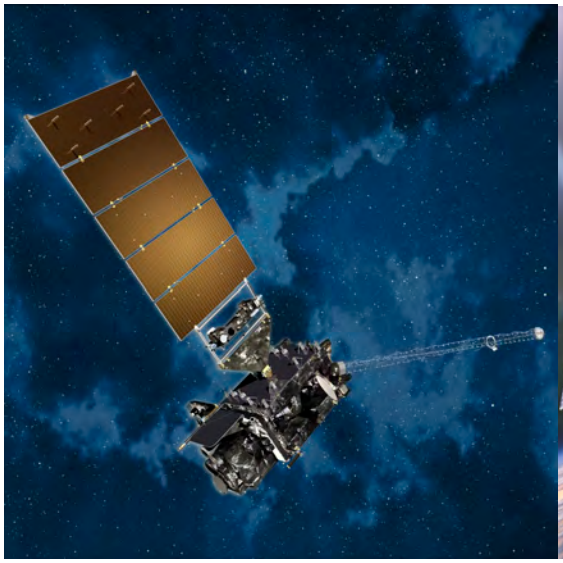

GOES-R

JPSS

COOPERATIVE INSTITUTE FOR CLIMATE and SATELLITES (CICS)

Annual Scientific Report

VOLUME I: Activities Summary

For the period:
July 1, 2014 – March 31, 2015
NOAA Grant NA14NES4320003

Dr. Fernando Miralles-Wilhelm, Director
April 30, 2015

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1 INTRODUCTION

This annual report of the Cooperative Institute for Climate and Satellites (CICS) is divided into two volumes. The first is a summary of all the activities of CICS including the administration and core tasks and the highlights of this year's scientific research and operational results, along with relevant appendices. The second volume is a compilation of reports on the over 100 individual CICS tasks that were undertaken this year for various National Oceanic and Atmospheric Administration (NOAA) funders, including the Center for Satellite Applications and Research (STAR); National Climatic Data Center (NCDC); Office of Oceanic and Atmospheric Research (OAR), National Oceanographic Data Center (NODC); Climate Program Office (CPO); National Weather Service (NWS); and Air R sources Laboratory (ARL). The acronyms in this report are compiled and defined in Appendix 1.

1.1 Background

The Cooperative Institute for Climate and Satellites (CICS) was formed in 2009 through a national consortium of academic, non-profit and community organizations, with leadership from the University of Maryland College Park (UMD) and North Carolina State University (NCSU) and principal locations in College Park, Maryland and Asheville, North Carolina. *The CICS Consortium* includes a wide range of research universities, non-profit organizations, and community groups. Its role is to augment the capabilities of CICS and to extend its ability to conduct innovative and original collaborative research with NOAA. CICS' cooperative agreement with NOAA was renewed for an additional five years in 2014.

CICS is administered as part of the NOAA/NESDIS/STAR Cooperative Research Program Institutes and was the first experiment by NOAA and academic institutions to engage a geographically dispersed, diverse set of more than 30 partner institutions across the United States to address environmental change, their prediction, and potential impacts.

Each of CICS' principal centers is collocated with or adjacent to its main NOAA partner**:** ***CICS-MD*** is adjacent to the NOAA Center for Weather and Climate Prediction (NCWCP). ***CICS-NC*** is collocated with the NOAA National Climatic Data Center (NCDC) in Asheville, NC; CICS-NC is an Inter-Institutional Research Center with the UNC System, where it is known as the North Carolina Institute for Climate Studies. The physical proximity at both locations greatly facilitates extensive and productive collaboration between CICS and NOAA scientists.

The range of expertise needed to support NOAA is broad and varied. It ranges from basic and applied research on the natural climate 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. It is clear that no one institution or even a small number of institutions can provide all the necessary exper-

tise. Thus CICS was implemented as a consortium of partners with expertise covering the breadth of NOAA's portfolio.

The CICS Consortium was developed to address the wide breadth of challenges associated with moving climate science research into a federal operational context for NOAA's NESDIS. Institutions were selected for demonstrated capabilities in climate research with a focus on observations, modeling and impacts. That is, institutions include both natural and social science expertise.

The current CICS Consortium membership consists of the University of Maryland College Park (UMD), the Joint Global Change Research Institute collocated with UMD, the University of North Carolina System (16 campuses, including NC State University), Land Surface Hydrology Group at Princeton University, Center for Hydrometeorology & Remote Sensing at University of California Irvine, the Climate and Radiation Group at Howard University, Columbia University/IRI, Institute for Global Environmental Strategies (IGES), City University of New York (CREST), University of Illinois at Urbana-Champaign, Oregon State University (CIOSS), University of Miami (RSMAS & CIMAS), University of Michigan, University of South Carolina (CISA & HVRI), the Barros Research Group at Duke University, Colorado State University (CIRA), Remote Sensing Systems, Climate Central, North Carolina Arboretum, Centers for Environmental and Climatic Interaction, Renaissance Computing Institute (RENCI), Oak Ridge Associated Universities (ORAU), and, Oak Ridge National Laboratory (ORNL).

Due to the geographic and institutional diversity of the Consortium, maintaining institutional interest in it and coherence across it is challenging. Consortium coherence is fostered by annual meetings and site visits by the CICS Executive Director, while ongoing interactions associated with funded research and development activities, as well as proposed collaborations for competitive awards, help maintain institutional and principal investigator interest.

Consortium membership is driven by stated federal needs to CICS. As needs are communicated to CICS, Consortium members' expertise is reviewed to ascertain whether the need can be addressed internally. If not, then a broader search is initiated to find an institution with the required expertise through a competitive process. Once an institution with the appropriate expertise has been identified, it is invited to join the Consortium and author a task proposal to the federal partner for review and support through the cooperative agreement.

Federally funded Consortium activities are supported through the CICS Cooperative Agreement via a series of subcontracts between the University of Maryland and North Carolina State University and specific Consortium members, with UMD or NCSU taking the lead dependent on the specific collaboration.

CICS is arguably unique among NOAA Cooperative Institutes in its distributed configuration. The initial membership of the Consortium was chosen to ensure a broad spectrum of expertise and experience appropriate to the proposed institute vision. Since CICS was established, some evolution in membership has occurred. A few of the initial members have found other methods to collaborate with NOAA, while others have been unable to identify a suitable niche. During the same period, several new partners have joined, extending the reach and capability of the Consortium.

The CICS Consortium provides NOAA with extraordinary opportunity to engage the extrafederal scientific and user communities on research, development, and outreach issues. It is a remarkably broad and flexible mechanism that enables NOAA to benefit from the collective capabilities of its members.

1.2 CICS Vision and Mission

CICS' vision and mission derive from the historical expertise of the lead institutions and partners that comprise the CICS Consortium, together with NOAA's requirements. The CICS vision and mission are closely tied to NOAA's Strategic Goals.

VISION

CICS' vision is to perform collaborative research aimed at enhancing NOAA's ability to use satellite and in situ observations and Earth System models to advance the national climate mission, including monitoring, understanding, predicting, and communicating information on climate variability and change.

MISSION

CICS' mission is to conduct research, education, and outreach programs in collaboration with NOAA to:

- Develop innovative applications of national and international satellite observations and advance transfer of such applications to enhance NOAA operational activities;
- Investigate observations and design information products and applications to detect, monitor, and understand the impact of climate variability and change on coastal and oceanic ecosystems;
- Identify and satisfy the climate needs of users of NOAA climate information products, including atmospheric and oceanic reanalysis efforts;
- Improve climate forecasts on scales from regional to global through the use of observation-derived information products, particularly through participation in the Climate Test Bed at the National Centers for Environmental Prediction (NCEP);
- Develop and advance regional ecosystem models, particularly aimed at the Mid-Atlantic region, to predict the impact of climate variability and change on such ecosystems; and

- Establish and deliver effective and innovative strategies for articulating, communicating, and evaluating research results and reliable climate change information to targeted public audiences.

The Research Themes for CICS are:

- **Theme 1: Climate and Satellite Research and Applications** incorporates the development of new observing systems, or new climate observables from current systems.
- **Theme 2: Climate and Satellite Observations and Monitoring,** focuses on: (a) development and improvement of climate observables from current systems, and (b) development of all continental and global fields of climate parameters that can be used for climate analysis and climate model initialization.
- **Theme 3: Climate Research and Modeling is** the research component that brings together (a) climate observables, modeling and validation in a comprehensive integrated whole, and (b) observational products with model development efforts to enable research into the improvement of forecasts of climate system variability on space scales ranging from regional to global, and time scales from a week or two to centuries.

Research is conducted through in situ and remotely sensed observations, together with component and coupled ocean-atmosphere-land modeling. This multi-pronged approach provides a foundation for understanding and forecasting changes in the global environment and regional implications. Data assimilation and regional downscaling are used to link the observations and models, enabling us to study the interactions between the physical climate system and biogeochemical cycles from global to regional scales.

The CICS Themes are unchanged from the original submitted proposal. As CICS research has evolved since 2009 in response to NOAA's needs, Topic Areas have been identified as useful organizing devices. **Figure 1** illustrates the relationship between the Themes and the Topic Areas. In **Figure 2,** we summarize graphically the stratification of active task funding by CICS Research Theme and by NOAA Strategic Goal.

