
NOAA SCIENCE ADVISORY BOARD

# NOAA SCIENCE ADVISORY BOARD REPORT ON THE REPORT OF THE EXTERNAL SCIENCE REVIEW COMMITTEE OF THE COOPERATIVE INSTITUTE FOR SATELLITE EARTH SYSTEM STUDIES (CISESS)

PRESENTED TO THE NOAA SCIENCE ADVISORY BOARD

APRIL 27, 2023

**EXTERNAL REVIEW**
**OF THE**
**COOPERATIVE INSTITUTE FOR SATELLITE EARTH SYSTEM STUDIES (CISESS)**
**THE UNIVERSITY OF MARYLAND (LEAD)**
**COLLEGE PARK, MD**
**NORTH CAROLINA STATE UNIVERSITY (CO-LEAD)**
**ASHEVILLE, NC**

**SUBMITTED TO THE**
**NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION**
**SCIENCE ADVISORY BOARD**
**ON**
**APRIL 2023**

## SUMMARY

An external review of the research, education, and outreach programs of the **COOPERATIVE INSTITUTE FOR SATELLITE EARTH SYSTEM STUDIES (CISESS)** was conducted on 21-22 February 2023 in College Park, Maryland. The CISESS consortium is co-lead by the University of Maryland, College Park (UMD) and North Carolina State University (NCSU). At UMD, CISESS is housed in the Earth System Science Interdisciplinary Center (ESSIC) and at NCSU, CISESS is co-located with NOAA's National Center for Environmental Information (NCEI) in Asheville.[1] The CISESS consortium includes academic, non-profit independent research organizations, non-governmental organizations, and HBCU partners. See Table 1 for a list of consortium members. CISESS builds on decades-long prior relationships between the National Oceanic and Atmospheric Administration (NOAA), UMD and NCSU. The current CISESS cooperative agreement started July 1, 2019.

Guidance for conducting the review was provided by the Cooperative Institutes Administration Office within the NOAA Office of Oceanic and Atmospheric Research (OAR). The review was conducted under the auspices of the NOAA Science Advisory Board (SAB) and, therefore, is subject to the requirements of the Federal Advisory Committee Act (FACA). A list of review panel members is provided in Appendix I. The review panel's on-site agenda is provided in Appendix II.

[1] The North Carolina component of CISESS is an Inter-Institutional Research Center of the University of North Carolina General Administration (UNC System), where it is known as the North Carolina Institute for Climate Studies (NCICS).

## SCIENCE REVIEW SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Science Review Panel consensus rating of CISESS is "Outstanding."

**Key Findings**

- CISESS science planning (vision, mission, objectives, operationalization) are well-aligned with NOAA and National Environmental Satellite, Data, and Information Service (NESDIS) strategic goals.
- The scientific activities developed in consultation with NOAA leverage CISESS resources and NOAA data and information provide many examples of value-add, innovation, and creativity. In addition, the quality of science, levels of collaboration and linkages to NOAA initiatives are high.
- Institutional cost-sharing is an important contributor to CISESS success.
- NOAA has benefited from CISESS expertise in emerging areas of technology and research.
- Metrics are extensive and impressive reflecting the breadth and depth of CISESS work, but may not reflect the nature and import of CISESS impacts.
- Communications and collaboration between CISESS lead institutions is appropriate and at times appears seamless.
- CISESS education and outreach efforts are very strong.
- Annual task funding model is an impediment to activities that contribute to the success of CISESS.

**Recommendations**

- Work with NOAA to enhance and/or expand opportunities for graduate students.
- Outreach and related activities would benefit from being funded as a separate task.
- Work with NOAA to determine possibilities for implementing a multi-year task funding framework where applicable.
- Look for opportunities to expand inclusion of CISESS consortium partners in CISESS funded activities.
- Continue maintaining current metrics and look for ways to identify other types of impact metrics.
- NOAA and the Cooperative Institutes (CIs) would benefit from including inputs and/or representatives in data management discussions and planning in an ongoing way.

leadership promoting better management of Maryland's natural resources and the protection and restoration of the Chesapeake Bay. This partnership with UMCES allowed CISESS to compete for and gain substantial funding through a UMD "Grand Challenge" competition that seeks to translate key climate findings into local solutions. North Carolina State University also is well known for its program in Marine, Earth and Atmospheric science although the physical separation from the main work force in Asheville makes the interaction less natural than the synergy at UMD. However, CISESS-NCSU's co-location with NCEI fosters significant collaboration in support of NOAA activities.

CISESS is funded through a five-year Cooperative Agreement with NOAA and includes a total funding ceiling for CISESS $175M. The CISESS current four-year spending totals $126M.

