



Progress Report

Project Title: Accelerate Improvements in Hurricane Intensity Forecasting Through Underwater Glider Field Campaigns

Award number: #NA22NOS0120178

Period of Activity: 03/01/2024 – 08/31/2024

Submission Date: 9/23/2024

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Co-investigators: Gerhard Kuska (MARACOOS), Travis Miles (Rutgers University), Jorge Brenner (GCOOS), Stephen Howden (GCOOS/University of Southern Mississippi), Julio Morell (CariCOOS), Patricia Chardón-Maldonado (CariCOOS), Jennifer Dorton (SECOORA), Catherine Edwards (Skidaway Institute of Oceanography, University of Georgia)

I. PROJECT GOAL:

The overall goal of this project is to conduct targeted and sustained underwater glider deployments during the 2023 and 2024 Atlantic hurricane seasons. Glider missions collect ocean observations that optimize the representation of ocean features in ocean-atmosphere coupled models used for hurricane intensity forecasts. The glider field campaign is designed to collect data in hurricane-prone regions of the U.S. (Caribbean Sea-Tropical Atlantic Ocean, Gulf of Mexico, and the South Atlantic Bight and Mid Atlantic Bight).

Objectives from the proposal are identified in Section II Progress and Accomplishments. High-level accomplishments and any issues identified by each project team member are included for each objective. Status of each deliverable is reported as complete, on-track, or delayed. If the milestone is delayed, a justification for the delay and description of activities employed or to be employed to mitigate the delay are provided.

II. Progress and Accomplishments

Objectives	Status
<p>Objective 1: Coordinate IOOS Regional Association (RA) and OAR Atlantic Oceanographic and Meteorological Laboratory (AOML) glider sampling to measure subsurface temperature and salinity profiles during the Atlantic hurricane season.</p>	
<p>The following accomplishments detail glider deployments during the 2024 Hurricane Season through 8/21/2024 and other work that is underway by each IOOS Regional Association (RA). Accomplishments:</p>	On-track

- MARACOOS completed refurbishment and upgrades of gliders. The following glider deployments have been completed to date:
 - MARACOOS_05 was deployed 6/19/24 to 7/9/24 on the MAB Shelf. The glider carried out a full cross-shelf triangle with a rechargeable battery. Full data was downloaded, and the glider re-ballasted and prepared for an upcoming deployment. Of note, this glider was purchased in late 2023 and delivered in spring 2024. This was its inaugural mission.
 - ud_476 was deployed 7/9/24 and recovered 8/5/24 from Lewes, DE. Unfortunately, the recently serviced and calibrated CTD from Seabird failed. Data from the glider were not submitted to the GTS due to the sensor failure. However, ud_476 carried an archival animal tag to develop a new animal location algorithm based on light, temperature, and diffuse attenuation.
 - MARACOOS_01 was deployed 8/5/24 and recovered 8/27/24 from Lewes, DE.
- The SECOORA glider team is comprised of members from UGA's Skidaway Institute of Oceanography (SkIO), University of South Florida (USF), and UNC-Chapel Hill. To date, two (2) 2024 Hurricane glider missions were completed off the coast of GA with the missions designed to capture the edge of the Gulf stream. Frontal stream eddies were captured during both missions with low oxygen, high nutrient cold water being upwelled into the ROI (see Appendix A for temperature, salinity, and density profiles).
 - SECOORA owned glider, Unit_1091, was deployed on 7/23/24 and recovered on 8/17/24.
 - Unit 1091 was redeployed on 8/20/24 with expected recovery in mid-Sept.
 - SkIO has been using the G3 rechargeable batteries to reduce time between glider deployments; however, there is a design flaw that leads to accidental unplugging while the glider is prepped for deployment.
- USF continued experimentation with 3D printed replacement fins for the glider Sam with mixed results. Longevity of functionality for the printed fins is in question and being researched further. Options to consider include coatings for the printed fins or moving to machined fins based on the printed prototypes.
- During the 2024 hurricane season, to date, CariCOOS and partners at NOAA-AOML, the US Navy, and OCOVI deployed 12 gliders during the reporting period with 8 hurricane gliders operating as of 8/31/24. Specific CariCOOS glider deployments are listed by date:
 - SG678, NG656 and NG735 were all deployed on 6/13/24 off Puerto Rico. NG735 had a navigation issue caused by an internal sensor malfunction and was recovered on 6/17/24. SG678 and NG656 remain at sea.
 - NG412 and NG284 were deployed in the USVI south of St. Thomas on 7/10/24. NG284 had a leak in the aft compartment and was recovered on 7/18/24. NG412 had an issue with the digifin leading to recovery on 8/7/224.
 - SG609, SG610, and NG278S were deployed off the south coast of Puerto Rico on 7/11/24. SG609 experienced issues with the buoyancy potentiometer, which measures the oil in the reservoir needed to control the exact displacement and was recovered on 7/13. SG610 and NG278S are still at sea.
 - SG649 was deployed off the north coast of Puerto Rico on 7/12/24 and is still deployed.