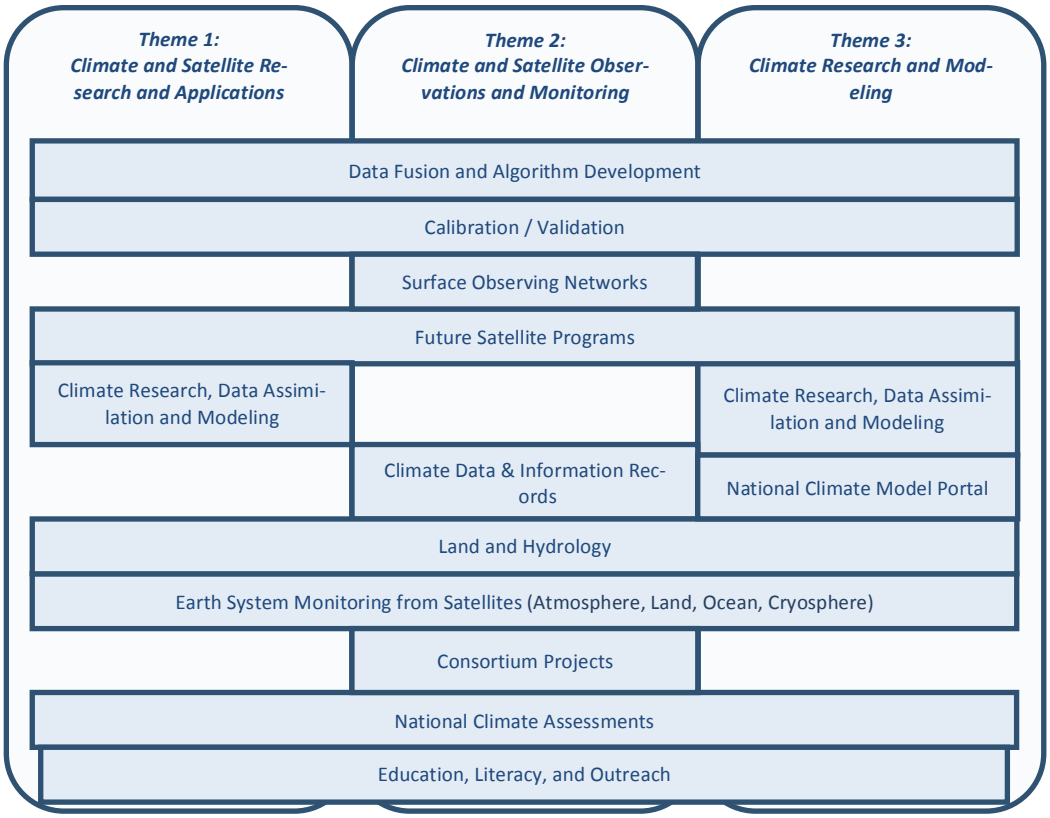

***Figure 1**: CICS Research Themes and Topic Areas*

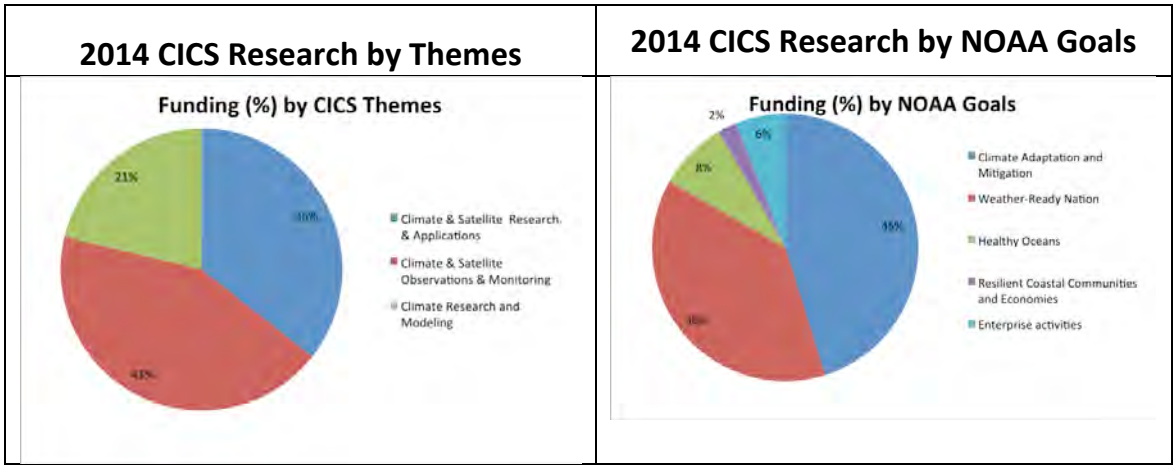

***Figure 2:** Distribution of CICS funding during the reporting period.*

1.3 CICS-MD

CICS-MD is based upon the model and experience gained by UMD through its management of the Cooperative Institute for Climate Studies in collaboration with NOAA beginning in 1984. ***CICS-MD focuses on the collaborative research in satellite observations and Earth System modeling conducted by STAR, which is part of the NOAA National Environmental Satellite, Data and Information Service (NESDIS) and NOAA/NWS/NCEP.*** During the first several years of the award, CICS-MD has initiated additional collaborations with other NOAA units in the Washington, DC area, including NODC and ARL.

CICS-MD's host organization is the Earth System Science Interdisciplinary Center (ESSIC), which is a joint center in the College of Computer, Mathematical, and Natural Sciences (CMNS) between the University of Maryland Departments of Atmospheric & Oceanic Science, Geology, and Geography, and the Earth Sciences Directorate at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC). ESSIC seeks to understand better how the atmosphere-ocean-land-biosphere components of Earth interact as a coupled system and how human activities influence this system through re-search that concentrates on four major areas: climate variability and change; atmospheric composition and processes; the global carbon cycle (including terrestrial and marine ecosystems/land use/cover change); and the global water cycle. ESSIC has fiduciary responsibility for CICS, provides the large majority of CICS-MD space, and hires and employs the majority of CICS-MD scientists and support staff. ESSIC has a cooperative agreement with NASA/GSFC that is in many respects similar to CICS.

Since CICS-MD includes UMD faculty, staff and students from several units, we have found it helpful to define CICS-MD members as faculty members who serve Task Leaders of a CICS task, individuals paid by a CICS task, and students and non-faculty employees who have been paid from a CICS task. The Satellite Climate Studies Branch (SCSB) of NESDIS/STAR is collocated with CICS-MD in ESSIC, and so we also include the federal employees in the SCSB as CICS-MD members.

1.4 CICS-NC

CICS-NC is an Inter-Institutional Research Center (IRC) of the UNC System, referred to as North Carolina Institute for Climate Studies (NCICS). It is administered by North Carolina State University (NCSU) and affiliated with all of the UNC academic institutions as well as a number of other academic and community partners. ***CICS-NC focuses primarily on the collaborative research into the use of in situ and remotely sensed observations in climate research and applications that is led by the National Climatic Data Center of NOAA/NESDIS.*** CICS-NC also is engaged in productive collaborative research with other NOAA elements, including the ARL Atmospheric Turbulence and Diffusion Division (ATDD). CICS-NC includes numerous partners from academic institutions with specific expertise in utilizing satellite observations in climate research, applications, and models.

1.5 CICS Consortium

The CICS Consortium includes a wide range of research universities, non-profit organizations, and community groups. Its role is to augment the capabilities of CICS and to extend its ability to conduct innovative and original collaborative research with NOAA. The CICS Consortium includes CICS-MD and CICS-NC. **Figure 3** shows geographic distribution of the current consortium partners (red diamonds are the principal nexuses. Black diamonds indicated CICS Consortium partners, and blue diamonds indicate the other NESDIS Cooperative Institutes).

CICS is arguably unique among NOAA Cooperative Institutes in its distributed configuration. The initial membership of the Consortium was chosen to ensure a broad spectrum of expertise and experience appropriate to the proposed institute vision. Since CICS was established in 2009, some evolution in membership has occurred. A few of the initial members have found other methods to collaborate with NOAA, while others have been unable to identify a suitable niche. During the same period, several new partners have joined, extending the reach and capability of the Consortium.

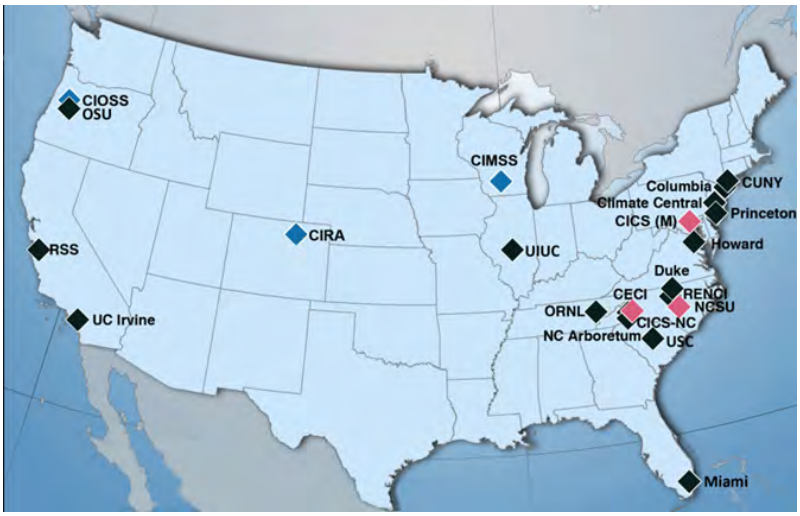

***Figure 3**: Spatial distribution of CICS Consortium institutions.*

The CICS Consortium provides NOAA with extraordinary opportunity to engage the extra-federal scientific and user communities on research, development, and outreach issues. It is a remarkably broad and flexible mechanism that enables NOAA to benefit from the collective wisdom and capability of its members.

1.6 Governance

A Memorandum of Agreement (MOA) governing CICS organization and operation was concluded between UMD and NOAA in 2011. The MOA describes the configuration and governance of CICS, and summarizes the functions of its several elements. The two prin-

cipal anchors, CICS-MD and CICS-NC, are described, and the initial membership of the Consortium is defined. This MOA will expire at the end of the initial 5-year term of CICS.

The CICS Executive Board comprises senior officials representing UMD, NCSU/UNC System, and NOAA and provides advice and direction to CICS leadership on strategic and executive issues. The CICS Council of Fellows is the primary planning and consultative body for CICS and provides scientific advice to the Directors. Council members are drawn from CICS task leaders, NOAA collaborating scientists, and other eminent scientists from CICS partners and Consortium members. The Executive Board current members are:

For UMD

- Dr. Patrick O'Shea - Vice President for Research
- Dr. Jayanth Banavar - Dean, College of Computational, Mathematical and Natural Sciences
- Prof. Antonio Busalacchi - Director, ESSIC

For NCSU/UNC System

- Dr. Mladen Vouk – Interim Vice Chancellor, Research, Innovation and Economic Development, NCSU
- Prof. Emeritus Ray Fornes - Professor of Physics, College of Physical and Mathematical Sciences, NCSU
- Dr. Chris Brown - Vice President for Research and Graduate Education, UNC

For NOAA

- Dr. Al Powell, Director, NESDIS Center for Satellite Research and Applications
- Dr. Bill Lapenta, Director, NWS/NCEP
- Dr. Michael Tanner, Deputy Director, NESDIS National Climatic Data Center
- Dr. Richard Artz/Dr. Bruce Baker OAR Air Resources Laboratory

Meetings of the Executive Board were held on May 28th and December 8th, 2014. These meetings were held simultaneously in College Park, MD and Asheville, NC, linked by a video-conference system. Materials from these meetings are attached in this report under Appendix 2.

2 HIGHLIGHTS OF THIS YEAR'S RESEARCH

2.1 Summary of Achievements

This year we added new metrics to reflect the involvement of CICS in the development of research products, including those submitted to NOAA for consideration of their use in operations. Our efforts to communicate our scientific discoveries and technological innovations to other scientists are measured by publications and presentations. CICS also continues to train the next generation of NOAA scientists.

CICS CUMULATIVE PERFORMANCE METRICS

Performance Metrics	
# of new or improved products developed (please identify below the table)	**231**
# of products or techniques submitted to NOAA for consideration in operations use	**110**
# of peer reviewed papers	**145**
# of non-peered reviewed papers	**46**
# of invited presentations	**250**
# of graduate students supported by a CICS task	**15**
# of graduate students formally advised	**25**
# of undergraduate students mentored during the year	**47**

These metrics are an attempt to quantify the annual accomplishments of CICS. This table is a sum of the performance metrics reported by individual task leaders and may contain errors or duplications. Performance metrics broken out for CICS-MD and CICS-NC are included in Volume 2 of this report.

2.2 Research Highlights

In the following sections we summarize the research highlights from the past twelve months of this agreement. Details of each of the research activities highlighted below are presented in Volume 2 of this report.

a. CICS-MD

These highlights for CICS-MD are segmented according to topic and NOAA partner. Funders from NESDIS include STAR, NCDC, NODC, OSD (Office of Systems Development),

GOESPO (GOES-R Program Office), and JPSSO (JPSS Office). Other NOAA funders include ARL, CPO, CPC (Climate Predictions Center), and NWS.

Data Fusion & Algorithm Development

Validation of Operational AMSR2 SSTs: GAASP AMSR-2 SST product has been evaluated and significant algorithm and calibration artifacts were identified. Validation has been redone for a revised product and similar algorithm-related features were noted. Advice was passed back to the GAASP development team to inform their enhancements to the Day-1 SST algorithm. [**JPPSO**]

Microwave and Diurnally Corrected Blended Sea Surface Temperatures: A global model of near-surface ocean warming has been developed and is being transitioned into operations. The model employs state-of-the-art turbulence closure and includes parameterizations for Stokes' Drift mixing to account for non-local effects. The model is forced by NCEP fluxes of heat and momentum, and wave parameters from the NCEP Wavewatch III model. Code has been developed and tested for the ingestion stage to apply the diurnal adjustment to each SST observation prior to QC and gridding. [**NESDIS/OSD**]

Assimilation of VIIRS SSTs and Radiances into Level 4 Analyses: Assimilation of VIIRS SST data into our high-resolution Geo-Polar Blended SST Analysis has now been transitioned into operations. Research has been conducted into producing more accurate SST retrievals from VIIRS radiances, with encouraging results. [**JPPSO**]

*Development of Global Soil Moisture Product System (SMOPS)***:** We have finished ingesting ASCAT soil moisture data from MetOp-B into SMOPS. Code has been delivered to Office of Satellite and Product Operations (OSPO) at NOAA/NESDIS. In addition, the cumulative distribution function (CDF) data base used for merging MetOp-B ASCAT soil moisture has also been generated mostly based on MetOp-B ASCAT soil moisture data. The new SMOPS version is expected to go operational in April, 2015. [**STAR**]

Blended Sea Ice Concentration Code for the IMS: A new blended ice concentration analysis is being developed for operational application at NOAA's National Ice Center (NIC). As part of this project, several improvements have also been made to the operational IMS snow depth analysis product. [**NIC**]

*Monitoring and Day-2 Algorithms for AMSR2 EDRs***:** Research algorithms precipitation, total precipitable water, wind speed, cloud liquid water, and sea surface temperatures were implemented for routine geophysical retrievals by NOAA. [**STAR**]

GCOM-W1 Soil Moisture Product Development and Validation **:** We have finished the development of GCOM-W1 AMSR2 soil moisture EDR product algorithm. The science code of the algorithm has been completed and delivered to GCOM-W1 team at NO-

