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DEPARTMENT OF COMMERCE
RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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AWARD INFORMATION	
1. Federal Agency: Department of Commerce / NOAA	2. Federal Award Number: NA19NES4320002
3. Project Title: Cooperative Institute for Satellite Earth System Studies	
4. Award Period of Performance Start Date: 07/01/2019	5. Award Period of Performance End Date: 06/30/2024
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REPORTING INFORMATION	
Signature of Submitting Official: Takeia Bradley	
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RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF MARYLAND, COLLEGE PARK	
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22. Recipient UEI: NPU8ULVAAS23	23. Recipient EIN: 526002033

ACCOMPLISHMENTS

24. What were the major goals and objectives of this project?

• Advance and refine the use of satellite information to operationally derive accurate measures of the Earth System components and develop long-term quality assurance of satellite observations that can be included in future reanalysis projects;
• Research and design best practices for management and stewardship of big data sets;
• Provide cutting-edge, end-to-end research and development services to assist the NOAA science enterprise in transforming raw data received from satellites and other sources into valuable information about the environment;
• Deliver innovative research products, education, training, and outreach to enhance the understanding and utility of that information for respective constituencies and engage with diverse stakeholders of such information;

Satellite Obs. Systems
Goal: To develop and implement NOAA GEO and LEO satellite systems, particularly through support for GOES-R series, JPSS, and SmallSat developments. This support will include gathering end-user requirements, developing products, and ensuring the quality, accessibility, and usability of end products.

Sensor Cal/Val
Goal: To perform calibration of Earth-observing satellite sensors, including the calibration of visible, infrared, microwave, ozone, and lightning sensors flown aboard NOAA's next-generation JPSS and GOES-R, other platforms, and inter-satellite integration.

Algorithm and New Product Development, Data Fusion, and Blended Products
Goal: To develop satellite-based algorithms for Earth System monitoring and validation strategies for derived products, and new applications ranging from weather to climate scales.

Components of the Earth System
Goal: To detect and understand changes in the components of the Earth System: atmosphere, oceans, land, biosphere, and human systems. Key focus areas will cover air quality, atmospheric gases and particles, vegetation, land surface properties, the changing cryosphere, the global oceans, and terrestrial and marine ecosystems.

Surface Obs. Networks
Goal: To improve the integration of additional data sources and collection methods of global observing climate networks and identify new pertinent climate variables to better characterize Earth's near-surface climate at relevant spatial and temporal time scales.

Data Stewardship and Climate Data Records
Goal: To develop systems that provide stewardship and data access for the Federal Government's billion-dollar investment in high-quality environmental data. The focus will be on developing and providing authoritative satellite Climate Data Records (CDRs) for the atmosphere, oceans, cryosphere, and land.

25. What was accomplished under these goals?

Under this project, the following performance metrics were accomplished during this period of performance.

Number of new or improved products developed that became or may become operational:178
Number of peer reviewed papers: 117
Number of books and book chapters: 31
Number of invited presentations:9
Number of presentations:252
Number of graduate students supported by a CISESS task:2
Number of graduate students formally advised: 9
Number of undergraduate students mentored during the year: 22
Number of consortium students: 43

Please see Appendix Q25_expanded.docx for a list of accomplishments. A smaller selection is presented here:
Theme 1
- Supported the completion of JPSS-2 CrIS Pre-launch Testing in preparation for the November 2022 Launch. Conducted Extensive Calibration and Validation activities in preparation for Beta and Provisional Maturity Review Levels for the NOAA-21 CrIS RDR and SDR data.
- Our work focuses on post-launch intensive calibration and validation of NOAA-21 VIIRS on the tasks of lunar calibration, DNB calibration, radiometric performance assessment and production of first light images. The production of long-term SNPP VIIRS Global Area Coverage (VGAC) data enables the development of climate data records quality downstream products.

Theme 2
- A global census of coastal Marine Heatwave evolution and drivers using high-resolution satellite data and computer vision. Marine heatwaves were calculated for a 20 year time period in the Chesapeake bay. NOAA Geopolar satellite data was validated against in situ data from the Chesapeake Bay Program, and spatial maps of marine heatwave characteristics were created.
- A major update of NOAA's State Climate Summaries for the United States was completed with the release in January 2022 of updated four-page summaries for each of the 50 states, an additional summary for Puerto Rico and the U.S. Virgin Islands, and an updated website hosting the summaries.
- Research efforts included evaluating the impact of historical drought events on mortality and morbidity—with preliminary results reflecting a greater impact on minority subpopulations—and a study to investigate the impact of drought on the occupational psychosocial stress of Midwestern farmers.

