deep exhibit spatial uniformity, with the flow field directed to the South East consistent with Ekman theory.



HF Radar January mean surface currents with divergence contours and satellite tagged Adélie (red) and Gentoo (green) penguin foraging locations reveal a preference for foraging at convergent features. During semi-diurnal periods, a region of persistent convergence exists to the south of the Joubin Island site. This feature may help to explain the foraging behavior of the penguins in Palmer Deep and why they are moving into dangerous waters for their predator enemies.

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As the analysis of this valuable data set continues, more results are being shared. For example, at the MTS/IEEE Oceans '17 Anchorage meeting Ms. Nicole Cuoto of Rutgers University will give presentation entitled, "Pathways and retention times in a biologically productive canyon system on the West Antarctic Peninsula". For anyone keen on linking physical with biological oceanography this is a must-see presentation.

But the value of this data extends far beyond the most elite scientific circles. Given the awe-inspiring location of the research and heart-wrenching plight of the Adélie penguins, this program has been warmly embraced by the education outreach community. In July 2017 Dr. Kohut came to Monterey, California where he participated in the 2017 Education And Research: Testing Hypotheses (EARTH). At the workshop, he engaged with over 20 teachers who work with middle and high school students across the country. Together they developed classroom lesson plans that incorporate the science of the CONVERGE team. Through these lesson plans, their students will be introduced to the CODAR data collected over Palmer Deep and the science it supports.

He will again address CONVERGE outreach inside the MTS/IEEE Oceans '17 Anchorage meeting, in session on Maritime Law, Policy, Education and Outreach, with a talk entitled, "Project Converge: A broader impact plan that engaged educators and students in the process of polar ocean science campaigns".



SeaSonde in Antarctica.  
Courtesy of UAF

# Just Another Day at the Office: Servicing the SeaSonde at Cape Simpson, Alaska

*From the journal of Hank Statscewich, University of Alaska Fairbanks*

**J**uly 19, 2017: Myself and fellow UAF technician Cayman Irving meet with our Inupiat whaling captain and deck hand in Barrow, Alaska. We are about to embark on a journey to our SeaSonde HF radar site located about 60 miles East of Barrow at a remote stretch of coastline fronting the Beaufort Sea called Cape Simpson. Our 32' foot landing craft, the Doctor Island, is loaded with tools, transponders, emergency survival gear (tent, stove, water, fuel, etc...) in case we get stuck by inclement weather, and our trusty 12 gauge shotgun loaded with cracker shells and slugs for ammunition, just in case the "locals" get curious...

You might be thinking that seems a bit rude, shotguns for a science project? Well this particular location is frequently inhabited by *Ursus maritimus*, aka Nanook of the North, aka the wiley Polar Bear, one of the few creatures on earth who consider humans food. In a dreary fog and rain, we hook up the Doctor Island to the tractor and drive down to the beach to launch her into the Chukchi Sea. With a radio check to the local search-and-rescue (SAR) team on shore, we confirm that our safety net is in place. About ten minutes later we round Point Barrow, the Northernmost tip of the United States and immediately see the leading ice edge of the Arctic Ocean. Chunks of the ice pack that has been grounded all winter long bob about in the calm seas. Curious seals pop their heads up but know better than get too close; for many generations the bearded seals of the area are prized as a delicacy in this part of the world. An alarm sounds in the closed cockpit of the vessel, our water pump for the engine cooling system isn't doing its job. A quick check down in the engine hold reveals that a seal (of the other kind) needs tightening. Wrenches are located and the fix is made, soon enough we are back up on step and cruising at 30 knots towards our intended drop zone. Slaloming in between ice floes at top speed, I feel like I'm in a video game, but with 100% confidence in the decades of experience that our native Barrow captain has under his belt, I sit back, relax and enjoy the view. After about two hours of finding open water leads through the jumbles of ice and fog, we approach within 500 yards of our GPS waypoint. As we slowly approach the beach, the wind turbines and solar panels of the Remote Power Module (RPM) emerge from the fog.

Cape Simpson is remote and lacking in any type of infrastructure including a source of electricity. To meet the power requirements of a CODAR SeaSonde, a satellite telemetry for real-time data feeds, a pair of vessel tracking AIS radios and a meteorological station, the University of Alaska Fairbanks developed the RPM. Four wind turbines and a solar array charge a large battery bank that powers the instruments through the ice-free season. All the instruments are housed in a walk-in freezer, a well insulated and water-tight enclosure with heating elements inside to ensure that all the electronics remain warm and dry in the harsh Arctic environment.

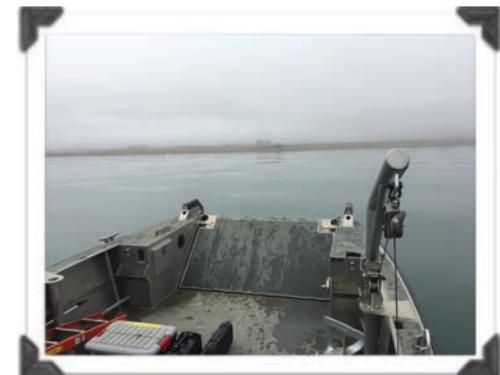
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Cape Simpson at approx. 71° N latitude.



Traversing the ice at 30 knots.



RPM seen from afar.



Remote Power Module designed and built by UAF.