AA/NESDIS/STAR. The code is now under integration into the production system and will be tested and go operational in the near future. [**STAR**]

Observing System Simulation Experiments (OSSEs) in Support of JCSDA's Contribution to NOAA's Quantitative Observing System Assessment Program (QOSAP): We have just hired a postdoctoral fellow in January '15 and initiated the project. Preliminary results on OSSEs and Observation System Experiments (OSEs) were obtained using the operational 3D hybrid data assimilation system. [**JCSDA**]

Calibration/Validation

Support for Diagnostic, Monitoring and Forecast Activities at the Climate Prediction Center: We are developing a subseasonal excessive heat outlook system for forecast Week-2 to Week-4. The feasibility of such a system was demonstrated and a prototype excessive heat monitoring system has been developed. [**CPC**]

*Improving the real-time monitoring and attribution of subseasonal tropical variability at NOAA Climate Prediction Center***:** We have developed an algorithm to calibrate IASI OLR data based on AVHRR observations. [**CPC**]

GEOG Task 1: AVHRR Surface Reflectance FCDR, the Normalized Difference Vegetation Index TCDR, the Leaf Area Index TCDR and the Fraction of Photosynthetically Active Radiation TCDR: CICS scientists have made great progress in the evaluation of the VIIRS cloud Mask (VCM) and VIIRS surface reflectance. The VIIRS surface reflectance has been promoted to provisional status on March 17,2014 and Validated Stage 1 on September 4, 2014 and VCM is now at validation stage 2. The methods and metrics for evaluation are well in place and a paper in RSE summarized our evaluation. We presented our results in several national and international meetings. [**STAR**]

GEOG Task 2: NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Science and Management Support for NPP/JPSS VIIRS Land Surface Albedo Product-Land Surface Albedo: We successfully achieved the status of provisional and V1 in the past year. We assessed the quality of the current surface albedo EDR data and compared them with the existing products. We developed the temporal filter to further improve the quality of albedo retrievals. [**STAR**]

GEOG Task 3: NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Science and Management Support for NPP VIIRS Surface Type EDR-Land Surface Type: Surface Type ED : Passed Validated 1 maturity review. [**STAR**]

Science and Management Support for S-NPP VIIRS Aerosol Optical Thickness (AOT), Aerosol Particle Size Parameter (APSP), and Suspended Matter (SM): We have maintained and improved the S-NPP VIIRS Operational Aerosol Algorithm on the NOAA IDPS, conducted intensive Calibration and Validation of the VIIRS Aerosol Products, and provided

the validated Products of daily global aerosol observations to user communities to support research and operational activities in weather, climate, and air quality. [**STAR**]

*Suomi NPP (SNPP) Visible Infrared Imager Radiometer Suite (VIIRS) Active Fire Data for Fire Management and Fire Weather Applications***:** The 2014 performance period's outcomes were successful in progressing toward the goals of the Proving Ground and Risk Reduction (PGRR) project which includes maximizing the benefits of VIIRS data for downstream end-users. We combined outreach and efforts with VIIRS active fire evaluation through coordinate prescribed fire events while presentations and training included audiences from both the research and operations communities. In addition, we continued to expand and improve our website to offer new data, an archive database, and user-friendly formats based on end-user feedback. [**STAR**]

Transition and Enhancement of ATMS Snowfall Rate Product and Its Fusion with Weather Radar Data: We built a CONUS ATMS Snowfall Rate retrieval system using the Direct Broadcast data. Using this system, the latency of the SFR product reduced to less than 30 minutes over US CONUS and Alaska. We also built the corresponding system MHS data over CONUS. [**STAR**]

Satellite Calibration and Validation (Cal/Val) efforts for STAR Precipitation Products: We have established a validation network for model and satellite derived precipitation estimates. The comparisons between the satellite rainfall products and ground based gauge and radar data are performed for instantaneous swath, daily, and seasonal validations. [**STAR**]

Development of the Satellite Sea-Surface Salinity Quality Monitor System: We are developing the Satellite Sea Surface Salinity Quality Monitor (4SQM) system. In this system, satellite data will be monitored for self- and cross-platform consistency, as well as consistency with *in situ* data. [**STAR**]

GOES-R Active Fire/Hot Spot Characterization – Validation and Refinement of GOES-R/ABI Fire Detection Capabilities: The GOES-R/ABI active fire deep-dive validation tool was developed. The tool uses high spatial resolution airborne and spaceborne reference fire data in order to quantify commission (false alarm) and omission error rates, and sub-pixel fire characterization retrievals. [**STAR**]

Lunar and Stellar Calibration for GOES-R Advanced Baseline Imager (ABI) in support of the Calibration Working Group: CICS scientists support Calibration and Validation work for GOES-R Advanced Baseline Imager (ABI) instrument through lunar calibration, stellar calibration, and Imagery Navigation and Registration (INR) of GOES-R ABI. [**STAR**]

VIIRS Operational Calibration Science Support and JPSS-1 Prelaunch Test Data Analysis: CICS scientists provides operational science support for S-NPP VIIRS instrument through support on-orbit calibration of VIIRS using the onboard solar diffuser (SD), lunar obser-

vations and vicarious methods, as well as inter-comparisons with instruments on other satellite using SNOs, support DNB stray light correction software development, and support the prelaunch test data analysis of VIIRS on JPSS-1. [**STAR**]

Scientific Support for Joint Polar Satellite System (JPSS) CrIS, VIIRS and OMPS Calibration: CICI Scientist Yong Chen developed the CrIS full spectral resolution (FSR) SDR processing system and delivered on 01/15/2015 to NOAA/STAR Algorithm Integration Team and Raytheon IDPS to test. This SDR software has been validated and will be JPSS CrIS baseline code. CICS Scientist Likun Wang developed novel methods to evaluate and improve radiometric, spectral, and geolocation accuracy of Cross-track Infrared Sounder (CrIS) Sensor Data Records (SDR) on current operational Suomi NPP and future JPSS satellites. CICS Scientist Chunhui Pan has developed new comprehensive data analysis algorithms and models to evaluate and characterize sensor orbital stray light contamination, wavelength calibration and optical system stability. CICS Scientist Slawomir Blonski provided continued support for the on-orbit calibration of the VIIRS instrument onboard the S-NPP satellite and began analysis of the pre-launch test data from the VIIRS instrument built for the future JPSS-1 satellite. [**STAR**]

Surface Observation Networks

Long-Term Changes in Cloudiness from Surface Observations: Variability and trends in total cloud cover for 1982-2009 across the contiguous U.S. from International Satellite Cloud Climatology Project (ISCCP), AVHRR Pathfinder Atmospheres Extended (PATMOS-x) and EUMETSAT Climate Monitoring Satellite Application Facility CLoud Albedo and RAdia- tion (CLARA-A1) satellite datasets are inter-compared with homogeneity-adjusted weather station data. [**CPC**]

Participation in Climate Research Activities at the Air Resources Laboratory: In 2014, the seven CICS research scientists working with NOAA's ARL made air quality measurements and forecasts to complement ongoing atmospheric chemistry studies at UMD. [**ARL**]

Future Satellite Programs: GOES-R

Year 4 GOES-R/JPSS Visiting Scientist Program: A CICS visiting scientist (VS) has lead the GOES-R and JPSS Proving Ground activities at the NOAA Center for Weather and Climate Prediction and the Tropical Analysis Branch of the National Hurricane Center since May 2011. These proving grounds allow forecasters and researchers the opportunity to evaluate new satellite technologies in every day operations. [**GOESPO/JPSSO**]

*Facilitating Direct CICS Support for Satellite Proving Ground Efforts***:** CICS-MD has acquired, installed, and implemented two computers running AWIPS-II, McIDAS, and WDSS-II. These software platforms allow for analysis and display of real-time data. Our IT staff is currently connecting to local data manger (LDM) feeds that mimic what the Satellite Broadcast Network (SBN) will soon provide. [**GOESPO/JPSSO**]

GOES Evapotranspiration (ET) and Drought Product System (GET-D): We are developing an operational evapotranspiration and drought monitoring system using GOES Land Surface Temperature product, meteorological data and other ancillary satellite remote sens- ing data. [**STAR**]

ATMS Derived Snowfall Rates to Support Weather Forecasting: The new ATMS snowfall detection and snowfall rate algorithms are being extensively evaluated using high quality in-situ and radar data. Evaluation of snowfall detection algorithm is complete, whereas the snowfall rate algorithm evaluation is under way. [**GOESPO**]

Washington D.C. Lightning Mapping Array Maintenance and Outreach: Several recent projects have helped improve the visibility of the DCLMA and demonstrate its value for severe weather analysis and public outreach. [**GOESPO**]

*Updating CRTM for Supporting GOESR-R AWG Applications***:** Vertical hydrometeor profiles from the Tropical Rainfall Measuring Mission (TRMM) 2A12 product were collocated with ATMS and being used as inputs in CRTM to simulate the Advanced Technology Microwave Sounder (ATMS) brightness temperature observations at 22 channels over selected West-North Pacific typhoon cases. Study results show that for cloud type with low cloud water content and ice content, the bias between observation and the simulation is similar. To verify the impacts of discrete dipole approximation model for ice particle scattering calculation, the DDA based single particle scattering look up table was adopted and used in CRTM. Simulation results show that, compare with traditional Mie scattering look up table used in CRTM, the DDA based simulation is more closely approach the satellite observation, especially at deep convective region in typhoon case, where the ice content is high. [**STAR**]

Technical Support of GOES-R Land Surface Temperature Algorithm and Validation: A combined regression and validation packages has been finished, a new multi-sensor LST monitoring and evaluation system has been established. [**STAR**]

*Validating GOES-R Land Surface Temperature Product Using Ground Campaign and Station Data***:** Retrieval algorithm for AHI has been generated and the validation tool has been updated to include the AHI data. [**STAR**]

Development of Algorithms for Shortwave Radiation Budget from GOES-R: We have developed new narrow-to-broadband transformation coefficients based on the newly-available spectral response functions for ABI. [**STAR**]

Future Satellite Programs: JPSS

*NPP/VIIRS Land Product Validation Research and Algorithm Refinement: Active Fire Application Related Product***:** This task supports the operational implementation of the Suomi-NPP/VIIRS Active Fire algorithm at NOAA. The input SDR data are routinely monitored, and reactive fire algorithm maintenance implemented in order to ensure highest product quality. Science algorithm updates are also ported into the operational system.

Additional programmatic tasks (e.g., product maturity assessment/review) and algorithm/user guide documentation are regularly addressed. [**STAR**]

Validation of Cryospheric EDRs GCOM AMSR2: The Advanced Microwave Scanning Radiometer 2 (AMSR2) instrument launched on May 18, 2012 onboard the Global Change Observation Mission 1st - Water "SHIZUKU" (GCOM-W1) satellite. A suite of AMSR2 operational algorithms have been developed for the retrieval of snow cover, snow depth and Snow Water Equivalent using heritage AMSR-E data as proxy and transitioned to operations. [**STAR**]

Improvement of Cloud Ice Microphysics for ATMS Snowfall Rate Retrievals: This project has just started and will enhance the ATMS SFR product by incorporation of advanced microphysics in radiative transfer model calculations. [**JPPSO**]

Science and Managerial Support to Global Space-Based Inter-Calibration System (GSICS): The Backus-Gilbert method is used for optimally remapping the ATMS FOVs to AMSU-A like FOVs. Differences in ATMS brightness temperatures introduced by remapping are firstly illustrated over the region of Hurricane Sandy which occurred in October 2012. Using the simultaneous nadir overpass (SNO) method, AMSU and ATMS remap observations are then collocated in space and time and the inter-sensor biases are derived for each pair of channels. It is shown that the brightness temperatures from SNPP ATMS are now well merged into the AMSU data family after remap and cross-calibration. [**STAR**]

*Advanced Radiance Transformation System (ARTS) for JPSS ATMS Calibration***:** For JPSS ATMS TDR processing, a full radiance transformation system (ARTS) is being developed. From the lessons studied from Suomi-NPP ATMS calibration, several major improvements are also made for ARTS, which include FFT-based destriping algorithm for warm and cold calibration counts, scan bias correction for warm target and cold space radiance, and refined lunar contamination correction for cold space calibration counts. Using RDR as inputs to ARTS, TDR and SDR can be generated directly with a high quality for many applications such as radiance assimilation in NWP system. [**STAR**]