Theme 3

ACCOMPLISHMENTS *(cont'd)*

26. What opportunities for training and professional development has the project provided?

1. CISESS Seed Grants. We offered seed funding grants to young scientists to develop new ideas to encourage new techniques to use satellite products, instruments, and models that may make a tangible contribution to advancing NOAA's mission. The program is open to all CISESS Task Leaders or Primary Scientists affiliated with the University of Maryland. During 2022 three new projects were approved, which add to other four selected in 2021. Amount: $30,000 (+$15,000 in 2nd year)
2. Opportunities for our scientists to develop mentoring skills and train students. The Summer Intern Program for Graduate and Undergraduate students (and High School Seniors) paired students with mentors according to shared interests. All interns were supported for 12 weeks, at 20 hs/week. During the summer of 2022, we mentored twenty-five interns. Some of them continued through the fall (and spring) with support from the mentors' tasks.
3. CISESS: Coral Reef Data Management and Information Systems to Achieve Desired Conservation Outcomes. CISESS staff held numerous small group training sessions to promote data management best practices and provide guidance to key stakeholders on how to submit data to NCEI. The team has developed multiple guides related to how to use the NCEI submission tools and make publications accessible to meet PARR requirements. Finally, NCEI adopted many of the training practices we piloted on our project to bring new staff up to speed on archiving practices as part of a larger training program to onboard new data managers within NCEI.
4. Ocean Remote Sensing. Satellite courses were attended by about 75 participants who benefitted from a tailored learning experience, hands-on work on a personal project of interest for their research, and direct contact with several CoastWatch staff. Additionally, this task organized training tutorials at the NOAA EDM workshop (Sep. 2022), and the Oceans 22 conference (Oct. 2022).
5. CISESS: Facilitating GOES-R GLM and MALMA Science. This project provided opportunities for undergraduate and graduate students to gain hands-on experience in conducting lightning observations and atmospheric science research.
6. Enhancing Ocean Exploration Data Stewardship. This project provided the opportunity to serve as the NOAA Ocean Exploration Representative aboard a federal, grant-funded project's at-sea fieldwork where I coordinated web coverage and served as a data management expert to provide guidance and services while learning more about deep-ocean communities. Led workshops on sample data management and provided training for new at-sea sample managers. Additionally, CISESS staff completed a facilitation course to learn how to better shape and run dynamic thinking/working sessions for my various teams.
7. Oceanographic Satellite Data Applications, User Engagement and Education for Improved Coastal Decision-Making on the U.S. East Coast. Developed and taught a 4-session data analysis class tailored to the needs of fishery researchers for understanding the environmental drivers of fish populations. An outcome from the class is analytical software (with a software tutorial) for fishery researchers to match environmental satellite data to fish-tag location data. This allows the researchers to understand fish movement due to ecosystem variability.
8. GOES-R/GOES-S Global Surface Reflectance/Albedo Products Cal/Val. The project team members have gained experience and knowledge in algorithm development, remote sensing data processing, and/or customer engagement, which could contribute to their professional development.
9. Global Navigation Satellite System Radio Occultation Research and Development. This project provided supports to 10 researchers. Training and professional development are provided with weekly group meetings, participating review and meeting

27. How were the results disseminated to communities of interest?

Dissemination activities at CISESS follow multiple paths expanded in questions 29-32. Here we present a summary and specific examples of dissemination activities: Dissemination to the public was also done through our website (cisess.umd.edu) and several other websites either at UMD or at NESDIS. CISESS provides weekly reports to STAR with the most recent advances and news that took place at the institute. Dissemination examples follow.