## II. STRATEGIC PLAN

### A. CISESS Vision, Mission, Goals

CISESS's scientific vision is well-articulated and well-aligned with NOAA goals related to accessing and using data and information from satellites and other sources to understand Earth systems "*[t]o advance NOAA's ability to generate data and information from the constellation of global observing platforms to understand and predict the different components of the Earth System through collaborative and transformative research and to transition this research into operational applications that produce societal benefits."* [p. 2-1][4]

CISESS articulates its vision through a five-part mission statement.

- *To produce reliable and authoritative data and make these data usable and available.*
- *To carry out research leading to understanding the Earth System at regional to global scales and from minute to decade time scales.*
- *To provide educational and outreach opportunities in NOAA-related research in areas that will contribute to the development of a diverse workforce in NOAA.*
- *To engage with stakeholders, understand user needs, and deliver actionable information about the Earth System.*
- *To identify emerging science needs requiring satellite and other Earth observations that will effectively and efficiently meet NOAA's mission.* [p. 2-1]

CISESS goals are linked to NESDIS and NOAA goals and provide pathways for operationalizing CISESS vision and mission.

- Support the NESDIS mission to provide access to environmental data and information
- Contribute to and enhance relevant research in support of NOAA's mission
- Innovative research, workforce development, and outreach [p. 2-2]

This strategic framework is also integrated with workforce development, education, outreach and engagement activities.

### B. CISESS Strategic Science Goals and NOAA Strategic Plan

To complement NOAA and NOAA/NESDIS strategic goals, CISESS aligns its scientific vision with the following grand scientific challenge. *"The grand scientific challenge of CISESS is to enhance our understanding of how the natural components of the Earth system —atmosphere, ocean, land, and biosphere—interact with human activities as a coupled system."* [p. 2-1]

CISESS operationalizes its science strategy along three research themes each with a number of sub themes as outlined in Table 2. The themes are intended to be mutually reinforcing and are designed to directly address the core scientific vision / grand challenge for CISESS. The vision, mission, themes and

[4] Unless noted otherwise, page numbers reference the *CISESS Mid-Term Review Report*, February 2023.

goals were collaboratively developed by the CISESS consortium members in consultation with NOAA line offices, NESDIS, National Weather Service (NWS), Office of Oceanic & Atmospheric Research (OAR), and National Ocean Service (NOS). See also Sections II.D and V.

*Table 2: Overview of Strategic Science Themes (Source: CISESS Mid-Term Review Report, February 2023)*

| **Theme** | **Sub-Element** |
|---|---|
| Satellite Services | • Satellite Observing Systems<br>• Sensor Calibration and Validation<br>• Algorithm and New Product Development, Data Fusion, and Blended Products |
| Earth System Observations and Services | • Components of the Earth System<br>• Surface Observing Networks<br>• Data Stewardship and Climate Data Records<br>• Research Supporting the Value Chain from Data Products to Societal Benefits<br>• Data-Intensive Science |
| Earth System Research | • Research to Operations (R2O) and Applications to Facilitate Weather/Climate-Related Decision Making<br>• Data Assimilation of Satellite Products<br>• Water Cycle Research and Collaboration with the National Water Center<br>• R2O: CISESS Proving Ground and Training Center Testbed |
| *Cross-cutting Areas* | • *Earth System*<br>• *Data Intensive Science*<br>• *Proving Ground & Training Center*<br>• *Research to operations and applications* |
| *Emerging Thematic Areas* | • *Artificial Intelligence*<br>• *Cloud Computing*<br>• *Support for Nanosatellite Technology and Commercial Satellite Data*<br>• *Support for Geostationary Extended Observations (GeoXO)*<br>• *Social Science* |

## C. Cross-Cutting and Emerging Themes

CISESS recognizes that some tasks may require work in more than one thematic area, or that work may be relevant to more than one theme. Identifying these types of cross-cutting themes helps to further align CISESS efforts with NOAA priorities. Additionally, the core research areas are further enhanced by a set of emerging themes identified by CISESS. Research in these emerging areas helps the Cooperative Institute identify and engage with relevant leading-edge science and technology. Emerging themes are mainly funded through internal seed grants in order to focus expertise in these leading-edge areas onto existing NOAA problems or new foci as outlined in evolving NOAA strategic plans.

## D. Cooperative Planning

CISESS updates its work plan annually via a process that starts with updates on NOAA priorities via a memorandum provided by STAR's director. CISESS consortium partners discuss specific tasking with

relevant NOAA line offices and the consortium partners with the best expertise to address a task. The resulting task proposals make up the research plan for the next year.