Climate Research, Data Assimilation and Modeling

Enhance Agricultural Drought Monitoring Using NPP/JPSS Land EDRs for NIDIS: We have produced the global drought maps using or without using near real time green vegetation frac- tion (GVF). The quality control procedures and parameters for Soil Moisture Operational Product System (SMOPS) soil moisture (SM) product are established using real time GVF and newer surface type prod- ucts. In addition, we assessed the improvement of assimilating SMOPS-blended SM on Noah model per- formances in both sparsely and densely vegetated areas. **[STAR]**

Enhancing NCEP-NAM Weather Forecasts via Assimilating Real-time GOES-R Observations of Land Surface Temperature and Green Vegetation Fraction: We have prepared the GOES-based input data sets for data assimilation (DA) experiments. In addition, a fully coupled NASA LIS and WRF assimilation system (NU-WRF) have been set up on S4

supercomputer in which EnKF DA algorithm is implemented to assimilate multiple land observations (SM and LST) into NWP model. The NU-WRF system will be used to test the impact of assimilating real-time GOES-R LST and GVF observations on NCEP-NAM forecasts. **[STAR]**

Student Support for NOAA's Climate Prediction Center: This year, graduate student Katherine Lukens, under the advisement of Dr. E. Hugo Berbery, continues on ascertaining the characteristics and behaviors of seasonal storm over North America for her PhD thesis on "The interconnectivity of extreme precipitation events, storm tracks, and modes of variability via the applications of large-scale global climate dynamics." [**CPC**]

CICS Support for NOAA's Climate Prediction Center: CICS researcher constructed ENSO composites based on the North American Multi-Model Ensemble (NMME) forecasts and found discrepancies between the model temperature composites and the observed. [**CPC**]

Science Support for Mesoscale Data Assimilation at EMC & JCSDA: An hourly-updated version of the NAM, called the NAM Rapid Refresh was built and placed over Europe and Africa. The month-long experiment was completed for clear-sky SEVIRI radiance data. The SEVIRI cloudy radiance data assimilation algorithm has been developed in GSI, and the initial single observation test has been completed. [**GOESPO**]

Use of LETKF sensitivity to improve QC of data from JPSS polar orbiting instruments and to detect the origin of the NCEP "5-day forecast skill dropouts": We succeeded and are working now to do final tests for operational implementation [**JPPSO**]

*Scientific support for an updated analysis of global stratospheric temperature observations during the satellite era***:** the main purpose of the work was to determine the changes in stratospheric temperature. [**ARL**]

Graduate Student Support: ENSO-related Precipitation In 20th Century Reanalysis, Reconstructed Precipitation and CMIP5 Models: CMIP5 models are able to simulate not only similar mean state of ENSO-related precipitation but also its seasonal evolution and transition as the observations, though detailed spatial patterns vary, though ENSO-related precipitation signals and asymmetry are weaker in models especially those models with the most severe biases in their precipitation mean state. The mean extreme of ENSO-related precipitation anomalies in 20CR, REC and some CMIP5 models are significant larger (on a significant level of 98%) in the 2nd half of 20th century than the 1st half. [**STAR**]

NOAA Air Quality Forecasting Research and Operational Support (GMU): 1) CICS scientists have Validated MODIS-based marine isoprene retrieval algorithm; 2) CICS scientists have Compared MODIS and VIIRS based marine isoprene products; and 3) Prepare to integrate and test the new Soumi-NPP VIIRS marine product in the NAQFC system. [**ARL**]

*Understanding the Impact of AMSU Derived Orbital Hydrological Products on Global, Merged Precipitation Products***:** Initial assessment study displays promising results. [**STAR**]

Subseasonal Tropical-Extratropical Interaction: The graduate student has been reading background material and learning GrADS while completing her coursework. [**CPC**]

Climate Data and Information Records/Scientific Data Stewardship

*CICS Support for the National Oceanographic Data Center***:** In 2014 CICS played a significant role in the development of improved satellite data products, working with the ocean science community to provide global and regional ocean data, and by validating new space-based ocean observing technologies. CICS enhanced NOAA's ability to understand, predict and communicate climate variability by data distribution and education through web based satellite data, detailed descriptions of these data, and the continued enhancement of the World Ocean Database. [**NODC**]

Climate Data Record for HIRS-OLR – Gauge Blended Analysis of Global Daily Precipitation: HIRS OLR retrievals are used in a gauge-satellite blended system to generate high-resolution analysis of precipitation estimate over land globally on a daily basis at CPC (POC: Pingping Xie). This precipitation estimation system has been evaluated with very favorable performance that CPC plans to derive a long time series of OLR-based precipitation record as well as putting this system into operational mode in the near future. [**NCDC**]

The Global Precipitation Climatology Project (GPCP) Data Products—Transfer to Operations at NCDC: The routine production of monthly, pentad and daily products from the Global Precipitation Climatology Project (GPCP) products will be transferred to NCDC for archival and dissemination. The GPCP codes are being organized, streamlined, updated and documented for product production from the level of the satellite-calibrated radiances to the final merged products at NCDC. [**NCDC**]

The Development of AMSU Climate Data Records (CDR's): **TCDR's of AMSU-A has been assessed. [**NCDC**]**

Land and Hydrology

Precipitation Research and Applications: A prototype precipitation retrieval algorithm is developed for passive microwave radiometers. The essential idea is to stratify the single data base into many smaller but more homogeneous databases by considering both surface condition and precipitation vertical structure information. We have implemented this algorithm using collocated SSMIS and ground based radar observations. Much improved precipitation detection and retrieval result have been obtained from this prototype algorithm. [**STAR**]

Earth System Monitoring from Satellites

Utilization of M-T SAPHIR to monitor S-NPP ATMS and MiRS products: ATMS and SAPHIR data were intercompared and validated using radiosonde and GPS-RO data. [**STAR**]

Towards Operational Arctic Snow and Sea ice Thickness Products: A novel technique to process snow radar data collected on airborne platforms over Arctic sea ice was developed resulting in a new snow on sea ice product. Snow depth on ice was analyzed as a function of ice type and surface roughness and compared with climatological values. Mean snow depth is thinner over first-year Arctic sea ice (~ 20 cm) than over multi-year ice (~ 35 cm). [**STAR**]

Real-Time Monitoring and Short-term Forecasting of Phenology from GOES-R ABI for the Use in Numerical Weather Prediction Models: We developed a time series of angular corrected NDVI/EVI2 from SEVERI data. The SEVERI EVI2 was compared with MODIS EVI2 in the Congo Basin where cloud cover frequently occurs and the results show that SEVERI EVI2 significantly improves the data quality for tropical forest observations. The phenology detection algorithm was able to identify the vegetation phenology in the Sahara Desert although the vegetation growth was subtle. [**STAR**]

National Climate Assessment

CICS: Research, Development and Implementation of National and Regional Physical, Ecological, and Societal Climate Indicators for the NOAA and the USGCRP National Climate Assessment: Kenney is leading the development of an interagency indicator system to bring together data, observations, and indicator products in innovative ways to better assess climate changes, impacts, vulnerabilities, and preparedness and move the research products into operations for decision support. [**CPO**]

Climate Science to Support Policy, Education, Literacy, and Outreach

Program Management at the Climate Program Office: Through engagement and the fostering of collaboration in carried out in this task, the University community has been more effectively connected with the NOAA scientific community. The results of this increased connectivity has been improved NOAA products and services including climate projections for North America, model components and performance, drought information, and improved understanding of extremes. Scientific progress has been fostered through new digital outreach techniques in addition to traditional facilitated community meetings. This outreach effort has helped coordinate and maximize the federal climate and Earth system model effort. [**CPO**]

Climate Outreach and Education at the Climate Program Office: Increased collaboration and cooperation with scientist from NOAA, other agencies, Cooperative Institutes, and the external community fosters the net output of research for the general public. Out-

reach using web interface and communicative materials has helped maximize the promotion of scientific stewardship of climate related information. [**CPO**]

Interpretation of Climate Data for Spherical Displays: This interagency collaboration develops ClimateBits videos to explain a variety of Earth science concepts to the general public on Science On a Sphere® and YouTube. This resource is increasingly requested for routine and special events around the world. [**OED**]

Consortium Projects

CUNY-CREST Support for Combining JPSS with Geostationary Imager data for Fused Earth Observation Parameters: Improving JPSS data with fusion tool: We are developing algorithms and software for fusing high spatial resolution data from the new generation of polar orbiting platforms (JPSS) with high temporal resolution data from geostationary platforms. The techniques will be applied to enhance both daily surface reflectance/emission products and derived products such as NDVI, vegetation fraction, vegetation health, LST and snow cover. [**STAR**]

CUNY-CREST Support for Development of Neural Network Algorithms for Retrieval of Chlorophyll-a in the Chesapeake Bay and Other Coastal Waters Based on JPSS-VIIRS Bands: Several NN approaches are explored together with other available algorithms to retrieve chlorophyll and mineral concentrations, CDOM absorption in Chesapeake Bay and potentially other coastal waters for the JPSS/VIIRS sensor, results are tested on field data as well as on satellite data. [**JPSSPO**]

CUNY-CREST Support for Coastal Site Data Uncertainties and in situ Validation: The Project has continued to provide a consistent stream of data from the SeaPRISM instrument on the Long Island Sound Coastal Observatory (LISCO) to NASA – AERONET and from the hyperspectral HyperSAS to the CCNY server. This quality assured in-situ OC data stream permitted evaluation of the quality of VIIRS retrieved OC products for coastal waters conditions, statistical analysis of VIIRS, MODIS and AERONET-OC data, and the impacts of the different processing schemes NASA and IDPS. [**JPSSPO**]

CUNY-CREST River and Lake Ice Mapping Using NPP/JPSS VIIRS Sensor to Support NOAA NWS: We have developed a river ice product over major rivers in Alaska and North Central US. This product is running operationally in NOAA NWS and displayed in their Advanced Weather Interactive Processing System. [**JPSSPO**]

Howard University Support of NOAA's commitment to the Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN): NPP-Satellite overpass coordinated upper air sonde and ground based remote sensing profile data collection as part of the GRUAN network has continued. Evaluation and analysis of collected data and comparison of suite of instruments with satellites is in progress. [**NCDC**]

OSU-CIOSS Support to the GOES-R Risk Reduction Program – Ocean Dynamics: Two methods are compared to estimate surface currents from SST fields. Data Assimilation is the preferred method; but modified Feature-Tracking velocities can also be useful, if carefully evaluated. [**STAR**]

OSU-CIOSS Support to JPSS Data Products & Algorithms: Validation of VIIRS Ocean Color products for the Coastal and Open Ocean: We have developed a new data system for visualizing and managing the VIIRS data for the West Coast. We are analyzing a 6 month time series of VIIRS and MODIS data for the Southern California Bight using Platform Eureka SeaPRISM for validation. [**JPSSPO**]

OSU-CIOSS Support to GOES Improvement and Product Application Program, GOES SST Assimilation for Nowcasts and Forecasts of Coastal Ocean Conditions): We have implemented assimilation of GOES SST, in combination with other data, to improve accuracy of real-time forecasts of ocean temperature, currents, and other oceanic variables along the Oregon coast. [**STAR**]

b. CICS-NC

CICS-NC highlights are arranged by topic with funders noted at the end of the highlight. CICS' primary NOAA funding comes from NESDIS/NCDC, but CICS also receives grants from OAR's Climate Program Office (CPO), the NWS Office of Science and Technology (OST), NESDIS/NODC, OAR/ATDD, NESDIS/JPSSO, the National Ocean Services (NOS), and the OAR's Earth System Research Laboratory (ESRL). Other funding comes from the National Science Foundation (NSF), the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA) and *EarthRisk*.