(1) Coral Reef Data Management and Information Systems. Results with data and publications are mainly disseminated throughout the scientific community via the Coral Reef Information System website, located here: https://www.coris.noaa.gov/. Additional results are disseminated through the NCEI ERDDAP site here:
https://www.ncei.noaa.gov/erddap/tabledap/index.html?page=1&itemsPerPage=1000
(2) Ocean Remote Sensing. All course materials are publicly available online to course participants and others for on-demand viewing. The CoastWatch learning portal is publicly available and 508 compliant: https://umd.instructure.com/courses/1336575
(3) CISESS: Lightning Validation and User Interaction Work. The results were disseminated to communities of interest through digital media like YouTube (https://youtu.be/lgvz4_qG7i8), social media like Twitter (https://twitter.com/JosephPattonWx/status/1514651179539701764), and blogs (https://satelliteliaisonblog.com/2022/04/06/bolt-from-the-blue-how-satellites-tell-the-tale-of-aircraft-dodging-developing-thunderstorms/).
(4) Scientific Research and Product Development to Support Monitoring and Prediction of Environmental Changes and Climate Impacts on Coral Reef Ecosystems. CISESS Scientists at NOAA CRW broadly communicated critical product information to its user community worldwide via the NOAA CRW website, email networks, social media accounts (Twitter and Facebook). Staff also continued its timely provision of all data products, datasets, and supporting metadata to NOAA NCEI and NOAA CoRIS for archiving, and all newly published scientific papers, including journal articles and Technical Memoranda (in a 508-compliant format), to NOAA CoRIS and the NOAA IR.
(5) CISESS: Facilitating GOES-R GLM and MALMA Science. The results were shared in the lightning research community through open-access data portals, outreach and education programs such as Maryland Day activity, presentations on academic conferences and seminars, collaborations and partnerships with academic institutions, and media releases.
(6) Oceanographic Satellite Data Applications, User Engagement and Education for Improved Coastal Decision-Making on the U.S. East Coast. Monthly and annual temperature time series statistics for 83 U.S. estuaries were included in the CoastWatch Web Data Portal for visual display. NOAA Fisheries Service ecosystem reports, containing the improved sea surface temperature data product as a seasonal temperature anomaly, are released seasonally to the regional fisheries management community, and annually briefed to the Mid-Atlantic Fisheries Management Council.
(7) Scientific Research on Subseasonal Drought Prediction and Monitoring. Our results have been shared with the Environmental Modeling Center (EMC) to discuss model performance and evaluation, as our findings can lead to alterations in their model development plan. Additionally, our results have been shared more broadly with the Drought Working Group at CPC to aid in further discussion of methods needed for forecast verification and predictive metrics.
(8) Support of GOES-R Land Surface Temperature Algorithms and Validation. The results were released to the public through the team's website, updated on a daily, weekly, and monthly basis. The operational product was provided to the communities at NOAA's CLASS and the AWS from Amazon. Multiple other channels were used, including direct collaboration, and email communications.

ACCOMPLISHMENTS *(cont'd)*

28. What do you plan to do during the next reporting period to accomplish the goals and objectives?

CISESS will continue to conduct collaborative research, education, and outreach programs aligned with NOAA's strategic goals to achieve the following objectives:

• Advance and refine the use of satellite information to operationally derive accurate measures of the Earth System components and develop long-term quality assurance of satellite observations that can be included in future reanalysis projects;

• Research and design best practices for management and stewardship of big data sets;

• Provide cutting-edge, end-to-end research and development services to assist the NOAA science enterprise in transforming raw data received from satellites and other sources into valuable information about the environment;

• Deliver innovative research products, education, training, and outreach to enhance the understanding and utility of that information for respective constituencies and engage with diverse stakeholders of such information;

• Design information products and systems to monitor changes in the Earth System: atmosphere, oceans, land, cryosphere, ecosystems, socioeconomics, and other components of the anthroposphere;

• Develop experimental virtual reality tools for use in forecasting environments; and

• Strengthen overall NOAA-related research capabilities and capacity at CISESS institutions to complement and contribute to NOAA's ability to reach its mission goals.

PRODUCTS

29. Publications, conference papers, and presentations

Please see Appendix "Publications RPPR Appendix 2023.doxc" for a complete list of publications.

CISESS produced a total of 179 peer-reviewed publications and two NOAA technical reports during this reporting period.

A total of 294 talks and posters were presented at national conferences. Of these, two were invited presentations.

PRODUCTS *(cont'd)*

30. Technologies or techniques

Please see the attachment "Products RPPR Appendix 2023.docx" for a list of products, datasets, calibration and validation techniques, and models

31. Inventions, patent applications, and/or licenses

Nothing to report

Attach a separate document if more space is needed for #6-10, or #24-50.