### E. Success Measures

CISESS tracks its performance qualitatively as reflected in the extensive set of activity summarized in CISESS annual reports and via a set of quantitative performance metrics. The quantitative metrics include new or improved products developed, peer reviewed papers, NOAA technical reports, presentations, graduate students supported and/or formally advised, and CISESS tracks number of students mentored. The 2018 CI Directors Tasking details quantitative metrics of this type which are reported annually in the NOAA Research Performance Progress Report (RPPR).

*Table 3: Cumulative CISESS Performance Metrics*

| Performance Metric | 2020 | 2021 | 2022 | Total |
|---|---|---|---|---|
| # of new or improved products developed that became or may become operational | 153 | 189 | 178 | **518** |
| # of peer-reviewed papers | 115 | 200 | 117 | **432** |
| # of NOAA technical reports | | 15 | 2 | **17** |
| # of books and book chapters | 26 | 31 | 47 | **31** |
| # of talks and posters | 359 | 468 | 252 | **1079** |
| # of invited presentations | 18 | 19 | 9 | **46** |
| # of graduate students supported by a task | 10 | 9 | 2 | **21** |
| # of graduate students formally advised | 13 | 26 | 9 | **48** |
| # of high school interns | 6 | 8 | 8 | **22** |
| # of undergraduate students mentored during the year | 10 | 24 | 22 | **56** |
| # of students mentored by Consortium members | 28 | 43 | 59 | **130** |

Years indicate the date of annual RPPR submissions. [p. 4-4]

## III. Science Review

CISESS science activities and research are organized along the three main CISESS science themes as described in Section II. In addition to the core themes, both CISESS at Maryland and CISESS at NCSU focus on emerging technologies – largely in artificial intelligence (AI) to improve products, and in open data dissemination protocols to make ever increasing volumes of Earth data available to the public. The open data discussions led to some interesting exchanges related to NOAA policy regarding the possibilities and challenges of fully open access to climate data.

### Theme 1: Satellite Services

CISESS supports NOAA's satellite observation capabilities by providing end-to-end scientific expertise and support, and transition of research into operations. Specifically, the satellite services task is broken into:

- **Satellite Observing Systems** activities include includes gathering end-user requirements, developing products, and ensuring the quality, accessibility, and usability of end products to develop and implement NOAA geostationary Earth orbit (GEO) and low Earth orbit (LEO) satellite systems, particularly through support for Geostationary Operational Environmental

Satellite (GOES) – R Series (GOES-R), Joint Polar Satellite System (JPSS), and small satellite (SmallSat) efforts.

- **Sensor Calibration and Validation** activities perform calibration of Earth-observing satellite sensors, including the calibration of sensors flown on NOAA's next-generation JPSS and GOES-R, other platforms (visible, infrared, microwave, ozone, and lightning sensors), as well as inter-satellite integration.
- **Algorithm and New Product Development, Data Fusion, and Blended Products** efforts develop satellite-based algorithms for Earth system monitoring and includes validation activities for derived products and new applications from weather to climate.

**Theme 2: Earth System Observations and Services**

CISESS' vision is to advance our understanding of Earth System processes using remotely sensed and in-situ observations, models, and information technology, towards increased societal value of NOAA Earth System research. Most of the efforts in this task are concentrated in CISESS NCSU and in its collaboration with NCEI in Asheville. This theme is broken down into:

- **Components of the Earth Syste**m – The overall goal of this effort is stated as understanding changes in the components of the Earth System: atmosphere, oceans, land, biosphere, and human Systems with key focus areas in air quality, atmospheric gasses and particles, vegetation, land surface properties, the changing cryosphere, the global oceans, and terrestrial and marine ecosystems. Efforts in the area of Vegetation and Land Surface properties align with NCEI Asheville's known science leadership.
- **Surface Observing Networks** – including the US Climate Reference Network. CISESS is an integral component of this effort, including ongoing activities to improve soil moisture and temperature as well as precipitation. An important component is also the development of value-added products such as the Heat Exposure product, and the creation of "Climate Normals" against which changes can be compared.
- **Data Stewardship and Climate Data Records** – is perhaps the largest component of CISESS in Asheville and takes the form of everything from satellite ocean data stewardship (including ocean temperature, salinity, heat content and steric levels), to coral data management, to curating surface wind climatologies, and data archive infrastructure architecture planning and support. In short, the whole gamut of expertise one needs to archive climate data records and extract useful information from those records. It is clear from both the report and the presentations during the review that CISESS NCSU has significant expertise in this area that is vital for the smooth operation of NCEI.
- **Research Supporting the Value Chain from Data Products to Societal Benefits –** is focused on transforming NOAA satellite/instrumental data and computational model outputs into information for decision-making to promote societal goals. During the meeting, some of the most compelling benefits of NCSU's contribution to CISESS was in the area of communication and user engagement workshops that connect user needs with available products and potentially the modification of products to better suit the user community. NCSU staff are also highly involved in *NOAA's State Climate Summaries*, *Global and Regional Sea Level Rise Scenarios for the United States*, the *North Carolina Climate Science Report* and the *Scientific Assessment of Ozone Depletion* to name just some. Finally, the CISESS group in Ashville is also very involved in

health aspects of climate and a very forward-looking presentation was given relating joint work between NCEI and the Center for Disease Control that is led by CISESS scientists.