Administration

Communications: This task promoted the Cooperative Institute for Climate and Satellites–North Carolina (CICS-NC) to its stakeholders and advanced the National Climatic Data Center's external and internal communications. **[NCSU and NCDC]**

Information Technology Systems Improvement, Management, and Maintenance: The CICS staff requires technological infrastructure and resources at a variety of levels. This task supports those needs by providing modern approaches to keep CICS-NC at the competitive edge of technology, as well as maintaining core technologies as a stable base for CICS-NC staff operations. These systems range from scientific computing to medium-scale office-oriented services. Improvements have been made in all aspects of CICS-NC's IT infrastructure towards a more reliable system that is both flexible and scalable while still supporting cutting-edge technologies that support the communication and computational needs of the administrative and research staff at CICS-NC. **[NCDC/NCSU]**

Climate Literacy, Outreach, and Engagement

Research Activities in Advancing Climate Literacy, Outreach, and Engagement across Public, Private, and Academic Institutions: Education, literacy, and outreach are all important elements of the broader CICS mission. CICS-NC engages in the improvement of both formal and informal education approaches to a variety of stakeholders and the public, ultimately to advance climate information and activities in adaptation and resilience. These activities are broadly grouped within K-12 education, undergraduate and graduate education, business and industry engagement, the general public, and other interdisciplinary stakeholder groups. **[NCDC]**

Climate Data and Information Records and Scientific Data Stewardship

Climate Data Record (CDR) Integrated Product Team (IPT) Support: Climate Data Record (CDR) IPTs are multi-disciplinary teams comprised of members from offices and organizations supporting the transition of research-grade CDRs into an initial operational capability (IOC) status. The IPTs are formed for the purpose of efficient and effective collaboration, coordination, and execution and reporting of member's office/organization tasks required to transition the CDR to an IOC state. Several CICS-NC scientists serve as Products and Operations Branch representatives on multiple CDR IPTs. **[NCDC]**

Expansion of CDR User Base (e.g., Obs4MIPs): The aim of this project is to provide NOAA Climate Data Records (CDRs) from observational platforms (e.g., satellite and in-situ datasets) that can be used for climate model evaluation (Coupled Model Intercomparison Project or CMIP5 for the IPCC Fifth Assessment Report). Several CICS-NC scientists have worked on a project to make observational products more accessible for climate model intercomparisons. **[NCDC]**

SNPP VIIRS Climate Raw Data Record Production Software Development: The VIIRS Climate Raw Data Record production software development and test were completed, and operational production began on October 19, 2013. **[NCDC]**

Graph Database Proof-of-Concept Federated Archive Search Tool (FAST): Created a proof-of-concept tool that demonstrates search capabilities across multiple, disparate datasets. **[NCDC]**

Suomi-NPP VIIRS Climate Raw Data Record System Infrastructure Development: Completed transition of the VIIRS Climate Raw Data Record into the NCDC operational environment while helping to define the processes for the 3-tier software development environment. **[NCDC]**

Transfer NOAA/NASA Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Sea Surface Temperature (SST) Processing to National Oceanographic Data Center (NODC): The Pathfinder Sea Surface Temperature (SST) time series has been extended to include NOAA-19 observations. This is a continuation of the previously submitted

time series that covered the Advanced Very High Resolution Radiometer (AVHRR) sensors NOAA-7 through NOAA-18. In addition, the coverage period of NOAA-7 was expanded to include September and October of 1981 through cooperative work with NCDC/RSAD and National Oceanographic Data Center (NODC) to provide the augmented Reynolds OI reference SST fields that are required to process the Pathfinder time series. **[NCDC, NODC]**

Net Surface Radiation Budget at High Spatial and Temporal Resolution from Multi-Sensor Data Fusion: A successful technique to estimate net surface solar radiation from geostationary earth orbit (GEO) satellites has been developed by adapting an algorithm developed for the NASA-operated Clouds and Earth's Radiant Energy System (CERES) instrument on board the EOS/Terra and Aqua. Comparison of results with ground site measurements revealed excellent agreements comparable to or better than other sophisticated methods or even CERES-parameterized flux products. **[NCDC]**

Independent Evaluations of the Calibration of the Visible Channel in the International Satellite Cloud Climatology Project (ISCCP) B1 Data: Calibration of the Geostationary Earth Orbit (GEO) visible channel in the ISCCP B1 data stream has been completed for all meteorological satellites for the period 1979-2009, through employing AVHRR channel 1 reflectance in the Pathfinder Atmospheres Extended (PATMOS-x) data and validated through other independent results. Separately, the pre-GVAR GOES data (prior to GOES-8) has been reprocessed to conform to a more consistent format with less noise and these reprocessed data files will soon replace the present ISCCP B1 data in the archive. **[NCDC/JPSSO]**

Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES data: The GSA algorithm is being implemented as the American contribution of an international collaboration between Europe, Japan, and the United States to produce a joint climate data record. **[NCDC]**

Uncertainty Quantification for Climate Data Records: Uncertainty quantification in climate research is a multidisciplinary area of increasing importance. Over time, global observing systems have undergone transformations on pace with technological advances and these changes require adequate quantification of resultant imposed biases to determine the impact upon long-term trends. The uncertainties in climate observations pose a set of methodological and practical challenges for both the analysis of long-term trends and the comparison between data and model simulations. **[NCDC]**

Comparison of ground-based temperature measurements with satellite-derived phenology: This research is a comparison of satellite-derived phenology measurements with ground-based temperature metrics. The goal of this project is to determine which of air or soil temperatures are better for estimating the growing season and will serve to improve U.S. Climate Reference Network (USCRN) drought monitoring. **[NCDC]**

High-resolution Infrared Radiation Sounder (HIRS) Temperature and Humidity Profiles: The HIRS project group is developing a global temperature and humidity profile dataset for the time period of 1978-present. Applying neural networks to High-resolution Infrared Radiation Sounder (HIRS) data produces the data for this project. **[NCDC]**

Maintenance and Production of CDR's for Microwave Sounding Unit (MSU) and AMSU Atmospheric Temperatures and NCDC Special Sensor Microwave Imager (SSM/I) Brightness Temperatures: MSU/AMSU brightness temperatures have been updated and transferred to CDR Archive at NCDC. SSM/I Version 7 brightness temperatures have been updated and transferred to CDR Archive at NCDC. **[NCDC]**

Evaluation and Characterization of Satellite Products: With the NOAA/NSIDC passive microwave sea ice concentration climate data record (CDR) successfully transferred into operations, and evaluation of the CDR was performed and and a global characterization of decadal trends of sea ice extents in the Arctic and Antarctic Oceans was performed. Also evaluated the NCDC blended sea surface winds. **[NCDC]**

The scope and the framework of long-term scientific stewardship for CDRs: Defined the scope of long-term stewardship for NOAA digital climate environmental data products based on U.S. laws and expert bodies' recommendation and associated functional areas. Also developed a unified framework for assessing the vigor of stewardship practice applied to individual environmental data products. Submitted a manuscript to a peer-review journal. **[NCDC]**

Toward the development of Climate Data Records for precipitation: Characterization of CONUS rainfall using a suite of satellite, radar, and rain gauge QPE products: This task uses a suite of quantitative precipitation estimates (QPEs) derived from satellite, radar, surface observations, and models to derive long-term precipitation characteristics at fine spatial and temporal resolution over CONUS for the period 2002-2012. This work is part of a broader effort to evaluate long-term multi-sensor QPEs from the perspective of developing Climate Data Records (CDRs) for precipitation. **[NCDC]**

Mapping the World's Tropical Cyclone Rainfall Contribution Over Land Using Satellite Data: Precipitation Budget and Extreme Rainfall: This work examines the over-land rainfall contribution originating from tropical cyclones for basins around the world for the period 1998-2009. Using the global database IBTrACS and satellite precipitation data from the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) product 3B42, the precipitation budget and extreme rainfall were determined for different TC basins around the world. **[NCDC]**

Dual-Polarization Signature of Microphysical Processes in Warm Rain: This work combines an explicit bin microphysical model with an electromagnetic scattering model. The goal is to assess the signature of microphysical processes (settling, coalescence, drop breakup, evaporation) on radar dual-polarization variables: the reflectivity factor at hor-

izontal polarization (Z_H), the differential reflectivity (Z_{DR}), and the specific differential phase (K_{DP}). **[NCDC]**

Reanalyzing Tropical Cyclones Imagery with Citizen Scientists: CycloneCenter.org is a web-based interface through which citizen scientists have already produced more than 300,000 classifications of tropical cyclone intensity and structure. Preliminary research has shown that these classifications can help address uncertainties in the historical record of these storms. **[NCDC, NCSU]**

Satellite Data Support for Hydrolic and Water Resource Planning and Management:
A new daily precipitation climate data set was developed. The PERSIANN Precipitation Climate Data Record (PERSIANN-CDR) is a precipitation dataset with product resolution at daily 0.25^0 lat-long scale. The product covers from 60^oS to 60^oN and 0° to 360° longitude, from 1983 to near current time. **[NCDC]**

Reanalysis of archived NEXRAD data using NMQ/Q2 algorithms to create a high-resolution precipitation dataset for the continental United States: This project has generated four years of a high-resolution gridded precipitation product for the entire continental United States at CICS-NC, with an additional seven years being produced at the National Severe Storms Laboratory/CIMMS in Norman, OK. The project group continues to work closely with these partners toward quality assurance and the transfer of this very large dataset. **[NCDC]**

Satellite Product Evaluation and Near Real Time Monitoring: This project applies the Satellite Product Evaluation Center (SPEC) tool to the Surface Fluxes and Analysis (SurFA) project used to generate a Near Real-Time Monitoring (NRTM) website. Ingest operations were supported with modifications to manifest creation in support of multiple archive site common manifest generation. **[NCDC]**

National Climate Assessment

National Climate Assessment Technical Support Unit (TSU): The Third National Climate Assessment (NCA3) was released on May 6, 2014, representing a landmark achievement for the TSU and CICS-NC. CICS-NC staff contributed to virtually all aspects of the report by providing scientific, editorial, graphics, project management, metadata, software engineering, and web design expertise. All of these efforts culminated in the very successful release of the report, which has been praised for its readability and accessibility. The NCA3 website (nca2014.globalchange.gov), which involved significant CICS-NC contributions, was also widely praised.

Trends in Extra-tropical Cyclone (ETC) Occurrence: Analysis of uncertainties in extra-tropical cyclone (ETC) occurrence have identified periods when the analyzed temporal variations can be considered reliable, including 1891-present for mid-latitude land areas

and the North Atlantic, 1921-present for the North Pacific, and 1931-present for high latitude land areas.

Development of Geospatial Visualizations, Online resources, and Decision Support Tools for the National Climate Assessment: Staff from UNC Asheville's NEMAC created maps and products for the National Climate Assessment; co-developed digital resource environments and interactive and static graphics for users of the Climate Assessment and Indicators team; and researched and presented a decision framework for use by the Climate Assessment. These new products support the overall advancement and progression of the National Climate Assessment program. **[CPO]**

Contributions of CICS-NC staff at the TSU to the release of the Third National Climate Assessment include:

- *Software Engineering Services*: This task focuses on ensuring the integrity and portability of the programs developed for the NCA and assisting the lead scientist in their creation and development. In addition, to facilitate the overall business of the NCA and its integrity, ancillary software tools were created and continue to be developed as part of the continuing assessment process.
- *Graphical Services*: CICS staff provided editorial, graphics, and production support for the National Climate Assessment, making significant contributions to the release of the NCA in May 2014.
- *Program Support:* Implementing new production processes and maintaining a supportive workforce are ongoing priorities. Coordinating TSU/USGCRP activities and delivering the Third National Climate Assessment report and website were primary accomplishments of the TSU in 2014.
- *Web Development*: Made major contributions to the development and delivery of the website for the Third NCA. Designed and implemented a new web site for CICS-NC. Concluded a performance evaluation of the NCA Comment and Review system. Completed web development support for Dataset Discovery Days and the Executive Forum on Business and Climate websites.
- *Copy Editor*: Provided editorial and production support for the NCA, contributing to multiple drafts and the final approved document. Facilitated delivery to layout and website production and contributed to the development of the shorter "*Highlights*" summary of the NCA.
- *Metadata Collection and Management*: TSU built a sustainable process and technical infrastructures to collect, curate, and display the metadata of the National Climate Assessment. The effort satisfies compliance with the Information Quality Act and includes traceability of data, contributors, and scientific analysis methods across graphics, visualizations, references, and photos, at a level of detail to satisfy a requirement to also be reproducible. TSU has completed approximately 75% of the collection.