<ul style="list-style-type: none"> ○ SG630 was deployed off the south coast of Puerto Rico on 7/13/24 and replaced glider SG609 which was recovered on 7/13/24 due to buoyancy issues. SG630 is still at sea. ○ NG738 and NG783 were deployed south of St. Thomas, USVI on 8/7/24. NG738 replaced NG412 which was recovered on 8/7/24 due to an issue with the digifin. Both NG738 and NG783 are still at sea. ● GCOOS is the glider mission planning leader for the Gulf of Mexico with collaborators from the Texas A&M Geochemical and Environmental Research Group (GERG), University of Southern Mississippi (USM), and USF. The team conducted 5 missions this season, to date: <ul style="list-style-type: none"> ○ GERG deployed Units 307 and 1148 on 6/7/24. Both gliders were in the water when hurricane Beryl made landfall in Matagorda, TX. Unit 307 did develop some issues ~2 weeks after the storm passed. It could not dive to required depth and it aborted due to low voltage after struggling for more than a week. This prompted a recovery on 8/27/24. Upon recovery, it was discovered that the glider had lost a wing which probably resulted from boat strike. Unit 307 completed 52 days at sea. Unit 1148 is still deployed and is on course to accomplish its 90-day mission. ○ GERG deployed Unit 308 on 8/11/24; however, on 8/13/24, the team conducted an emergency recovery due to an anomaly detected in the flight data. The team found the glider with a broken wing rail and a missing wing, likely caused by a propeller strike from a boat. Following a thorough onboard inspection, the team repaired and redeployed the glider and it is still at sea. ○ USM received two Hefring Seascout gliders (Ori, with a CTD and PAM, and Nori, with just CTD). The USM team underwent two days of Hefring training in May and several test missions with Ori and Nori occurred between 6/24/24 and 8/11/24. There has been a learning curve for USM glider operators as firmware and control software updates have been needed during test missions. USM is working out glider issues with Hefring to make the system a valid low-cost alternative for hurricane glider data. ○ USM has determined that the 30-day battery life promised by the company is actually 14 days in the shallow water where USM is operating. Therefore, two glider missions (1-Nori and 1-Ori) accrued a total of 28 wet days. While USM continues to work with Hefring to better the system, USM intends to deploy more missions in the 2024 hurricane season and early 2025 season. Plots of data from Ori are available in Appendix B. 	
<p>Objective 2: Submit real-time ocean glider profiles to the IOOS National Glider Data Assembly Center (GDAC), where data are quality-controlled and harvested by the NWS for assimilation into the operational NOAA Real-Time Ocean Forecast System (RTOFS)</p>	
<p>Near real-time data from the above listed deployments (except for ud_476) were submitted to the IOOS GDAC.</p> <p>Additional data management accomplishments:</p> <ul style="list-style-type: none"> ● GCOOS GANDALF: 15 completed deployments available on GANDALF and 29 on-going deployments are available. DMAC team member Xiao Qi provided updates to the 	<p>On-track</p>