SeaSonde with RPM at Cape Simpson, Alaska

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Ocean current measurements are critical for understanding marine ecosystem and coastal processes, delineating critical habitat, designing offshore structures, mitigating impacts from offshore development, search-and-rescue operations, and responding to contaminant spills in the marine environment. The Cape Simpson HFR site has expanded the UAF surface current mapping efforts to include the western Beaufort Sea, where no surface current measurements have previously been made. This region, which lies at the junction of the Chukchi and Beaufort continental shelves, has a complex, but poorly understood circulation. The circulation here is complex because it includes currents flowing northeastward from the Chukchi Sea and thence eastward around Pt. Barrow and onto the inner Beaufort shelf and shelfbreak. This flow often collides with a westward wind-driven flow over the Beaufort Sea shelf. The intermingling of these water masses is further complicated by the complex bottom topography near Pt. Barrow that includes shoal regions and a canyon. The western Beaufort coast is an eroding coast and currents in this region act as vehicles for the resuspension and transport of coastal sediments. It is also a critical fall habitat for foraging bowhead whales migrating south from their eastern Beaufort feeding grounds to the Bering Sea and the area's coastal waters are utilized by numerous sea birds. The need for this environmental information is pressing given the serious interest in exploration (and possible development) of the hydrocarbon potential of the Chukchi and Beaufort seas.

Before stepping off our craft, our captain and helper do a complete scan of the coastline to make sure we aren't going to surprise any of the locals. We are given the thumbs up to disembark and as we begin to round up our gear and tools I can tell from the excited snatching of the binoculars and pointing that our deck hand has spotted something in the distance. I squint and peer as hard as I can but I can't see through the pea soup fog beyond the RPM. I wander back into the cab and ask, what are you guys so excited about?

"A herd of caribou," says the captain, "look they are making their way toward us, at least 500 of them."

A few moments later, the herd approaches, great big bulls, cows and babies traversing the arctic tundra all the way to the coast, avoiding the mosquitoes that are nicknamed the Alaskan, "state bird." Against the backdrop of the lapping waves on the shore, I can hear their grunts and clicks of hooves on the tundra. They are close, within 100 yards, the sound of their smacking jaws as they munch on lichen is now the only sound. We are mesmerized by the display of raw nature. Just as soon as they appeared out of the mist, they are gone again.

After completing a systems check on the exterior of the RPM, we unlock the enclosure and peer inside. The battery bank is happy at 24.8 V DC and we have been making solar power on all three PV strings. We install the SeaSonde electronics, a new mac-mini, turn power on to the electronics and boot up the system. Transmit power is acceptable, VSWR within limits and we are receiving strong signals on two of the three receive channels. A quick check at the receive dome base reveals the problem: a single coaxial connector had been stressed so I swap out with a new one. An easy fix, Eureka!!!

On this particular trip, the only major repairs that Cayman and I make are to a wind turbine mast that had been badly damaged by a winter storm. After that, our remote power site is once again fully functional, the SeaSonde operating, satellite data streaming back to Fairbanks and the AIS systems once again fully operational. The site had not seen any human intervention since almost seven months ago so I think we have been lucky considering the locale... All told, the site visit lasts just a few hours but the memory will last a lifetime. We board our vessel and make the long trip back to Barrow with the knowledge that our SeaSonde site will provide valuable data to the scientific community and the United States Coast Guard (in light of the increased vessel traffic in the region), and to the state of Alaska by providing it with the necessary data for the informed management of its marine resources.



Caribou grazing on the Arctic tundra.  
All images are courtesy of Hank Statscewich, UAF

# Upcoming Events

*CODAR company staff and its affiliates will be participating at the following upcoming events. We hope to see you there!*



## **MTS/IEEE Oceans '17 Anchorage**

18-22 September 2017, Anchorage, Alaska USA

Explore CODAR equipment on display inside the U.S. IOOS exhibit stand #817.

## **Radiowave Oceanography Workshop (ROW) 2017**

19-21 September 2017, Lunenburg, Germany

A number of presentations by SeaSonde users from USA and Europe on the analysis or application of SeaSonde data are included in the workshop agenda. CODAR Europe team member Pedro Agostinho will present on the application and evaluation of CODAR AIS-assisted automatic antenna pattern measurement technology with the Espichel Cape SeaSonde.

## **Mid-Atlantic Bight Physical Oceanography and Meteorology Meeting (MABPOM) 2017**

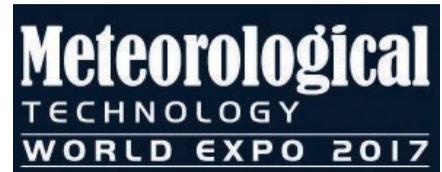
28-29 September 2017, Wanchese, North Carolina, USA

CODAR is proud to co-sponsor this consistently high-caliber scientific event.

## **Meteorology Technology World Expo '17**

10-12 October, Amsterdam, Netherlands

Meet CODAR staff and explore CODAR technology on display at exhibit stand #7075.



## **Oceanology International (OI) China 2017**

1-3 November 2017, Qingdao, PRC

CODAR affiliate Laurel Technologies will be featuring SeaSonde and RiverSonde technologies in their company exhibit stand along with a suite of other impressive ocean observing technologies.

## **AGU/ASLO/TOS 2018 Ocean Sciences Meeting**

11-16 February 2018, Portland, Oregon, USA

Meet CODAR staff and Explore CODAR technology on display at exhibit stand #205.



## **Oceanology International (OI) 2018**

13-15 March 2018, London, England UK

Meet CODAR staff and Explore CODAR technology on display at exhibit stand #E10.