- *Analysis of Observational and Modeled Climate Data*: Analysis of several observational and model datasets was performed and 23 figures were produced for the Third NCA report, along with the compilation of associated metadata.
- *Science Editor/Publication Support*: Provided editorial, graphics, and production support for NOAA's Technical Support Unit to the National Climate Assessment, making significant contributions to the development and delivery of the full report and accompanying *Highlights* document.
- *Scientific Support Activities*: Scientific analysis of Coupled Model Intercomparison Project, Phase 5 (CMIP5) and CMIP3 data was performed to support the development of the Third National Climate Assessment (NCA). **[CPO/NCDC]**

Surface Observing Networks

Validation of U.S. Climate Reference Network (USCRN) Soil Moisture and Temperature Observations: This research is an analysis of USCRN soil observations for developing an understanding of spatial and temporal variability of soil moisture and temperature. The goal of this project is to determine the changes in soil observations and will serve to improve USCRN for drought monitoring and satellite calibration. **[NCDC]**

Research Dealing with the Impacts of Climate on Health: This report illustrates the collaboration and interaction with the CDC's Climate and Health Program. The goal of this interaction is to increase the understanding of climate change on human health and assist with projects that can further this knowledge. **[NCDC]**

Climate Monitoring and Research Support for NOAA's Air Resources Laboratory (ARL) Atmospheric Turbulence and Diffusion Division (ATDD): Additional USCRN stations were installed in Alaska, continuing the expansion of the Alaska Climate reference Network (ACRN). **[ATDD]**

Investigating the Hydrological Impacts of Tropical Cyclones over the Carolinas from Observational and Modeling Based Perspectives: Four Tropical cyclones (Floyd 1999, Isabel 2003, Frances 2004, and Irene 2011) that impacted the Carolinas were simulated using the Weather Research and Forecasting model (WRF) for an ensemble of microphysical parameterizations. Modeling results were compared against surface and remotely sensed observations to assess the model's ability to capture such extreme events and their impacts on local communities. **[NCDC]**

Development and verification of US Climate Reference Network (USCRN) Quality Assurance Methods: A field campaign was initiated this year with NOAA's Air Resources Laboratory (ARL) precipitation testbed in Marshall, CO. The field study focused on gauge evaporation over the summer of 2013, which showed USCRN gauges were prone to evaporative losses. However, preliminary results indicate that evaporative losses had little impact on total precipitation. In addition, a website was developed to both im-

prove the dissemination of USCRN climate-quality data and serve as a spatial check for manual quality control (QC). A manuscript describing the new precipitation algorithm for the USCRN network was drafted and is currently being reviewed by the USCRN Project Science Manager. **[NCDC, CPO]**

Collocated US Climate Reference Network (USCRN) and Cooperative Observer Network (COOP) Comparisons: A manuscript describing network differences between USCRN and COOP networks was completed and submitted for internal review. Pending reviewer responses to revised manuscript, the document will be submitted for publication in a peer-reviewed journal. **[NCDC]**

Maintenance and Streamlining of the Global Historical Climatology Network – Monthly (GHCN-M) Dataset: A new land surface temperature Databank has been publically available through beta releases and work is underway to transition from research to operations. This product will lay the groundwork for the next iteration of GHCN-M, which will include updates to quality assurance and bias correction. **[NCDC]**

Workforce Development

Global Surface Temperature Portfolio-Data gap impacts on global surface temperature anomalies trends using GFDL CM3-CMIP5 model: Data gaps from US NOAA Temp/MLOST and UK HadCRUT4 were applied to NOAA GFDL CM3-CMIP5 model to analyze the impacts on temperature trends for different periods and for future scenarios. We found a decrease on surface temperature trends when data gaps are taking into account. **[NCDC]**

Global Surface Temperature Portfolio-Evaluation of global surface temperature methods: The purpose of this task is to evaluate the strengths and limitations of the best-known existing global surface temperature datasets (NOAA Temp/MLOST, UK HadCRUT4, NASA GISTEMP, University of York, and Berkeley BEST). **[NCDC]**

Estimation of land surface precipitation for contiguous U.S. using a new spatial interpolation method: A new spatial interpolation method that takes into account topography is applied to estimate monthly land surface temperatures for US and compare with NOAA/NCEI and PRISM estimated precipitation fields. **[NCDC]**

Global Surface Temperature Portfolio- Land Surface Temperature Analysis and Assessment of HIRS Surface Temperature Collocated with USCRN Observed Surface Temperature and Global Land Surface Temperature Datasets: Bias and RMSE are calculated for HIRS surface temperatures vs. the USCRN observation network and global reanalysis datasets (ERA-40, ERA-Interim, MERRA, and NRA). Results show that the bias and RMSE are low when compared to USCRN, especially for nighttime temperatures. **[NCDC]**

Consortium Projects

Improving Prediction of Heavy Precipitation Events in the Eastern US: This project utilized the NOAA GEFS Reforecast database to develop a model-error climatology for heavy precipitation in the eastern US. Comparison of reanalysis and reforecast data, for event-relative composites stratified by precipitation character and synoptic weather setting, is providing insight in to model error sources during heavy precipitation. **[ESRL]**

Programming and Applications Development for NOAA's Climate Services Portal (NCSP): Staff from UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) assisted with the enhancement and launch of the Multigraph website, the development of the Climate Explorer application, and the design and development of the U.S. Climate Resilience Toolkit. These products support the overall advancement and progression of the NOAA's Climate Services Portal (NCSP) program. **[NCDC]**

Spatio-Temporal Patterns of Precipitation and Winds in California: Precipitation frequency as a function of altitude in northern California does not correspond to the standard idealized relationship. It is widely variable with respect to both basin and storm type. **[ESRL]**

Other CICS PI Projects

Water Sustainability and Climate Change: a Cross-Regional Perspective: Model simulations from the CMIP5 hindcast experiment were found to reproduce observed temperature trends for the southeast and southwest U.S. for the period 1981-2010. Trends in the number of extreme monthly temperatures are simulated well for most regions, but not for the northwest. **[NSF]**

Identifying Tropical Variability with CDRs: Climate Data Records are being leveraged to develop new diagnostics for tracking and predicting the MJO and equatorial waves. These diagnostics are tested in near-real time on monitor.cicsnc.org/mjo where they are served to hundreds of users in the public and private sectors every month. **[NCDC]**

3 NOAA/CICS CORE ACTIVITIES

CICS core activities include education, coordination, scientific computing, outreach, management and administration related to CICS-MD, CICS-NC and Consortium efforts. During the past 12 months, CICS leaders have continued to establish the essential administrative and management activities required to support the collaborative science and research. Activities include institute administration, office administration, accounting and finance, proposal development/support, contracts and grants management, human resources, information technology, international linkages, and education and outreach. In addition, further progress has been achieved on the full suite of core activities, as described below.

3.1 Management and Administration

CICS is led by its Executive Director, Dr. Fernando Miralles-Wilhelm at the University of Maryland, and is hosted by ESSIC. The primary mechanisms that support the Executive Director in ensuring coherent collaboration across the entire Consortium include the Council of Fellows, the Science Meeting(s), and the support of the CICS-MD and CICS-NC Directors.

CICS-MD is led by Dr. Hugo Berbery of UMD. CICS-MD includes research and professorial faculty members from ESSIC and the Department of Atmospheric and Oceanic Science (AOSC), the Department of Geographical Sciences (GEOG), and the Department of Astronomy (ASTR), and supports a number of Research Associate and Faculty Research Assistant positions in each unit. In addition, CICS-MD supports a number of graduate research assistants. CICS-MD financial and personnel operations are supported by each employing unit. Administrative work is handled by the CICS-MD Coordinator, Debra Baker. ESSIC Assistant Director Andrew Negri also provides support on personnel and other matters. The ESSIC Business Office, directed by Mr. Jean La Fonta, manages the UMD funding and accounting efforts as well as the subcontracts for CICS-NC and Consortium members.

CICS-NC is led by Dr. Otis B. Brown, Director of the North Carolina Institute for Climate Studies (NCICS) and is hosted by NCSU on behalf of UNC System. CICS-NC collocated within the National Climatic Data Center in Asheville, NC. The CICS-NC administrative team includes:

- Janice Mills, Business Manager
- Theresa Stone, Program Specialist
- Jenny Dissen, Director of Climate Literacy, Outreach and Engagement
- Jonathan Brannock, Network/Systems Analyst
- Scott Wilkins, Operations/Systems Specialist

3.2 Coordination

A continuing challenge for CICS is to ensure that collaboration and communication across the entire Consortium contributes effectively to advancing NOAA's research mission. Several mechanisms are utilized to this end, ranging from direct discussions among the Directors to participation in the annual Cooperative Research Program (CoRP) Symposium to facilitating visits among students and scientists associated with CICS and other Cooperative Institutes.

3.3 Education

CICS 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. CICS 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 CICS education, outreach, and engagement activities, CICS 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, CICS 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 CICS mission. CICS 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 K-12 Education, Undergraduate Education, Graduate and Postdoctoral Education, Opportunities in Education Outreach, and Private Sector Engagement. Below are descriptions of the various activities CICS has tackled in the past year.

K-12 Education

CICS reaches out through various activities to K-12 students to help advance climate science, literacy and education particularly focusing in on STEM skillsets. Over the past several years, CICS scientists have given presentations, led lectures, taught courses, developed curricula, lent equipment, and mentored high-school students.

As we continue to develop and refine our method for informing the public about the latest findings in climate science through short videos displayed on *Science On a Sphere* as well as YouTube, we conducted a case study on what the public learned from one of our stories and had many opportunities to present our work at a variety of venues ranging from science meetings, educator workshops, and a briefing on Capitol Hill. The culmination of this year's efforts on the EarthNow project was the introduction of the new ClimateBits product led by CICS-MD.

A test of the effectiveness of various presentation methods of an EarthNow climate feature story was conducted at the Maryland Science Center (MSC). Four groups received the same information in different ways (live or auto-run SOS show, hands-on activity with SOS show, hands-on activity with no SOS show) and a control group did not hear the information. This test led to the conclusion that certain geoscience concepts can be more quickly and effectively learned with a spherical display. A summary of this case study has been accepted for publication in the peer-reviewed *Journal of Geoscience Education* special theme issue on outcomes from climate literacy efforts.

EarthNow was presented to more than 40 K-12 teachers from around the country attending the Smithsonian Science Education Academies for Teachers 2013 Biodiversity and Earth's History and Global Change workshops (**Figure 4**). Surveys of teachers indicated enthusiasm for using EarthNow stories to illustrate ecosystem changes and connections between ocean currents, atmospheric circulation and biodiversity, as well as climate-scale oscillations such as El Niño. The workshop organizers have asked us to participate again for their 2014 workshops.

Figure 4*: CICS scientist Stephanie Schollaert Uz presenting an overview of the application of satellite data to biology for the Smithsonian Science Education Academy for Teachers Biodiversity Workshop. Additionally, she set up the Magic Planet in the back of the classroom so teachers could experience a spherical display.*

On July 2014, Schollaert Uz briefed the U.S. House of Representatives Oceans Caucus on making NOAA data accessible to everyone through the use of spherical displays. This briefing was arranged in response to the president's proposed STEM realignment, which would have cut programs such as this project. Thankfully, our briefing appeared to have the desired effect and Congress did not support the proposed realignment.

For the 2nd annual CICS-MD Science Meeting in November 2014, we shared our new effort on this project to address a need by museum docents and the general public to see and hear climate science concepts explained simply: ClimateBits (**Figure 5**). Museums can use these videos within an SOS show or anybody can use them online for background information, including links to more detailed information. An initial proof-of-concept video on Solar Radiation was tested on a variety of audiences (e.g. Maryland Science Center docents, K-12 teachers and students, Alliance for Climate Education team). Discussions with several museums about ClimateBits have been favorable: docents say they need such a tool. NASA likes this idea and is partnering with us to develop several.