**Theme 3: Earth System Research**

Earth system research at CISESS focuses on leveraging NOAA satellite capabilities to monitor and predict ecosystems at regional to basin scales. Projects under this theme are organized under four broad categories: Applications to Facilitate Weather/Climate-Related Decision Making, Data Assimilation, Water Cycle Research, and R2O Through CISESS Proving Ground and Training Center Testbed.

- **Applications to Facilitate Weather/Climate-Related Decision Making**: CISESS provides applications tailored to improving forecast skill at multiple time and space scales to improve decision support for a wide range of environmental conditions.
- **Data Assimilation of Satellite Products**: CISESS develops new and improved methods to integrate satellite products into Earth System models.
- **Water Cycle Research**: In collaboration with National Water Center, CISESS scientists work on algorithms to derive land surface and water cycle information from satellite observations to improve end-to-end models of the water cycle.
- **CISESS Proving Ground and Training Center Testbed**: CISESS facilitates R2O by operating a proving ground and testbed for new products and providing training for Earth System forecasters in the interpretation of these products.

## IV. EDUCATION/OUTREACH

CISESS organizes its education and outreach efforts along three dimensions: workforce development, education and outreach, and user engagement.

CISESS scientists provide training, mentoring, and related advisory support to junior scientists, post-doctoral fellows, and students including high school, undergraduate, and graduate. A successful CISESS program provides paid summer student internships. Students work for twelve weeks with a mentor responsible for training the student and at the end of the internship, interns prepare a written report and present their work at a student workshop.

CISESS-UMD runs both a Remote Sensing Laboratory (RS Lab) and a Proving Ground and Training Center (Viz Lab). The RS Lab is developing a low-cost microwave radiometer for student training and for supporting JPSS programs. The Lab has also worked on designing a robotic ground-based cal/val system and worked on the integration and demonstration of field campaigns to support VIIRS and ABI Cal/Val. The Viz Lab has worked on real-time NOAA weather and climate product analysis in virtual reality.

CISESS educational and training programs facilitate a flow of qualified individuals moving into NOAA roles from their tenure at CISESS. During the first 3.5 years of operations, fifteen CISESS scientists and technical staff have transitioned to NOAA.

CISESS leverages routine communications channels for outreach such as its website, news feeds, and social media. Additionally, both CISESS co-leads, UMD and NCSU, have developed and maintain a number of outreach partnerships such as the Asheville Museum of Science (e.g. “Ask a Scientist Series”), the NC Science Festival, direct support of NOAA NCEI Outreach and Communications Branch, development of a virtual webinar series for a target audience of Cooperative Extension agents, and participation in Maryland Day (ESSIC booth w/CISESS scientists).

Direct user engagement is categorized in three ways, industry and business (private sector), general public, and NOAA and the wider scientific community. An example of CISESS engagement with the private sector, is the 2021-2022 series of five Department of Commerce sectoral listening sessions with

over five hundred participants. These sessions were co-planned and executed with CISESS-NCSU staff and NCEI Information Services leads. The sectors covered included, Retail (October 2021), Insurance/Reinsurance (December 2021), Architecture and Engineering (January 2022), NOAA New Blue Economy (February 2022), and Travel, Tourism, and Recreation (March 2022). Examples of efforts directed at engagement with the general public include CISESS-NCSU coordination of the development of the Annual State of the Climate report led by NCEI with several CISESS scientists each year also contributing. At UMD, the University has defined Climate Impacts as one of the Grand Challenges in its strategic plan. CISESS/ESSIC faculty partnered with faculty in AOSC, GEOL, and GEOG submitting a proposal for a program for Translating Research to Societal Impact in Earth and Climate Science, with funding of $1M/year for three years. The proposal was successful. CISESS will use "a research impact philosophy" to draw on the results of our funded research activities to deliver monitoring and prediction to Maryland communities. CISESS broader engagement with the scientific community includes conference participation and organizing, developing and hosting various seminar series, scientific papers, and other external presentations. CISESS researchers have also provided training resources that leverage their work such as developing and providing a training module for NCAR's Corpsmember Orientation, Motivation, Education and Training (COMET) Satellite Applications for winter Weather: mesoscale Banded Snowfall" program.