PRODUCTS *(cont'd)*

32. Other products

Please see the attachment "Products RPPR Appendix 2023.docx" for a list of products, datasets, calibration and validation techniques, and models

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

Name: Ellen Williams
Role: PD/PI
Number of months (calendar) on project: 3
Contribution to the project: Dr. Williams is the tasked with overall responsibility of the Cooperative Institute, including managing the relationship between Consortium members, and between the overall Consortium and NOAA. She serves as the primary point-of-contact of the CI with NOAA. . She provides overall CI scientific and operational leadership, r working with NOAA and Consortium team members. . She reports to the CISESS Executive Council.
Residence: State of Maryland

Name: E. Hugo Berbery Role: PD/PI
Number of months (calendar) on project: 12
Contribution to the project: As Deputy Director of CISESS, Dr. Berbery also acts as Director for the campus in MD: tasked with supporting management of the overall Consortium, as well as management of the MD campus of CISESS, with scientific and financial responsibility over all research, education, and outreach/engagement activities taking place in this campus. In the role of CISESS Deputy Director and Director of the Maryland Campus, he supports the Director in managing the Consortium. He oversees scientific research, education, and outreach/engagement activities taking place in the Maryland campus as well as financial operations. At CISESS, Dr. Berbery has worked on advancing the Institute's scientific profile, improving its visibility, and developing best management practices.
Residence: State of Maryland

Name: Otis B. Brown Role: Co-PD/PI
Number of months (calendar) on project: 12
Contribution to the project: Dr. Brown is responsible for the campus of CISESS in NC, tasked with overall management, scientific and financial responsibility over all research, education, and outreach/engagement activities taking place in this campus.
Residence: State of North Carolina

The attachment "Task Leaders RPPR Appendix 2023" lists task leaders and primary scientists.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS *(cont'd)*

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Nothing to report

35. What other organizations have been involved as partners?

CISESS University of Maryland
CISESS N. Carolina State University
CUNY City University of New York
GMU George Mason University
OSU Oregon State University
UA U. of Alabama Tuscaloosa
UCI U of California Irvine
UMBC UM Baltimore County
RTI Research Triangle Institute
SDSU South Dakota State University

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS *(cont'd)*

36. Have other collaborators or contacts been involved?

Colorado Center for Astrodynamics Research, University of Colorado at Boulder (CU-B)
Universities Space Research Association (USRA)
Science and Technology Institute (STI)
Department of Natural Resources and Environmental Management, University of Hawaii at Manoa (UH-M)
Sonoma Technology, Inc. (Sonoma)

IMPACT

37. What was the impact on the development of the principal discipline(s) of the project?

(1) By assimilating ocean surface drifter paths with altimeter sea level in a coupled atmosphere-ocean forecast system, this project was able to improve the accuracy of the model states related to tropical cyclone intensity forecasts informing how they respond to changes in environmental conditions.
(2) CISESS staff effectively support the NOAA Coral Reef Watch (CRW) mission and allow CRW to continue reporting to its user community worldwide on the coral reef environment. Staff leads all user interactions, the program's educational and outreach efforts, and coordination/development of domestic and international collaborations and MOUs/MOAs to expand and advance the CRW program.
(3) JSTAR - Microwave Integrated Retrieval System (MiRS) Retrieval Algorithm and Imagery Product Development. The use of retrieval products from MiRS impacts downstream application developers who leverage these products to enhance their value-added products, which can improve situational awareness of operational weather forecasters and emergency management officials.
(4) Leveraging Machine Learning to Enhance the Quality of Ocean Observations. This project contributed an important proof-of-concept for the application of robust, automated, and machine-learning-based quality control (QC) methods to large in situ and satellite oceanographic datasets. Having such QC methodology in place is the foundation of doing meaningful scientific research using these data.
(5) Scientific Research on Subseasonal Drought Prediction and Monitoring. This project directly impacts our knowledge base on model performance and skill associated with drought prediction. As a launching off point, this work will directly impact our knowledge of modeling hydrologic processes and the evaluation of meteorological forcing datasets.
(6) This project evaluates and improves the quality of multi-mission RO data through processing/retrieval algorithm and software development, validation and bias-monitoring activities for multi-RO missions and addresses the new challenges from the new design of the TRIG receiver in COSMIC-2 and commercial weather data missions. This work supports the RO mission-related decision making at NOAA STAR and OSSAP, and optimizes the exploitation of multi-RO derived atmospheric profiles for assimilation into National Weather Service (NWS) numerical forecasts and models.
(7) Facilitating GOES-R GLM and MALMA Science. This project generated new knowledge and insights into the dynamics of lightning activity, as well as its relationship to other atmospheric phenomena, such as thunderstorms, hurricanes, and atmospheric chemistry, and also had implications for the development of new satellite-based observations and technologies for monitoring and analyzing the Earth's atmosphere, including the GOES-R GLM and other satellite instruments. It had a significant impact on the development of the principal discipline(s) of atmospheric science and Earth system studies, contributing to new knowledge, insights, and technologies in these fields, as well as new collaborations and partnerships to further advance research and development in these areas.
(8) Microwave Integrated Retrieval System (MiRS) Algorithm and Product Development for the EPS-SG Microwave Sounder (MWS). This project is for preparation of the Metop-SG-A1 MWS launch. MiRS will be applied to the operational MWS data once it is available. The accurate surface type classification is one of the key steps for the MiRS retrieval procedure since 1DVAR algorithm