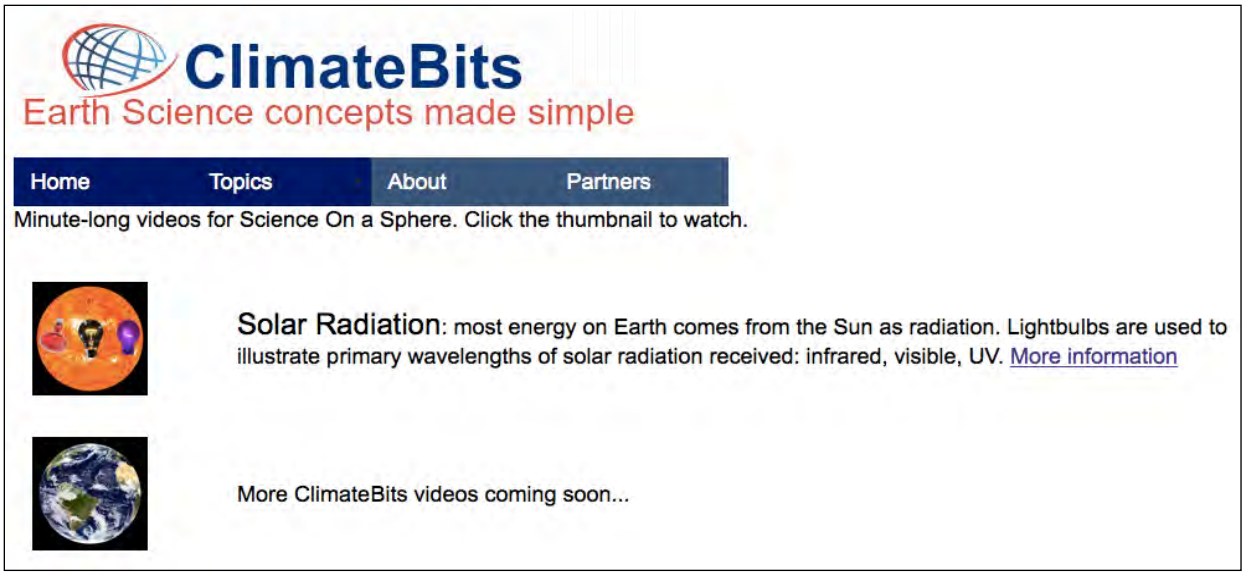

Figure 5*. ClimateBits website: http://climatebits.umd.edu launched 12-20-13, including an initial proof-of-concept video on Solar Radiation with more videos in development.*

In February 2015, we conducted training at the Bishop Museum, Honolulu, HI to learn how they use their sphere and show them interpreted products (EarthNow and ClimateBits). Although EarthNow products had automatically loaded to their SOS system, they had not noticed them before and were excited about updating their visitor-controlled kiosks to include these so visitors can select them. They also really like the idea of ClimateBits and said they will be helpful toward their effort to create 3rd-5th grade curriculum using the SOS, among other potential applications.

CICS continued our support to the EarthNow project, including authoring three quarterly climate science feature stories on fracking, tropical widening, and El Nino's effect upon marine life around the Pacific. The fracking story received wide international praise for handling such a controversial issue in such a balanced and scientific way. One docent at MSC expressed concern that the story was not critical enough of wastewater disposal by fracking companies, which led to several beneficial discussions over e-mail and by phone. He later said that he was impressed with the level of research that went into creating the story and feels the story is accurate and a welcome addition to the MSC playlist, where it's been playing every hour since it was published. The other stories only received positive comments.

Undergraduate Education

CICS supports education, literacy and outreach to university-level students by providing internship opportunities, mentoring and advising for graduating college seniors, undergraduate and graduate student researchers who have a strong desire to enhance their

research and analysis skills by working with NOAA and CICS. CICS' competitive internship program is very comprehensive and designed to prepare a young meteorologist or climatologist for an entry-level data analysis position or provide desirable research skills in preparation for graduate studies. Students will learn professional "tools of the trade" such as scientific software engineering best practices with Python-based scientific programming, High-Performance Grid Computing, GIS, and Adobe Creative Suite.

CICS-MD is closely linked to University of Maryland's undergraduate programs. The Department of Physics offers a BS degree with a concentration in Atmospheric Sciences, while Department of Geographical Sciences (GEOG) has its own undergraduate program,

The Department of Atmospheric and Oceanic Science (AOSC), where many CICS scientists are either members or affiliated researchers, has recently established its own undergraduate program. The program has been designed to teach broad based knowledge in meteorology, oceanography, climate and air pollution. The degree satisfies the requirements for federal service positions as a meteorologist or oceanographer, and also follows the American Meteorological Society's statement on bachelor's degrees in Atmospheric Science. The emphasis of the program is on preparing undergraduates to become generators of knowledge, or researchers, instead of idle consumers of knowledge that others produce. Undergraduates are already working on thesis projects with their CICS advisors, and the close partnership between the AOSC department and CICS is a major recruiting tool for the undergraduate program. For the last two summers, CICS has hosted an undergraduate student in Maryland (**Figure 6**) to provide training in scientific methods applied to climate studies. Given the growing interest in students as well as scientists, the intent is to expand this activity.

Figure 6*: (a) Jim Carton, AOSC Chair, during an undergraduate ocean science class. (b) An undergraduate student presents her poster with results of her summer research at the CICS-MD Science meeting*

AOSC also offers a Professional Masters degree. The graduate degree is designed for working professionals who need cutting-edge skills and knowledge in atmospheric and oceanic science, air quality and computational methods. It offers the rigor required to

understand scientific advances in the field and the flexibility needed by individuals to customize the curriculum towards their educational goals. The professional masters is organized into three certificate tracks. A certificate is earned after the completion of four classes, and two certificates plus two classes from the third track earns the student a masters degree. The plan is especially attractive to working students who may have to relocate for their jobs before finishing an entire masters program. In the professional masters, students can keep the certificates they earn should they need to leave early. This is in marked contrast to academic masters programs where students keep nothing but classroom credit if they must leave early. We anticipate that the program will be especially attractive federal employees and contractors needing additional training for their jobs or for a promotion.

CICS personnel are involved in teaching courses like Geography 415 (Land Use, Climate Change, and Sustainability), AOSC 432 (an undergraduate atmospheric dynamics course), and AMSC 460 (an undergraduate scientific computation course). Other CICS researchers are engaged in teaching courses and classes at other universities. For example, James Reagan has helped create an alumni mentorship program at Cornell University for Atmospheric Science undergraduates, while Cezar Kongoli has mentored one undergraduate student at American University during her admission and one-year study abroad academic program at Oxford University, UK. He is currently mentoring another undergraduate student from American University on her graduate degree program in environmental management at Oxford University, UK.

Mentoring undergraduate students in *science policy research* is an important goal of our research program. Such experiences provide opportunities to do research that uses and supports NOAA mission science and helps the students to hone their science interests, skills, and talents outside of the classroom. Thus, we take the education of student interns and fellows very seriously and develop a robust set of opportunities to develop their skills in science policy coordination and research methods. We actively engage the students in meetings and provide them with opportunities to learn the process of effective technical team and research coordination. We hone their skills in science editing and research through report preparation and editing, drafting policy memos, writing professional emails, developing and managing datasets, and assessing scientific literature and writing reviews. Additionally, we regularly hold professional development sessions to help the interns and fellows learn about networking, writing cover letters and resumes, and providing professional introductions. We invite the students to attend scientific conferences, congressional briefings, seminars, and informal networking receptions with scientists and practitioners.

During the summer, the policy program brings in a cohort of 4-5 undergraduate students because we find that the students are able to work together to address questions, they can learn from each other's strengths, we can build professional development programs for the entire group, and they have more fun and a better research experience. Historically about half of our summer policy students have been from UMD and the other half from other universities around the U.S. We also include Ph.D. and Masters students (who have their own support through programs such as the Washington

State University IGERT) who would like to work part of their time on Indicators activities and part of their time on a science policy research project, thesis, or dissertation chapter that would support the long-term Indicators goals and lead to a peer-reviewed manuscript. The addition of graduate students has been very successful because it provides the undergraduate students additional mentors and allows them the opportunity to participate in a greater diversity of research projects by assisting the graduate students.

CICS task leaders have taught special summer courses at CREST on topics such as Geographical Information Systems and MatLab for students from Summer REU and Education Outreach Programs for High School and Senior Students. Four undergraduate students from the CE department learned how to download, read, and process GOES IR, CALIPSO, and CloudSat data for use in a GOES-R project in the summers of 2011 and 2012. One REU undergraduate and one high school student learned how to acquire, read, and process satellite (GOES & MODIS) data, as well as to understand some of the cloud physical properties.

CICS-MD has launched a summer program to provide training and outreach opportunities for both graduate and undergraduate students. The CICS-MD Summer Initiative (CSI) pairs students with mentors to conduct original scientific research and help train future NOAA scientists. The CSI provides a framework that includes software tutorials, informal student presentations, weather/climate discussions, and interactions with other institutions to maximize the student experience. The CSI not only focuses on training this year's students, but also works to recruit future CICS-MD students. Summer interns hail from a wide variety of backgrounds, including UMD undergraduates, Hollings Scholars from other states, and UMD graduate students. These students (**Figure 7**) are sponsored through various projects, but the availability of funding often becomes a limiting factor. The number of students (12+) and proximity to their mentors lead to an extremely successful 2014 CSI, and lessons learned will be applied to future summer initiatives.

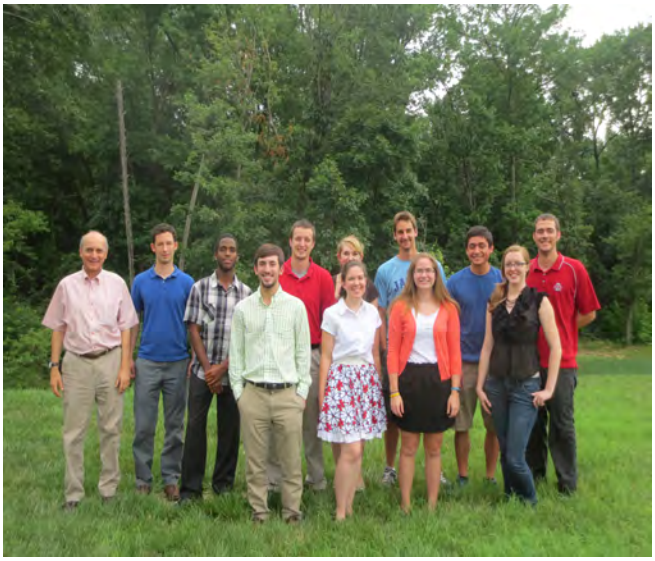

Figure 7: *The CICS-MD Summer Initiative*

Graduate and Postdoctoral Education

CICS-MD is located in College Park MD and centered on the Earth System Science Interdisciplinary Center (ESSIC). ESSIC is a joint center between the University of Maryland Departments of Atmospheric & Oceanic Science (AOSC), Geology (GEOL), Geography (GEOG), and the Earth Sciences Directorate at the NASA/Goddard Space Flight Center. ESSIC's goal is to enhance understanding of the coupled interactions of the atmosphere, ocean, land, and biosphere components of the Earth and the influence of human activities on this system. This is accomplished via studies of the interaction between the physical climate system (*e.g.*, El Nino) and biogeochemical cycles (*e.g.*, greenhouse gases, changes in land use and cover). The major research thrusts of the center are studies of Climate Variability and Change, Atmospheric Composition and Processes, the Global Carbon Cycle (including Terrestrial and Marine Ecosystems/Land Use/Cover Change), and the Global Water Cycle. This research is accomplished is via analyses of in situ and remotely sensed observations together with component and coupled ocean-atmosphere-land models. Together these provide a foundation for understanding and forecasting changes in the global environment and regional implications. Data assimilation and regional downscaling provide the means by which the observations and models are linked to study the interactions between the physical climate system and biogeochemical cycles from global to regional scales.

CICS-MD has entered in an agreement with STAR/NESDIS to establish the provision for scientists (Visiting Scientists, Research Scientists and Research Associates/Postdoctoral Fellows) to be appointed as NOAA/STAR temporary scientific staff. These positions will be located at STAR headquarters (University of Maryland Research Park, College Park, Maryland) and in other locations as deemed appropriate by the NOAA/STAR program manager. CICS-MD is located at the same research park, thus facilitating exchanges and visits without any additional expenses. Support for these positions will be from NOAA/NESDIS Center for Satellite Applications & Research (STAR) via (a) STAR central funding or (b) STAR science projects.

Professional interactions will be fostered among the CICS-MD and NESDIS/STAR Postdoctoral fellows and resident scientists in both groups by 1) scientific collaborations, 2) working visits, 3) scientific conferences, workshops, and seminars, 4) sharing of facilities, software, and data sets, and 5) other means required to foster this working agreement.