## V. SCIENCE MANAGEMENT

CISESS was established to provide 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. They have done this largely by hiring and promoting world class research scientists that lead individual efforts, and help identify emerging areas through grants from other agencies or occasionally from CISESS itself. They lead successful science initiatives, education and training, outreach activities, and transitioning CISESS staff to the NOAA Federal workforce during the last several years.

CISESS has very strong connections to and interactions with NESDIS. As such, new intellectual opportunities are often derived in conjunction with NOAA. Tasking normally happens in conjunction with negotiations w/NOAA. Other opportunities for identifying new research and development activities include, professional interactions, seed grants, and synergies from other situations such as co-location w/NOAA.

The 2021 seed grant activity initiated at UMD in 2021 is a strong example of the types of innovative activities created and managed at CISESS the outcomes of which are of high value to NOAA. The funds are allocated to assist in the development of transformational research in the form of proof of concepts that can be used to facilitate conversations with NOAA regarding potential new areas for future CISESS tasking. The approach is cost-effective with one-year grants, with the option to a second year in the amount of $30,000 (+$15,000 if extended to a 2nd year). The first set of seed funds projects includes Building and Deploying Tools to Better Observe Lightning in the Washington D.C. Region and Beyond; Developing Low-Cost Microwave Radiometers for Student Training and Supporting JPSS Programs; Real-Time NOAA Weather and Climate Product Analysis in Virtual Reality; and Emulating Microwave Measurements Using ABI Observations. [p. L-1-3] It should be noted, however, that the funds that support this activity are derived from Task 1.

NOAA strategic thinking benefits from the 'over-the-horizon' expertise and the results from these exploratory efforts at CISESS. Discussions are in progress around other topics to consider for future tasking include AI, cloud computation, nanosatellite technology and commercial remotely sensed data, support for GEOXO science, as well as ways to develop and implement the findings from social science.

*Table 4: CISESS Personnel (2021-22)*

| Category | UMD | NCSU | Consortium Partners |
|---|---|---|---|
| Research Faculty/Research Scientists | 91 | 27 | 34 |
| Postdoctoral Fellows | 14 | 1 | 1 |
| Graduate Students | 8 | 9 | 5 |
| Undergraduate Students | 10 | 6 | 13 |
| Research Support Staff | 5 | 5 | 18 |
| Administrative Staff | 12 | 3 | 4 |
| **TOTAL** | **140** | **51** | **75** |
| Receiving <50% NOAA funding (not including students) | 23 | 3 | 19 |
| Located/co-located at NOAA Facility (NCWCP, Silver Spring, NCEI, etc) | 70 | 35 | 2 |

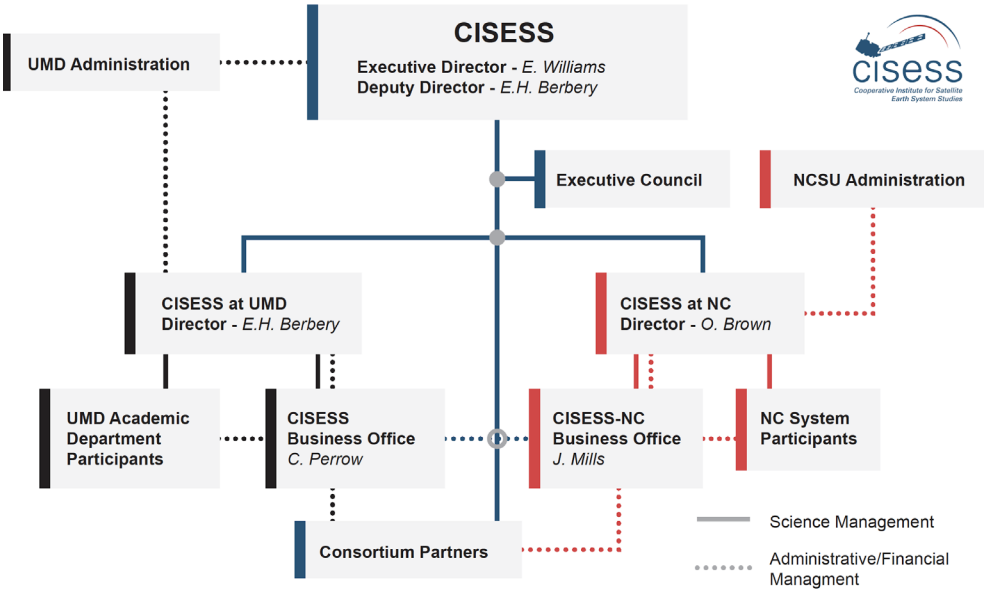


*Figure 1: CISESS Organizational Chart*

Communications and planning between UMD and NCSU take place routinely and on an *ad hoc* basis as needed. Both organizations enjoy clear support from the highest levels of university research offices at both host institutions. The committee agreed that CISESS does an excellent job managing an effort of this size and complexity while also recognizing that the management of CISESS is not without administrative challenges.

