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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
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
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REPORTING INFORMATION	
Signature of Submitting Official: Monique Anderson	
16. Submission Date and Time Stamp: 04/28/2020	17. Reporting Period End Date: 03/31/2020
18. Reporting Frequency: (●) Annual ( ) Semi-Annual ( ) Quarterly	19. Report Type: (●) Not Final ( ) Final
RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF MARYLAND, COLLEGE PARK	
21. Recipient Address: 3112 LEE BLDG 7809 REGENTS DR, COLLEGE PARK, MD 20742-0001 USA	
22. Recipient UEI: NPU8ULVAAS23	23. Recipient EIN: 526002033

ACCOMPLISHMENTS

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

The Cooperative Institute for Satellite Earth System Studies (CISESS) is a national consortium of academic and nonprofit institutions, with leadership from the University of Maryland College Park (UMD) and North Carolina State University (NCSU). The CISESS Consortium's primary objectives are to 1) support NOAA's National Environmental Satellite Data and Information Service (NESDIS) mission of providing "secure and timely access to global environmental data and information from satellites and other sources to both promote and protect the Nation's environment, security, economy, and quality of life"; 2) promote and augment the research capabilities of NOAA's mission "to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources"; and 3) deliver innovative research products, education, training, and outreach aligned with these missions.

The grand scientific challenge of CISESS is to enhance the understanding of how the natural atmosphere–ocean–land–biosphere components of Earth interact with human activities as a coupled system. CISESS will engage in collaborative and transformative research activities with NOAA scientists to enhance NOAA's ability to generate and use satellite and in situ observations and Earth System models to meet that challenge, advance NOAA's science mission, and identify emerging science needs that will effectively contribute to meeting NOAA's mission in the future. In conjunction with its research operations, CISESS will educate and train students and scientists in areas of priority to NOAA and carry out relevant outreach and engagement activities with the scientific community, decision makers, and the public.

CISESS research activities are organized around three broad science themes: Satellite Services, Earth System Observations and Services, and Earth System Research. Through a research program aligned with these three major themes, CISESS will contribute to NOAA mission-directed research leading to greater observation, understanding, and prediction of the global Earth System. The activities proposed with the three themes are interconnected and tightly coupled to allow for rapid feedback, prototyping, and development. CISESS will provide the capabilities and expertise to improve systems for data access, quality, management, processing, analysis, assimilation, modeling, dissemination, and visualization.

The range of expertise needed to support NOAA is broad and varied—from basic and applied research on the natural Earth System, through study of the coupling of the Earth System to societal responses, social science, and policy research, to stakeholder engagement and communication with the general public. The CISESS Consortium brings together a broad complement of institutions that, collectively, are well equipped to address the wide variety of scientific, research, and outreach functions to support NOAA.

Together, this diverse group of institutions brings research, education, outreach, and engagement interests and an exceptional capacity to work collectively and collaboratively to address a wide variety of objectives and challenges. The breadth of capacity and capability of CISESS individuals and organizations presents an innovative organizational approach commensurate with the breadth and complexity of the challenges of the Earth System to our environment and global society. Through this broad geographical coverage, the CISESS Consortium provides NOAA with extraordinary opportunity to engage the extra-federal scientific and user

25. What was accomplished under these goals?

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

# of new or improved products developed that became operational 156
# of products or techniques submitted to NOAA for consideration in operations use 121
# of peer reviewed papers 94
# of NOAA Technical Reports 60
# of invited presentations 538
# of graduate students supported by a CICS task 39
# of graduate students formally advised 82
# of undergraduate students mentored during the year 75

ACCOMPLISHMENTS *(cont'd)*

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

During this period, this project provided professional development activities for 163 scientists, 34 graduate students, and 28 undergraduate students, through work on research tasks with NOAA scientists.

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

- Climate Literacy, Outreach, Engagement and Communications
CISESS Engagement Director Jenny Dissen provided sectoral and operational customer engagement support to NCEI's Center for Weather and Climate including the planning and hosting of the 2019 NCEI Users' Conference. Conference participants shared their environmental data requirements, uses, and applications as well as providing feedback on how current products could be improved. CISESS Science Public Information Officer Tom Maycock shares the research findings of Institute scientists through web stories, press releases, social media, the Institute's newsletter Trends, and various outreach events.
- Drought-related health impacts: advancing the science for public health applications
CISESS Consortium member University of Nebraska Medical Center (PI Jesse Bell) and the National Integrated Drought Information System (NIDIS) convened a National Drought and Public Health Summit. The Summit provided a forum for stakeholders to discuss drought and its impacts on human health and highlight current drought research and preparedness activities.

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 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 and advance regional ecosystem products and models, mainly aimed at the Chesapeake Bay and the Gulf and Mid-Atlantic regions, to monitor and predict the impact of changes in the health of the ecosystems
• Strengthen overall NOAA-related research capabilities and capacity at CISESS institutions in a way that complements and contributes to NOAA's ability to reach its mission goals

PRODUCTS

29. Publications, conference papers, and presentations

A total of 94 peer-reviewed publications were produced by CICS during this reporting period.