IMPACT *(cont'd)*

38. What was the impact on other disciplines?

(1) Ocean Remote Sensing. (a) Contributed climate indicators to the central Pacific fishing council to inform resource managers of ocean conditions and trends; (b) Contributed climate indicators to the NOAA National Marine Ecosystem Status website to inform wide audiences of status and trends in US Large Marine Ecosystems
(2) Enhancing Ocean Exploration Data Stewardship. This project has contributed to establishing industry standards for data archival and discovery for oceanographic information. We have led an initiative that aims to collaboratively work with federal partners, universities, research institutions, and private partners to locate and acquire oceanographic data funded through federal grants for NOAA Ocean Exploration. This has increased the FAIRness (finability, accessibility, interoperability, and reusability) of ocean data.
(3) Oceanographic Satellite Data Applications, User Engagement and Education for Improved Coastal Decision-Making on the U.S. East Coast. Fish population biology and ecosystem-based fisheries management are two disciplines that both benefit from this project's environmental data, educational outreach, and teaching materials on the use of satellite data to inform fish population changes due to environmental variability, for example populations shifts due to climate change.
(4) VIIRS Global Surface Albedo Products Cal/Val. The development of algorithms for analyzing satellite data and monitoring land surface anomalies could potentially have applications in fields such as environmental science, geography, and remote sensing.
(5) Ocean Carbon and Acidification Data System. The newly developed OA indicator product will be crucial in advancing OA research in the fields. It will help guide society's OA mitigation and adaptation efforts.
(6) GOES-R/GOES-S Global Surface Reflectance/Albedo Products Cal/Val. The project's results may have had broader impacts beyond the remote sensing and geostationary satellite data processing communities. For example, the improved GOESR LSA/BRF products have been used in other fields, such as meteorology, climate modeling, or agriculture, to support decision-making and monitoring activities. The project's test data for the GOESR NBAR dataset have also been used by other researchers or organizations working on land surface applications.
(7) A global census of coastal Marine Heatwave evolution and drivers using high-resolution satellite data and computer vision. The use of satellite data to track hot water in the bay could be applicable to ecosystem studies going on in the bay, or other large estuaries around the globe.
(8) LST Product Monitoring and Validation; Algorithm Development/Improvement. This project can contribute to public health decisions related to heatwave alert, urban heat island etc. It also has an impact on agriculture by providing more accurate information on temperature, drought, irrigation scheduling etc. The LST products can be used in weather and climate prediction.
(9) Facilitating GOES-R GLM and MALMA Science. This project helped to advance our understanding of the complex interactions between the atmosphere, the Earth's surface, and the space environment by providing new and more detailed observations of lightning activity. This led to a better understanding of weather patterns, climate change, and other environmental processes that affect our planet. In addition, this project also helped to improve the safety and efficiency of air travel, as well as the planning and deployment of renewable energy infrastructure by providing more accurate and timely data on weather patterns and severe weather events.

39. What was the impact on the development of human resources?

A large number of CISESS tasks are dedicated at training postdocs and students in different topics of the institute.

Facilitating GOES-R GLM and MALMA Science. The project provided opportunities for students and early-career scientists to gain hands-on experience in cutting-edge research related to atmospheric science, satellite-based observations, and lightning detection. This allowed them to develop important technical and analytical skills, as well as to gain practical experience working with data and instrumentation in a real-world setting. The project also helped to foster collaborations between academic institutions and government agencies, providing a platform for scientists and researchers from different backgrounds to work together on common goals.