## VI. FINDINGS

- **CISESS science planning (vision, mission, objectives, operationalization) are well-aligned with NOAA and NESDIS strategic goals.** The science planning is collaborative and forward-looking.
- **The scientific activities** developed in consultation with NOAA leverage CISESS resources and NOAA data and information **provide many examples of value-add, innovation, and creativity**. In addition, the **quality of science, levels of collaboration and linkages to NOAA initiatives are high.** During the review, a series of science presentations were made that highlighted the quality of the PIs involved in the research, the collaboration between PIs at CISESS, and the linkages of the research to NOAA initiatives. The science presentations highlighted several applications for improving decision support ranging from improved characterization of tropical cyclone environments to identifying air quality hazards and harmful algal blooms. The Earth System theme provides several additional examples of CISESS' strong commitment to user engagement to define applications and train decision makers in their use. CISESS has made tangible contributions to enhancing water cycle monitoring from satellite observations including the development of new atmospheric water vapor, snowfall, soil moisture, and evaporation datasets. The presentations left a very good impression on the review committee.
- **Institutional cost-sharing is an important contributor to CISESS success.** However, relying on cost-sharing carries risks as publicly-funded host institutions may be driven to look for ways to cut costs and cost-sharing arrangements are an easy target for budget-tightening activities. An entity such as CISESS has to make continuing efforts to justify the cost share. Examples of CISESS success leveraging cost sharing from the Universities includes funding summer student interns as well as supporting emerging thematic areas. While no formal cost-share requirement exists, we simply note the benefit of the existing agreement for the success of the Institute.
- **NOAA has benefited from CISESS expertise in emerging areas of technology and research.** It is clear that NOAA has already benefited significantly from expertise in AI/ML as well as cloud computing and social science. The summaries of the project reports included in the CISESS report included a high number of activities in the Satellite Service area related to AI initiatives and Cloud Computing. Some activities appeared to be folded into the project tasks but there were also 2-3 seed grants each year that focused on emerging technologies that were supported by internal CISESS funds.
- **Metrics are extensive and impressive reflecting the breadth and depth of CISESS work, but may not reflect the nature and import of CISESS impacts.** CISESS tracks performance and success of its activities via publications, products developed, and presentations given as prescribed. Using JSTAR, JPSS and GOES-R categories as representing the above activities, CISESS publishes approximately 85 articles, produces approximately 125 products, and gives approximately 150 presentations per year related to the above activities. The NCSU group publishes about 30 journal articles per year, produces roughly 60 products per year, gives about 14 presentations per year and entrains significant numbers of students into its activities.
- **Communications and collaboration between CISESS lead institutions is appropriate and at times appears seamless.** The relationship between NCEI and CISESS NCSU appeared to be seamless with frequent communications between the two sides and almost an interchangeable nature to the science activities. It appears as if CISESS NCSU was leading many of the efforts in user engagements and exploratory connections between climate data and other disciplines.
- **CISESS education and outreach efforts are very strong.** The review committee was uniformly impressed by the level of level of user engagement that is ongoing with respect to climate data.

Classes for capacity / skill building are very effective. Listening sessions are an excellent example of a great connection to NOAA efforts.

- **Annual task funding model is an impediment to activities that contribute to the success of CISESS.** For example, it would be helpful to be able to fund graduate students on a multi-year basis.

## VII. RECOMMENDATIONS

- **Work with NOAA to enhance and/or expand opportunities for graduate students.** Relatively few graduate students are focused on Emerging Thematic areas. This could be improved by NOAA funding a small number of graduate students annually through a competitive process that focuses specifically on areas of emerging scientific interest.
- **Outreach and related activities would benefit from being funded as a separate task.** There are clear benefits from outreach efforts, i.e. listening sessions, actions. Outreach needs to be included as a funded task in order to ensure sustained effort and further development. Look for ways to review and enhance UMD task funding model for dedicated outreach personnel.
- **Work with NOAA to determine possibilities for implementing a multi-year task funding framework where applicable.** This would help to reduce administrative costs associated with an annual task funding cycle and provide more efficient use of available funds.
- **Look for opportunities to expand inclusion of CISESS consortium partners in CISESS funded activities.**
- **Continue maintaining current metrics and look for ways to identify other types of impact metrics.** However, these types of metrics, i.e. publications, are standard and may not adequately represent or provide insight into the impact or value of CISESS activities of relevance to NOAA. The review committee suggests looking for ways to identify and/or promote awareness of these types of results.
- **NOAA and the CIs would benefit from including inputs and/or representatives in data management discussions and planning in an ongoing way.** Cloud based access to climate data has potential pitfalls related to misuse of data or its interpretation. In addition, CI data and compute continues to grow exponentially with implications for NOAA data stewardship. Promoting information exchange in these areas would be beneficial to both sides.