PRODUCTS *(cont'd)*

30. Technologies or techniques

Nothing to Report

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

• Assessment Technical Support Activities
-Assessments Collaboration Environment (new website)

• Development and Support of NOAA Climate Products and Services
-Climate Explorer v3.0 (interactive graph/map tool part of Climate Resilience Toolkit)

• Developing and Validating Heat Exposure Products Using the U.S. Climate Reference Network
-Hourly and sub-hourly heat exposure indices, including heat index (HI), apparent temperature (AT) and wet-bulb globe temperature (WBGT)

• NCEI Innovates: Developing 1991-2020 Normals along the Northeast and Lid-Atlantic Coasts
-1991-2019 Coastal Normals for areas in and around the U.S. Northeast and Mid-Atlantic
- ArcGIS Online interactive web map

• Scientific Data Stewardship for Digital Environmental Data Products
The NCEI/CICS-NC-developed Data Stewardship Maturity Matrix (DSMM) has been adapted by several international groups, including the Working Group on Information System and Services of the Committee on Earth Observation Satellites and the International Expert Group on Climate Data Modernisation (IEG-CDM) of the World Meteorological Organization (WMO) Commission for Climatology

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

Name: Fernando Miralles-Wilhelm
Role: PD/PI
Number of months (calendar) on project: 3
Contribution to the project: Dr. Miralles-Wilhelm is the tasked with overall responsibility of the Cooperative Institute, with the specific role of managing the relationship between Consortium members, between the overall Consortium and NOAA, and with purview over developing an integrated research, education, and outreach/engagement agenda for the entire Institute. Because of the nature of academic institutions, this role is assigned to a tenured faculty member at the University of Maryland (lead institution for CISESS) to ensure institutional support at the academic level, which is particularly important for research and education activities. Because of this requirement, this role also involves teaching, research, and service responsibilities and is funded only partially by CISESS (3 months or 0.25 FTE). He oversees all CISESS budgetary decisions, serve as the primary point-of-contact of the CI with NOAA, and lead the preparation of annual research plans and project progress reports to NOAA. He provides overall CI scientific and operational leadership and be responsible for working with NOAA and Consortium team members to ensure a successful research, education, training, and outreach/engagement program. He reports to the CISESS Executive Council and is advised by the CISESS Council of Fellows.
Residence: state of Maryland

Name: E. Hugo Berbery
Role: Co PD/PI
Number of months (calendar) on project: 12
Contribution to the project: As Deputy Director of CICS, 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 CICS, with scientific and financial responsibility over all research, education, and outreach/engagement activities taking place in this campus. In the role of CICS 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 CICS, 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 CICS in NC, tasked with overall management, scientific and financial responsibility over all research, education, and outreach/engagement activities taking place in this campus. He initiated

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?

The CISESS Consortium consists of UMD and NCSU as lead institutions and the University of North Carolina System (17 campuses, including NCSU); the University of Maryland, Baltimore County (UMBC); the University of Alabama (UA); the University of Alabama in Huntsville (UAH); the City University of New York (CUNY); George Mason University (GMU); Oregon State University (OSU); Howard University (HU); the University of Michigan (UM); the University of South Carolina (USC); the University of Georgia (UGA); the University of California, Irvine (UCI); South Dakota State University (SDSU); Florida International University (FIU); and the University of Nebraska Medical Center (UNMC) as academic institutions. Nonacademic institutions of the CISESS Consortium are the Pacific Northwest National Laboratory (PNNL), the University Corporation for Atmospheric Research (UCAR), The Nature Conservancy (TNC), and the Research Triangle Institute (RTI).

Partners contributions to the project: Collaboration (all).

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

36. Have other collaborators or contacts been involved?

Nothing to Report

IMPACT

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

CISESS has contributed to enhance the understanding of how the natural atmosphere–ocean–land–biosphere components of Earth interact with human activities as a coupled system. CISESS has engaged in collaborative and transformative research activities with NOAA scientists to enhance NOAA's ability to generate and use satellite and in situ observations and Earth System models to meet that challenge, advance NOAA's science mission, and identify emerging science needs that will effectively contribute to meeting NOAA's mission in the future. In conjunction with its research operations, CISESS has educated and trained students and scientists in areas of priority to NOAA and carry out relevant outreach and engagement activities with the scientific community, decision makers, and the public.