Coral Reef Data Management and Information Systems to Achieve Desired Conservation Outcomes.
CISESS staff have taken advantage of many different professional development training opportunities over the course of the past year. Zachary Mason recently finished a degree in Computer Science and Software Development and Rebecca Wenker has been working on obtaining a certificate in GIS science. In addition, staff have supported training activities to onboard new staff as data managers within the NCEI archive system.

GOES-R ABI cal/val support. It provides skill development opportunities, training and education, and enable collaborative research between academia and government agencies.

Ocean Remote Sensing. The CoastWatch satellite course provide professional development opportunities to NOAA staff and others to get skilled in using satellite data in their research and applications.

VIIRS Global Surface Albedo Products Cal/Val. The project provided opportunities for the team members to develop technical and research skills in the areas of satellite data analysis, algorithm development, and land surface monitoring. Additionally, the Long-term-monitoring (LTM) system developed by the team have provided training opportunities for users to learn about satellite product quick maps and real-time validation results.

Global Navigation Satellite System Radio Occultation Research and Development. This research work provided support to 10 researchers and professional training/development to these researchers.

IMPACT *(cont'd)*

40. What was the impact on teaching and educational experiences?

*CISESS supports and engages in various educational and outreach-related activities to advance the following areas: (1) Increase awareness of climate science and changes in the climate system; (2) Grow the understanding of how climate data is collected, observed, analyzed, and used in research purposes; (3) Increase awareness of climate datasets and products, and how educational teachers/professors can make use of climate data products for teaching climate science; (4) Demonstrate capacity building on the various impacts of climate change across public, private, and academic arenas; (5) Increase private sector understanding and use of climate data and information for their strategic and operational use.
*CISESS regularly mentors high-school and undergraduate students . The Summer Intern Program for Undergraduate students (and High School Seniors) paired students with mentors according to shared interests. All interns were supported for 12 weeks, at 20 hs/week. During the summer of 2022, we mentored twenty-five interns. Some of them continued through the fall (and spring) with support from the mentors' tasks.

Specific examples:
*CISESS staff at the Coral Reef Data Management and Information Systems have made it a priority to continue outreach to students and educators by posting educational content on the CoRIS site and by working closely with internal and external organizations to promote coral reef-based educational content on websites and social media.
*CISESS scientists contributed data and information to the FadingColours art installation (https://www.stenfertkroese.com/fadingcolours/). FadingColours, exhibited already in Linz (Austria) during the Ars Electronica Festival, in Theater Rotterdam (Netherlands), and in Nicosia (Cyprus) as part of the Work in Progress (WIP) festival, featured NOAA CRW's daily global 5km satellite coral Bleaching Alert Area product data. The algae on display in FadingColours indicate the coral-algal perspective of our world. They are also contributing data and information to a new art exhibition, CORALS. Marco Barotti, a Berlin-based media artist with Studio Marco Barotti designs data-driven kinetic sound sculptures that resemble animals and plants and deal with environmental and social issues. CORALS, which is being developed in collaboration with the Science Gallery Berlin and the BIFOLD, (a centre for big data and machine learning at the Technische Universität Berlin), will develop a kinetic sound sculpture that resembles a coral nursery. An AI able to analyze ocean conditions using sea surface temperature, ocean acidification, UV radiation, and other environmental datasets will be used to create a digital twin of a coral. Marco plans to use NOAA CRW's daily global 5km coral bleaching heat stress product data as the core of the art installation.
*Oceanographic Satellite Data Applications, User Engagement and Education for Improved Coastal Decision-Making on the U.S. East Coast. The teaching materials, developed for the data analysis class on utilizing satellite data with fish tag locations, are available indefinitely on the UMD Canvas Learning Management System, allowing fisheries researchers access to software and other analytical tools for understanding fish population changes due to environmental variability. 27 fisheries researchers attended the 4-session virtual class.
*Facilitating GOES-R GLM and MALMA Science. The project provided a platform for the development and implementation of new curricula and educational resources related to atmospheric science, satellite-based observations, and lightning detection. This allowed educators to incorporate cutting-edge research and data into their teaching, providing students with a more engaging and

41. What was the impact on physical, institutional, and information resources that form infrastructure?

Nothing to report

Attach a separate document if more space is needed for #6-10, or #24-50.