## VIII. SUMMARY AND CONCLUSIONS

The review committee found the material presented by CISESS to be comprehensive, detailed and explored all aspects of the review criteria. The committee appreciated the efforts of CISESS leadership and staff developing and providing the review material, arranging the extensive set of briefings during the site visit, and providing a smooth-running meeting coordinating across multiple institutions and collaboration tools.

Based on the findings described above and the nature of the recommendations provided by the review committee, the science review committee agreed on an overall rating for CISESS of **Outstanding**.

## APPENDIX I

## LIST OF EXTERNAL REVIEWERS

**Anthony Guillory**, NASA Marshall Space Flight Center, Project Manager

Anthony Guillory is a Project Manager at the Marshall Space Flight Center. Prior to this position, he was the Airborne Science Project Manager at the Wallops Flight Facility on Wallops Island, Virginia, overseeing a fleet of NASA research aircraft, and a Mission Manager at NASA Langley Research Center. Guillory received a B.Sc. Degree in Atmospheric Science from the University of Louisiana Monroe and an M.Sc. Degree in Meteorology from Florida State University.

**Christian Kummerow**, former Director of the Colorado State University Cooperative Institute for Research in the Atmosphere

Professor Chris Kummerow joined the Colorado State University Department of Atmospheric Science Faculty in June 2000. Prior to joining the department, he worked at the NASA/Goddard Space Flight Center serving as the Project Scientist for the Tropical Rainfall Measuring Mission (TRMM). He is currently a member of the Joint TRMM Steering Team. Kummerow is also a member of the Advanced Microwave Scanning Radiometer team and plays an active role in planning and defining new spaceborne missions geared toward obtaining a better understanding of the Global Water and Energy Cycle. He holds a B.Sc. in Physics (1982) from the University of California-Berkeley and a Ph.D. in Atmospheric Physics (1987) from the University of Minnesota, Minneapolis.

**Tristan L'Ecuyer**, Director, Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison

Professor Tristan L'Ecuyer has been Director of the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison since Jan. 1, 2019. L'Ecuyer joined the faculty of the Department of Atmospheric and Oceanic Sciences (AOS) in August 2011. Prior to joining AOS and CIMSS, he worked as a research scientist at Colorado State University (CSU) in Fort Collins, CO. He has more than 20 years of experience designing, implementing, validating, and analyzing global satellite datasets. He has developed several new global satellite datasets including rainfall, snowfall, and radiative fluxes from NASA's CloudSat satellite mission, the first cloud radar flown in space. He currently leads the Polar Radiant Energy in the Far-Infrared Experiment, a NASA Earth Ventures mission that will use CubeSats to fill a substantial gap in understanding energy exchanges in the Arctic and Antarctica. L'Ecuyer is a member of the NASA CloudSat/CALIPSO Science and Precipitation Measurement Mission science teams. He chairs the Global Energy and Water Exchanges Data Analysis Panel and serves on numerous NASA and NOAA advisory panels. He received his Ph.D. in Atmospheric Science from CSU in 2001 and holds B.Sc. and M.Sc. degrees in Physics from Dalhousie University in Halifax, Nova Scotia, Canada.

**Christopher Lenhardt** (Chair), NOAA Science Advisory Board member, Renaissance Computing Institute (RENCI), UNC

Christopher Lenhardt is a Senior Data Scientist in the Earth Data Science group at the Renaissance Computing Institute (RENCI), a research center in Chapel Hill at the University of North Carolina. Prior to RENCI, Lenhardt was the director of the NASA-funded Earth observing system data archive, the

Distributed Active Archive for Biogeochemical Data at Oak Ridge National Laboratory. His information science and data curation career started with CIESIN (Center for International Earth Science Information Network) at Columbia University. At CIESIN he became CIESIN's associate director for Information Services, the group responsible for leading-edge science data archiving, metadata generation and management, and user services. While at CIESIN, Lenhardt also served as the deputy director for the Socioeconomic Data and Applications Center, another NASA distributed active archive.

He served two terms as a member of the NOAA Data Access and Archiving Requirements Working Group (DAARWG) and served as DAARWG chair. Lenhardt also leads the Strategic Cooperation Board for the Cooperation EU-US project, which seeks to align science research infrastructures. Other service and leadership roles include terms as President and Vice-President of the Federation of Earth Science Information Partners, and he is active at the national and international level in science data organizations. He also served on the board of directors for the Foundation for Earth Science. He received an M.Sc. in Political Science from the University of Michigan and an M.Sc. in International Relations from the London School of Economics and Political Science.