Specific impacts can be detailed as follows:

Algorithm development and calibration/validation efforts
• Scientific support for NOAA's JPSS satellite series. For each of the instruments (ATMS, CrIS, VIIRS, and OMPS), scientific staff apply critical capabilities for maximum beneficial collected data usage and support key performance parameters.
• Geostationary surface albedo (GSA) algorithm (being used as US contribution to international effort to produce joint climate record; new technique to estimate net solar radiation from geostationary (GEO) satellites.
• NOAA GOES-16/17 post-launch mission scientific assistance/support, including the calibration/validation, research/development, and dissemination of GOES-R data.
• Improvements to the quality and usability of US Climate Reference Network (USCRN) soil moisture measurements (https://www.ncdc.noaa.gov/crn/).
• Pre- and post-launch Radio Occultation (RO) data retrieval, processing, analysis, validation, and bias-monitoring in support of the Global Navigation Satellite System (GNSS) RO activity.
• Calibration of the visual channel of the International Satellite Cloud Climatology Project (ISCCP) B1 data.
New applications/products development
• Initial data stewardship maturity matrix (DSMM) for long-term stewardship of NOAA data products.
• New approaches to uncertainty quantification for observational datasets; novel statistical approach for fusing multiple platform/instrument observations.
• Version 4 of NOAA's Global Historical Climatology Network monthly temperature dataset, which aligns GHCNm temperature values with GHCN-D daily data and expands global coverage.
• Expansion of the Snowfall Rate (SFR) estimates for applications in weather forecasting.
• Scientific stewardship for Ocean Color Science Quality Reprocessed products for High Resolution Sea Surface Temperature and Salinity.
Increased data accessibility/utility:

IMPACT *(cont'd)*

38. What was the impact on other disciplines?

Nothing to Report

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

CISESS has supported NOAA's commitment to developing a future diverse workforce, and to this end it is led by a Minority Serving Institution (UMD is a MSI) and has significant participation of other MSIs. CISESS supports K–12, undergraduate, graduate, and postdoctoral education through mentoring early career staff, advising, teaching students, supporting student research activities, enabling student internships and fellowships, and advancing research collaborations.

Specific impacts on the development of Human Resources include:
• Created information/discussion exchange venues bringing together industry decision makers, academic researchers, and federal data experts (e.g., Executive Forum for Business and Climate and Dataset Discovery Days).
• Targeted outreach efforts with local schools and other STEM organizations (e.g., science museum, science festivals, STEM high schools, etc.).
• Established annual CISESS summer intern initiative, a mentoring program for undergraduate students to work on NOAA-related research.
• Established annual CISESS Science Meetings for sharing knowledge and stimulating collaborative opportunity discussions.

IMPACT *(cont'd)*

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

CISESS supports NOAA's commitment to the development of a society that is environmentally responsible, climate resilient and adaptive and utilizes effective, science-based problem-solving skills (e.g. STEM based learning) in education. CISESS scientists and educators participate in NOAA's climate education programs to advance the development of strong and comprehensive education and outreach activities about climate and oceanic and atmospheric sciences.

Through CISESS education, outreach, and engagement activities, CISESS scientists involve students in climate science and enable students and teachers to explore and understand the large volumes of climate data that NOAA collects about the Earth. Working collaboratively with other academic and public partners, stakeholders, and the private sector, CISESS supports and engages in various educational and outreach-related activities to advance the following areas:
i. Increase awareness of climate science and changes in the climate system
ii. Grow the understanding of how climate data is collected, observed, analyzed, and used in research purposes
iii. Increase awareness of climate datasets and products, and how educational teachers/professors can make use of climate data products for teaching climate science
iv. Demonstrate capacity building on the various impacts of climate change across public, private, and academic arenas
v. Increase private sector understanding and use of climate data and information for their strategic and operational use

Education, outreach and engagement are all important elements of the CISESS mission. CISESS engages in the improvement of both formal and informal education approaches to these areas of foci, as both of these approaches are important to the development of climate-literate citizens and a climate-adaptive society. These activities are broadly grouped within Undergraduate Education, Graduate and Postdoctoral Education, and Outreach Activities.

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

Nothing to Report

IMPACT *(cont'd)*

42. What was the impact on technology transfer?

Nothing to Report

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

CISESS supports the NESDIS mission of providing secure and timely access to global environmental data and information from satellites and other sources in order to promote and protect the Nation's security, environment, economy, and quality of life, as well as NOAA's broader mission to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources.

The need for global Earth System frameworks that included human system drivers and feedbacks has been recognized since the 1980s, notably documented in the pioneering report by the Earth System Sciences Committee of the NASA Advisory Council, chaired by Francis P. Bretherton (National Research Council 1988). This conceptual framework captures the interactive dynamics of the key components of the coupled Earth System with two-way feedbacks. This framework combines data collection from satellites and other sources, analysis techniques, and modeling to couple Earth System natural components, such as atmosphere, land (including vegetation and land use), and water (including oceans, ice, atmospheric, surface and subsurface water), with human components such as population demographics, freshwater, energy, agriculture, food production, industry, development, and transportation. The focus will be on activities with spatial scales ranging from regional to global and time scales spanning from minutes to decades, covering a variety of forecasting needs across societal (human system) applications and sectors. The investigators and institutions assembled in the CISESS Consortium have the expertise and resources necessary to develop and evaluate complex algorithms, products, and models that exploit both satellite and in situ measurements in order to provide information on the atmosphere, land, ocean, biosphere, and anthroposphere.

IMPACT *(cont'd)*

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

0 , No expenditures have been made under the CICS Cooperative Agreement in foreign countries.

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

Nothing to Report

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?

Outcomes of CISESS are the following:

•harness 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;

•contribute 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;

•provide 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;

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

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

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.