<p>ARGO float visualization tool for GANDALF and the HYCOM streamlines tool.</p> <ul style="list-style-type: none"> • In conjunction with Kevin Martin of USM, Bob Currier developed a GANDALF module to support the Hefring Oceanscout, and successfully submitted data from two deployments to the IOOS GDAC. • SECOORA glider operators are submitting delayed mode glider data to the SECOORA Research Workspace within 30 days of glider recovery. These data are then made available to the IOOS GDAC. • CARICOOS glider data undergo quality control procedures to ensure accuracy. Data is also archived/distributed through CARICOOS THREDDS/OPeNDAP and ERDDAP servers for easy access and visualization. Additionally, the data are being used to monitor heatwaves, offering insights that can help mitigate their effects on coral nurseries and support coral reef restoration efforts. • CARICOOS is using enhanced satellite-based monitoring, incorporating new parameters and refining glider-derived products to support real-time piloting. 	
<p>Objective 3: Coordinate IOOS Regional Association (RA) and OAR Atlantic Oceanographic and Meteorological Laboratory (AOML) glider sampling strategies with the IOOS Glider Lead and the National Weather Service (NWS) National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC) to improve model forecast accuracy</p>	
<p>Project team representatives from each RA participate on IOOS-led glider calls. These calls are hosted on Mondays and are bi-weekly during the non-hurricane season and weekly during hurricane season. Additional collaboration efforts are listed here:</p> <ul style="list-style-type: none"> • Representatives from each RA participated on the Hurricane Glider Briefing (Virtual) hosted 4/26/24 conducted for NOAA and US Navy leadership. • Each RA coordinates with national efforts through participation in the Underwater Gliders User Group (UG2 - https://underwatergliders.org/) community with representatives from each RA planning to participate in the September UG2 meeting in Michigan. 	
<p>Additional Areas of Success and CHAOS collaboration</p>	
<p>Project team success stories that are not specifically part of the proposal, but which contribute to the overall IOOS and project team missions, are provided below:</p> <ul style="list-style-type: none"> • USF and GCOOS are active participants in the GOMO/EEOTT (CHAOS) group. • MARACOOS leveraged projects deploying gliders in the Mid-Atlantic including those funded by NJ Department of Environmental Protection, NY State Energy Research & Development Authority, NY Department of Environmental Conservation, Rutgers, Orsted, Invenergy, and the NJ Research Monitoring Initiative. • MARACOOS: 3 NSF Research Experience for Undergraduate (REU) interns, 1 NJ Wind Institute Fellow, and 2 Middlesex County Community College students participated in glider deployment and recoveries. Additionally, VIMS (C2PO Lab) trained undergraduate research assistant Fiona Gordon in glider operations, sensor development, and integration of an accelerometer into the Slocum glider for high resolution measurement of waves and glider motion. • The SECOORA team at USF (Garrett Miller) continued development of a new piloting resource 'The Brewery'. The Brewery allows for reviewing all glider datapoints with 	

<p>user-friendly map features and dashboard alerts for pilots. It uses R-code and is intended to be open source for the broader Slocum glider community that wants alternatives for real time data analysis and piloting. While the website does not allow a replacement for Slocum piloting applications provided by the manufacturer, it does allow for some enhanced piloting and scientific analysis. The code for the application is currently shared on a github page (https://github.com/oceanscienceguru/shiny_glidern).</p> <ul style="list-style-type: none"> • USF team member Chad Lembke was accompanied by a local news team on a glider deployment for a story published on 4/23/24. Participants had broad discussions related to the proposed IOOS 2025 budget cuts and their impacts on science programs. The story is still available online: https://baynews9.com/fl/tampa/news/2024/04/23/glider-usf-noaa • Dr. Nwankwo C. Uchenna, GCOOS, made video recordings during glider deployments in August. The video was a continuation of the recording from 2023. These recordings are focused on the hurricane glider missions. The video is not finalized but the GCOOS team will share it with the IOOS program office and the hurricane glider team when it is complete. • CARICOOS glider operations were featured in a TV Interview on 7/2/24 on Teleonce’s program “Un mar que hierve: temperaturas altas llegan hasta mayor profundidad en el mar.” Julio Morell and CariCOOS team members discussed high sea temperatures and their impacts and how underwater gliders assist with assessing these conditions. • A CariCOOS team member participated in and presented at the 2024 UNESCO CoastPredict General Assembly for the Ocean Decade on 8/8/24. • Between May and August 2024, CARICOOS welcomed over 100 visitors from summer camps and schools, including participants from the NASA OCEANOS Internship, Escuela Montessori Alejandro Tapia y Rivera, La Parguera, Lajas, Puerto Rico Marine Sciences Camp, Verano Ecológico, Fideicomiso de Conservación e Historia de Vieques, and VI Children's Museum. These activities offered participants valuable insights into the challenges of ocean monitoring and the critical role observations play in disaster preparedness and prevention efforts. 	
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III. PROJECT CHALLENGES/MODIFICATIONS:

- None noted

IV. PUBLICATIONS:

Aristizábal Vargas, M. F., Kim, H.-S., Le Hénaff, M., Miles, T., Glenn, S., & Goni, G. (2024). Evaluation of the ocean component on different coupled hurricane forecasting models using upper-ocean metrics relevant to air-sea heat fluxes during Hurricane Dorian (2019). *Frontiers in Earth Science*, 12. <https://doi.org/10.3389/feart.2024.1342390>

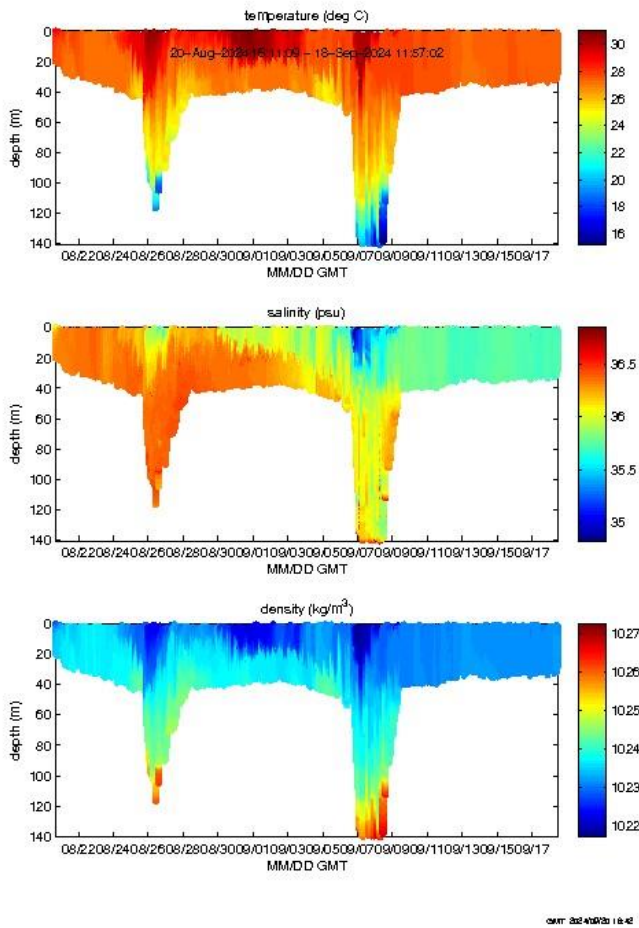
Martin, K. M., O. Braswell, S. Tsei, S. Howden (2024). Sampling High Dynamic Shallow Waters, using an Oceanscout Glider, to Observe Barrier Layers. Underwater Glider User Group Workshop ’24, September 10-11, 2024, University of Michigan, Ann Arbor, MI.

V. BUDGET SUMMARY:

- Were the oldest ASAP TAS BETC accounting lines invoiced first?