**Shelley Stall**, American Geophysical Union (AGU), Vice President, Data Leadership

Shelley Stall is the Vice President for the AGU's Data Leadership Program. She works with AGU's members, their organizations, and the broader research community to improve data and digital object practices with the ultimate goal of elevating how research data is managed and valued. Her diverse experience working as a program and project manager, software architect, database architect, performance and optimization analyst, data product provider, and data integration architect for international communities, both nonprofit and commercial, provides her with a core capability to guide development of practical and sustainable data policies and practices ready for adoption and adapting by the broad research community.

Stall's recent work includes the Enabling FAIR Data project (https://copdess.org/enabling-fair-data-project/) engaging over 300 stakeholders in the Earth, space, and environmental sciences to make data open and FAIR targeting the publishing and repository communities to change practices by no longer archiving data in the supplemental information of a paper but instead depositing the data supporting the research into a trusted repository where it can be discovered, managed, and preserved.

Stall is a certified Enterprise Data Management Expert through the CMMI Institute's Data Management Maturity program. She is also a Certified Data Management Professional through DAMA's certification program and Project Management Professional through the Project Management Institute. She holds a B.A. Degree in Mathematics from Shippensburg University of Pennsylvania and an M.B.A. in Operations Information Technology from Ball State University's Miller College of Business.

## APPENDIX II

### CISESS 5 Year Science Review Agenda

### ESSIC – 5825 University Research Court, Suite 4001

**Tuesday, February 21, 2023**

8:00 a.m. Review Panel Executive Session

9:00 a.m. Welcome & Introductions, *E. Williams, CISESS Executive Director*; *E.H. Berbery, CISESS Deputy Director*; *Otis Brown, CISESS-NC Director*

9:15 a.m. UMD Academic and Scientific Environment, *Prof. Amitabh Varshney, Dean of CMNS*

9:30 a.m. NCSU Research Environment, *Mladen Vouk, NCSU Vice Chancellor for Research*

9:45 a.m. NCEI vision, *Dr. Deke Arndt*, *Director of NCEI*

10:00 a.m. Break

10:30 a.m. Overview of CISESS, Science Plan, and CISESS Initiatives,
*E. Williams (35 min presentation/15 min questions))*
*H. Berbery (14 min/6 min)*
*O. Brown 14 min/6 min)*

12:00 p.m. Working Lunch

1:00 p.m. *Gary Matlock, DAA for Science, NOAA/OAR*

1:15 CISESS Science Highlights
*8 presenters (12 min/3 min each)*

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|---|---|
| 1:15 pm | Kayo Ide (Data Assimilation) |
| 1:30 pm | Jennifer Runkle (Climate and Health) |
| 1:45 pm | Xi Shao (Radio Occultation; sensor calibration) |
| 2:00 pm | Daile Zhang (Lightning) |
| 2:15 pm | Kenneth Kunkel (National Climate Assessment) |
| 2:30 pm | Denis Willett (Data Science) |
| 2:45 pm | Veljko Petkovic (The Hydrologic Cycle) |
| 3:00 pm | Jonathan Brannock (NOAA Open Data Dissemination) |

3:15 p.m break

3:30 p.m. CISESS Education & Outreach Highlights, Part I
*3 presentations (12 min/3 min each)*

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|---|---|
| 3:30 pm | Jenny Dissen (Engagement and Outreach Overview) |
| 3:45 pm: | Erick Geiger/Jacquie De La Cour - Coral Reef (recording) + Terrence Pierce (6 min each) |
| 4 pm | Melanie Abecassis (Coastwatch; climate indicators) |

4:15 p.m. Executive Session of Review Panel

5:00 p.m. Day 1 Debrief

6:15 p.m. Dinner

**Wednesday, February 22, 2023**

9:00 a.m. UMD Research Environment, *Prof. Gregory F. Ball, UMD Vice President for Research*

9:30 a.m. CISESS Education and Outreach Highlights, Part II

*3 presenters (12 min/3 min each)*

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|---|---|
| 9:30 am | Jenny Dissen (NOAA Listening Sessions) |
| 9:45 am | Javier Villegas Bravo (Satellite Liaison at NOAA) |
| 10 am | Douglas Rao (National Center for Artificial Intelligence / Related Activities) |

10:15 a.m. Visit CISESS MD Facilities

11:15 a.m. Science Management, *E. Williams*

11:30 a.m. Questions and Feedback from Review Committee

12:00 p.m. Working Lunch – Executive Session of Science Panel

3:00 p.m. Break

3:15–4:15 p.m. Debrief and discussion