IMPACT *(cont'd)*

42. What was the impact on technology transfer?

Most CISESS activities under the topics of Calibration/Validation and Algorithm Development have a significant technology transfer component linking research to operations. Below we present some examples of these transfers.
(1) All the modifications for enhancing CRTM scattering calculations to improve the assimilation of ATMS observations are transferred to the NOAA operational repositories and are under evaluation within the NOAA FV3/JEDI system.
(2) Scientific Research on Subseasonal Drought Prediction and Monitoring includes evaluating model and forecast performance that lends itself to the R2O framework. Through evaluations areas of strengths and weaknesses in the forecast/model paradigm are highlighted, proposing mechanistic reasons for poor performance, and developing tools/methods that will ultimately aid in prediction when incorporated by the Prediction Branch at CPC.
(3) CrIS VIIRS radiance cluster software has been transitioned to NOAA Algorithm Scientific Software Integration and System Transition Team for operational implementation.
New techniques for enhancing the accuracy of geostationary imagery (GOES-R ABI) were developed. The new techniques have been shared with other organizations, both in the United States and internationally, to help improve weather forecasting and develop climatic change dataset.
(4) NOAA CRW is the world's leader in observing, predicting, and communicating changes in the coral reef environment to users globally. Satellite coral bleaching heat stress products and the modeled Four-Month Coral Bleaching Outlook have successfully and accurately monitored and predicted all major mass coral bleaching events observed globally since 1997, and provide other critical information to users, especially during times of high oceanic heat stress. In response to CRW's modeled Outlooks and near real-time satellite monitoring of the coral reef environment, and staff's regular communication with our users worldwide, users have reduced local stressors (e.g., by closing major scuba diving and fishing areas) during periods of high oceanic heat stress, rescued rare corals, and shaded and cooled key nursery reefs. Additionally, users apply our products to identify locations for new conservation and restoration projects, to give transplanted corals or corals grown in-situ the best chance at survival. Staff also publishes regularly in the scientific literature, including co-authoring papers involving applications and analyses of CRW products, algorithms, and methodologies, and contributes to national and international assessments of coral reef conditions.
(5) Scientific Research on Maximizing the Forecasting Capabilities of Geostationary and Polar Satellite Data Sets. The work ensures that all new products are put on AWIPS-II to assist in the NAWIPS to AWIPS transition, while making sure the forecasters still have access to high priority satellite products in NAWIPS to deliver their products.
(6) Oceanographic Satellite Data Applications, User Engagement and Education for Improved Coastal Decision-Making on the U.S. East Coast. The improved satellite sea surface temperature data product, Multi-Sensor Composite Sea Surface Temperature (SST) from AVHRR and VIIRS (see above), developed by this project, has been integrated operationally into NOAA Fisheries Service ecosystem conditions reports for advising the fishery management community on fish population management decisions.
(7) NESDIS STAR Science Enterprise Support for Water Quality, Hydrology Modeling and Water Cycle. The RAPID Matlab software is in the process of being transferred to a Python version for Cloud platform operational run. The blending Python software is in the process of implementation to SSEC for test runs.
(8) An updated GCOM-AMSR2 precipitation retrieval – GPROF2017 will be transitioning to NOAA operations shortly after its