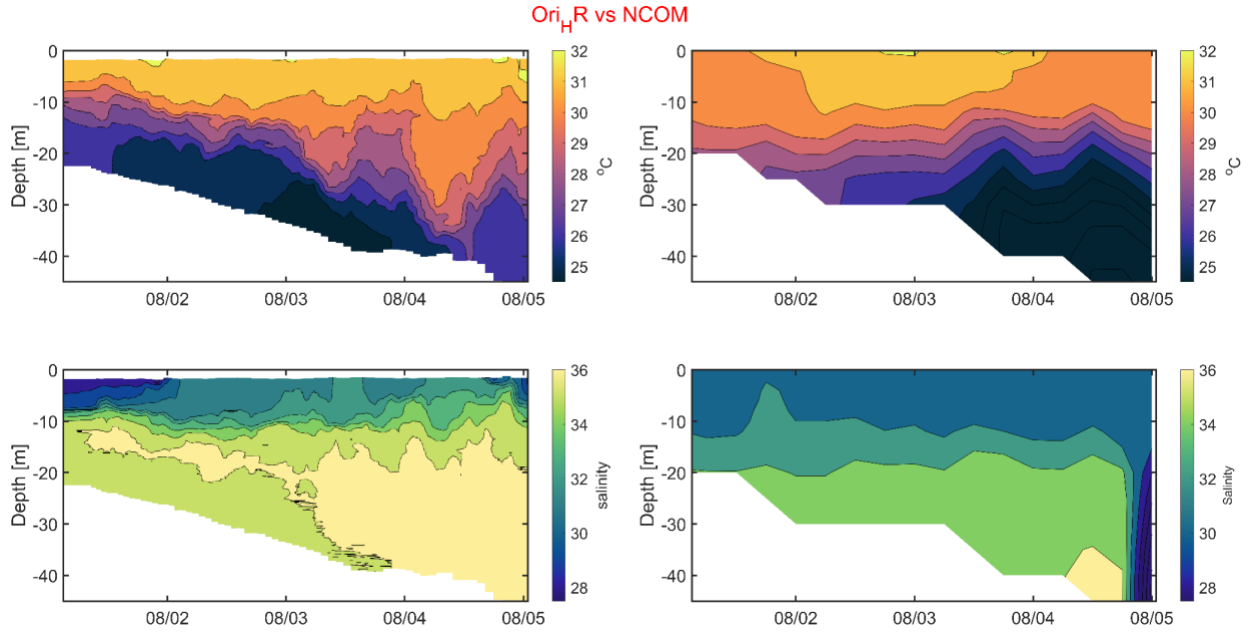
- Yes
 - Give details on any delays with initiating a contract/subaward. Note any issues with the previous year funds or other issues that occurred during the reporting period. Will this result with a work stoppage or cause significant problems with the partnership?
 - SECOORA has issued all subawards related to this award and all subawards have been fully executed.
 - Give a brief update on project invoicing for the reporting period. Were there any delays with invoicing or payment?
 - SECOORA is receiving invoices from all project team members for this award. Note that SECOORA receives quarterly invoices from subawardees; therefore, there is a delay between when a subawardee conducts work and when SECOORA is given an invoice for that work. SECOORA regularly monitors invoicing frequencies with subawardees.
 - Provide details on any property or equipment charged directly to the award having a useful life of more than one year and an acquisition cost of \$5,000 or more per unit during the period.
 - No equipment was purchased during this reporting period.
 - Include changes in key scientific, technical or management personnel, not included in certification.
 - No changes
 - Include changes to the organizational structure such as: changes in status or partners organizations and points of contact. As a reminder, a change to the award's Principal Investigator and a change in an award's Key Person Specified in the Application requires NOAA approval through Grants Online.
 - No changes to organizational structure
 - Provide an update about travel completed during the reporting period.
 - SECOORA, the Lead PI for this award, does not have any funds for SECOORA personnel travel. Subawardees (i.e., other RA glider team members) are using travel funds to cover roundtrip travel to glider deployment/recovery locations.
 - Are there any plans to initiate a new partnership (contract or subaward) during the next reporting period?
 - No
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Appendix A



Temperature (upper, deg C), salinity (middle), and density (lower, kg/m³) from unit_1091 mission August-September 2024 in two round-trip cross shelf sections from the 20m isobath to the upper slope and back. Temperatures less than 20° C indicate water that has been upwelled onto the outer shelf and upper slope by frontal eddies that move northward along the edge of the Gulf Stream, bringing cool and nutrient-rich water into the photic zone.

Appendix B



CTD data for Temperature (top, left graph) and Salinity (bottom, left graph) for the Hefring Oceanscout Ori mission, operated by USM. The Ori temperature and salinity data is compared to the Navy Coastal Ocean Model temperature (top, right graph) and salinity (bottom, right graph) for the same ROI.