43. What was the impact on society beyond science and technology?

(1) Ocean Remote Sensing. (1) A better trained NOAA workforce, well-versed in satellite products available and what information can be derived from them. (2) Climate indicators to inform the US public and officials on the status of US LMEs.
(2) JSTAR SDR CrIS: Support for JPSS CrIS Calibration and Validation. Accurate global infrared brightness temperature data not only ensures high quality weather forecasting, but also to provide assistance to communities who are in need of this information for long-term community decision-making.
(3) Development of Long Time Series of 1km Soil Moisture Products and their Anomalies for NWM and NWP Users and Climate Analysis. Better satellite soil moisture observation can improve weather forecast, as well as climate predictions of the drought and flood conditions, which are crucial information to the policy maker as well as the entire society.
(4) Facilitating GOES-R GLM and MALMA Science. By providing new and more accurate data on lightning activity and other atmospheric phenomena, the project helped to improve our ability to forecast severe weather events, such as thunderstorms, tornadoes, and hurricanes. It also helped to increase public awareness of the risks associated with these events and to improve emergency preparedness and response efforts. Therefore, this project had a wide-ranging impact on society beyond the fields of science and technology, contributing to public safety, community resilience, environmental sustainability, and public awareness and engagement with scientific research and environmental issues.
(5) NESDIS STAR Science Enterprise Support for Water Quality, Hydrology Modeling and Water Cycle. Flood Inundation Model products will enhance capability of FEMA and other agencies during and after the hurricane/storm/flooding events.
(6) LST Product Monitoring and Validation; Algorithm Development/Improvement. LST is very useful in the illustration of extreme events including heatwave, frost hazard, wildfire and drought etc. The project contributes to environmental monitoring and disaster management related to climate change mitigation and adaptation, public health with regard to heat stress and related illnesses etc.
(7) Oceanographic Satellite Data Applications, User Engagement and Education for Improved Coastal Decision-Making on the U.S. East Coast. Society is concerned about the economic impacts of climate change. For example, changing fish populations may reduce fishery harvests in certain areas, and new sustainability practices must be put in place. This project contributes satellite environmental data, and educational and analytical resources to use the data, for the fisheries management community to make informed decisions about the utilization of marine natural resources.
(8) A developed coastal and global ocean acidification (OA) indicator product will guide society's OA mitigation and adaptation efforts.
(9) The further development of new methods for estimating upper ocean heat content serves to improve forecasts of tropical cyclone intensity and coral bleaching events. Respectively, these forecasts serve to reduce loss of life/property and to understand potential effects on our marine resources from these extreme events.
(10) The GOES-R ABI project has a significant impact on society by upholding the high quality of the imagery to improve weather forecasting, supporting disaster response efforts, and tremendous economic benefits.
(11) Enhancing Ocean Exploration Data Stewardship. This project has prioritized locating and archiving missing NOAA-Funded ocean data that otherwise would be lost to time. This comprises millions of dollars worth of data for long-term preservation and use

IMPACT *(cont'd)*

44. What percentage of the award's budget was spent in foreign country(ies)?

1 , In FY22, we worked with ReefSense, an Australia-based subcontractor who provide services to Coral Reef Watch and its CISESS staff. This is about 1.4% of the total budget in FY22. (The web page would not allow us to enter a decimal number in the box, so we reported the closest integer.)

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

Nothing to report

Attach a separate document if more space is needed for #6-10, or #24-50.

CHANGES/PROBLEMS *(cont'd)*

46. Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to report

47. Changes that had a significant impact on expenditures

Nothing to report

Attach a separate document if more space is needed for #6-10, or #24-50.

CHANGES/PROBLEMS *(cont'd)*

48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Noting to report, N/A

49. Change of primary performance site location from that originally proposed

Nothing to report

Attach a separate document if more space is needed for #6-10, or #24-50.

PROJECT OUTCOMES

50. What were the outcomes of the award?

Specific outcomes (e.g., products, datasets, publications) were presented in questions 29-32

General outcomes tend not to change from year to year as they respond to the larger goals of the institute.

• identified emerging science needs requiring satellite and other Earth observations that will contribute to effectively and efficiently meeting NOAA's mission;

• contributed to NOAA mission-directed research that will utilize these observing systems and lead to an understanding of the Earth System at regional to global scales and from minutes to decades;

• provided educational and outreach opportunities in NOAA-related research on applications of satellite data and information, supporting students' participation in areas that will contribute to the development of a diverse workforce in NOAA;

• harnessed expertise in satellite and in situ observing systems required to produce reliable and authoritative data, and provide project management and data stewardship skills necessary for making these data usable and available;

• engaged with stakeholders, offer the communication expertise required to understand user needs, and deliver actionable information about the Earth System.

DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)

Gender:

- ◯ Male
- ◯ Female
- ◯ Do not wish to provide

Ethnicity:

- ◯ Hispanic or Latina/o Not
- ◯ Hispanic or Latina/o Do not
- ◯ wish to provide

Race:

- ◯ American Indian or Alaska Native Asian
- ◯ Black or African American
- ◯ Native Hawaiian or other Pacific Islander
- ◯ White
- ◯ Do not wish to provide

Disability Status:

- ◯ Yes
  - [ ] Deaf or serious difficulty hearing
  - [ ] Blind or serious difficulty seeing even when wearing glasses
  - [ ] Serious difficulty walking or climbing stairs
  - [ ] Other serious disability related to a physical, mental, or emotional condition
- ◯ No
- ◯ Do not wish to provide

Attach a separate document if more space is needed for #6-10, or #24-50.