Graduate degrees for CICS-MD students are granted by the Departments, and many ESSIC faculty members have joint appointments and affiliations with AOSC, GEOL and GEOG. CICS-MD scientists include numerous faculty members from ESSIC and from the partner Departments. CICS-MD is able to draw on the extensive heritage of collaboration between UMD and NOAA that has enable numerous NOAA scientists to take courses in the physics of the atmosphere and ocean, and to obtain advanced degrees, as illustrated by the (until recently) Executive Director of CICS, Phillip Arkin, and Mitch Goldberg, the Chief of the Satellite Meteorology & Climatology Division.

CICS-MD scientists often provide lectures or teach courses, and several new courses have been developed specifically to enhance the University's educational program in the

areas of most relevance to CICS and NOAA research. For example, Introduction to Earth System Science (AOSC 680) presents an introduction to the study of the earth as a system, including the atmosphere, oceans, land, cryosphere, solid earth, and humans. It covers cycling of materials and energy in the earth system: the energy cycle, the hydrologic cycle, the carbon cycle, the nitrogen cycle, as well as climate processes and variability, including land-atmosphere, ocean atmosphere, biosphere-climate, and human interactions, and short- and long-term variability in climate.

CICS-NC is located within a University of North Carolina Inter-Institutional Research Center in Asheville NC and administered by NCSU through the Department of Marine, Earth and Atmospheric Sciences (MEAS). MEAS includes approximately 40 faculty, 100 graduate students and 150 undergraduates involved in basic and applied studies of Earth Systems. Principal concentrations include weather prediction, air quality, air-sea interactions, storm and climate modeling, hydrology, geochemistry, oceanography, surface processes and regional geology. The NCSU Department of Statistics is among the nation's oldest and most prestigious, having been founded by renowned statistician Gertrude Cox in 1941. It receives support from both the College of Physical and Mathematical Sciences and the College of Agriculture and Life Sciences. Their graduate program is the largest in the country, with about 170 graduate students with an undergraduate program that is the second largest in the country with about 100 students.

As part of enhancing and supporting graduate students and postdoctoral students, CICS engages in several activities, including support of postdoctoral fellows in innovative research, mentoring of graduate students and early career staff, support through fellowships, and advancing research efforts through delivering seminars and presentations.

CICS scientists offer early career mentoring of students and participate in advisory panels. CICS has an extensive mentoring program for graduate students where they participate in reviews of students' research, provide supervisory and mentorship support, and aid in early career development areas. CICS supports postdoctoral fellows working in Maryland and North Carolina, and through selected support, enable postdoctoral fellows to travel and present at a variety of state and national conferences, e.g., the American Geophysical Union Annual Meeting, the American Meteorological Society Annual Meeting, and the Climate Diagnostics and Prediction Workshop that is part of CPC activities. Over the past few years, CICS-NC has supported a total of 6 post-doctoral students to work in various research capacities supporting both CICS-NC and NCDC staff, as part of the broader workforce development. Research topics included the development of a next generation integrated global surface temperature analysis, global surface albedo calculations, scientific programming and visualization of satellite data information, climate variability of tropical cyclones and water vapor, quantitative precipitation estimation, temperature extremes analysis, amongst others.

CICS also engaged in interdisciplinary activities for education and outreach support. For example, Cezar Kongoli (CICS-MD) has supervised two students at the Department of Environmental Studies of American University (Washington DC) in the areas of remote sensing of coastal wetlands and statistical modeling and analysis of marine ecosystem

health. Ms. Dissen served on a panel on energy, environment, and climate at Harvard University for their Science Policy Careers Symposium, held in May 2012, to provide support and share career experience with postdoctoral students about careers in science policy.

Many CICS scientists support and advice PhD students in different programs at the Universities in Maryland and North Carolina. In Maryland, there are about 20 graduate students involved in CICS research, while in North Carolina approximately 5 graduate students are working on CICS themes.

The National Research Council's 2010 ranking of PhD programs places the AOSC department firmly in the top ten Earth Science programs nationwide and higher than any other institution on the East Coast. Approximately 20% of the graduate students have been employed by NOAA.

The Department of Atmospheric and Oceanic Science of the University of Maryland has created a Graduate Fast-Track program for accomplished scientists. Graduate students with exceptional scientific achievements may, through written petition to the Graduate Director, replace the written portion of the Comprehensive Exam with a seminar followed by an oral examination. Approximately six NOAA scientists have already taken advantage of this program. About twenty civil servants and contractors have returned for their PhDs following the normal path.

CICS scientists often provide lectures, deliver seminars, and give presentations on their research areas. Since 2009, CICS researchers have published more than 300 peer-reviewed papers and given hundreds of presentations at a large number of conferences/meetings/workshops on the topics of climate research and applications, satellite and observation monitoring, and climate modeling. Staff members also serve on proposal review boards and have conducted many reviews of papers for journals. For a full list of seminars and scientific visitors, please refer to the Appendix H; for a full list of presentations and invited talks, please refer to Appendix I.

CICS scientists participate in the annual CoRP Symposium, and CICS helps to support CUNY/CREST graduate students participation as well. CICS also facilitates summer visits by CUNY/CREST students to NESDIS Cooperative Institutes, providing them with hands-on experience with software and techniques relevant to their research projects. This summer exchange program has led to increased visibility and employment opportunities for students and early career scientists, and provides excellent candidates for open positions at NOAA and the CI's.

3.4 Outreach and Engagement

There is a need to advance climate science and climate change literacy for decision makers as they explore practical and cost-effective approaches to leverage available resources. Provision of climate data for applications and decision capabilities, which can factor into strategic, planning, and operational decisions, requires partnerships across public, private, and academic organization. CICS will engage in several meaningful cli-

mate engagement and outreach activities to the private sector as well as the general public. CICS will contribute to enhancing NOAA's efforts to communicate research results to the scientific community, decision-makers and the general public using several methods. We will present our collaborative research results at appropriate scientific meetings and other fora, and will publish them in the scientific literature once they are sufficiently complete. Scientists at all the participating institutions have excellent publication records, including substantial published work describing the results of collaborative research with NOAA scientists.

Since scientific publication tends to reach the scientific community more effectively than other target audiences, we propose to utilize other innovative approaches as well. These activities are often more effective when carried out in conjunction with CICS partners who have particular areas of expertise. To this end we will establish an *Outreach Enterprise Team* that will identify opportunities for the necessary activities. Critical expertise and connectivity for this effort will come from the Asheville *Buncombe Sustainable Communities Initiative (ABSCI)*, an Asheville NC-based non-profit group that brings together important community elements with an interest in climate research, innovation and entrepreneurial activities. ABSCI will be particularly valuable to the efforts of CICS to enhance the effectiveness of climate information products that result from research into satellites and climate. Another crucial contribution to the Outreach Enterprise Team will be provided by *Climate Central*, a non-profit organization established by a team of eminent climate scientists to ensure that critical climate information is made available in accessible form to decision-makers and the general public. *Climate Central* and CECI are both members of the CICS Consortium, ensuring that NOAA will benefit effectively from their expertise and networking capabilities.

CICS engagement and outreach activities require developing frameworks, delivering presentations, engaging in relationship-building and capacity-building activities, enabling catalytic support of innovation in uses of climate data, engaging in individual and executive-level roundtable discussions, as well as providing ongoing operational support to NOAA organizations like NCDC, NODC, and CPC.

Key highlights of proposed activities in outreach are framed under these areas:

- Advancing climate literacy for private sector partnerships through interdisciplinary activities, including outreach to energy industry, insurance industry, plant-based sector, and executive roundtable sessions
- Engagement and outreach to local and national TV meteorologists and other media interested in climate information
- Providing operational support to activities in NOAA organizations like NCDC in advancing their engagement activities in collaboration with the Climate Services and Monitoring Division and the Sectoral Engagement Team, communication with the Communications Officer, and literacy with the Education Lead
- Engagement and outreach and literacy activities to the general public

Developing communication and informational materials on the CICS activities and progress to share with CICS partners, and to inform the general public

Training Operational Forecasters

Several CICS Scientists work closely with operational meteorologists to implement their science and products, in what is usually called Satellite Proving Ground Activities. For example, CICS Research Associate Michael Folmer works as the "Satellite Liaison" at the OPC/HPC/SAB Proving Grounds (PGs), helping to coordinate their PG activities. Satellite PGs connect NOAA with its partners to bridge the gap between research and operations, provide unique sources of information, and support end-user education and training. The PG approach ensures communication between product developers and operational forecasters, allowing end users to contribute expertise to the final products (i.e., how it is displayed and integrated into operations). User feedback during algorithm development affords a wealth of information that helps focus research activities on end-user applications. This feedback mechanism also supports the development of effective education and training tools early in the product development process.

CICS currently develops satellite products and provides indirect support for Satellite PG efforts, but has no direct method for implementing new or existing experimental products. An ongoing project seeks to develop an operational framework which allows CICS to maximize its Satellite PG contributions by creating a variety of gateways to the public. The four major components are to install and implement McIDAS and AWIPS-II, build a Local Data Manager (LDM), improve the CICS-led STAR Precipitation Calibration and Validation center, and expand education, training, and outreach activities. This research will allow CICS to become a stronger, more diverse, and more direct PG provider, which will enhance collaboration, improve operational products, and simplify the feedback mechanism.

CICS will provide satellite education and training materials through e-learning modules, seminars, weather event simulations, and special case studies. NOAA, collaboratively through the NESDIS and the NWS, partners with the COMET, VISIT, and SPoRT to develop and deliver training on the new features, operations, and capabilities of future satellite missions. The academic community is another important user of satellite data, for informational, educational, and research purposes. Some specific academic institutions collaborate with NOAA/NESDIS to develop and implement PG demonstration products. The planned implementation of McIDAS and AWIPS-II at CICS also will provide a valuable education and training opportunity for UMD graduate and undergraduate students. Such activities will help develop students with remote sensing experience who then can enter the work force to staff future NESDIS activities as support contractors and civil servants.

Engagement and Outreach to the General Public

CICS reaches out to the general public and relevant communities in a variety of ways. The University of Maryland sponsors an annual event called Maryland Day (**Figure 9a,b**; http://www.marylandday.umd.edu/) that enables CICS-MD to reach a large audience, on the order of 70,000 visitors, in a campus-wide open house. For the last several years, CICS has contributed significantly to the ESSIC exhibit at Maryland Day, permitting CICS to "show off" many of its talented researchers and promote the NOAA mission to the general public.

Figure 9a*: Images of Maryland Day (April 25, 2015)*

CICS-MD has been using a visualization technique called “The Magic Planet” to reach out to the public. The Magic Planet displays datasets of weather and climate moving across its surface. The images displayed are used to educate visitors of all ages, earth systems and how they relate to the environment. CICS makes presentations at Maryland Day, the Maryland Science Center in Baltimore, and the National Zoo. Furthermore, a supplemental target was to promote the use of *Earthnow,* a web-based blog operated by

the same research institutes, among docents (staff and volunteers) that carry out presentations at SOS sites in museums and science centers across the country (and around the globe).

***Figure 9b**: Images of Maryland Day (April 25, 2015)*

To fulfill this task, training sessions were held bi-weekly at the Maryland Science Center (MSC) in Baltimore, Maryland. The project identified supplemental methods to promote public learning, interest, and focus on earth science, short-term weather, and long-term climate change. These methods included (a) podcasting some of the *Earthnow* content and including it in automatic SOS playlists, (b) promoting the use of local stories and topical events in SOS presentations and *Earthnow* posts (by using local sources, working closely with museum staff and data providers and developers) and (c) creating future docent training material based on feedback received in an online survey of docents, as well as on the systematic observation of the public's engagement and perception (opinion) of the SOS live presentations.

CICS recently supported the launch of *CycloneCenter.org*, a joint activity with NCDC, UNC Asheville, and Zooniverse that enables the public to help analyze the intensities of past tropical cyclones around the globe. The general public is able to log in and answer questions about images as part of a simplified technique for estimating the maximum surface wind speed of tropical cyclones. This example of public collaboration allows for the completion of a large number of classifications in just a few months—something that would take a team of scientists more than a decade to accomplish. The end product will be a new global tropical cyclone dataset that provides tropical cyclone intensity estimates, confidence intervals, and a wealth of other metadata that could not be realistically obtained in any other fashion.

Outreach at CICS-MD has the potential to grow into a major resource for raising climate awareness around College Park, MD, the Washington D.C. metropolitan area, and beyond. For the past three years, CICS scientists have been conducting outreach and informal education through a NOAA Office of Education project to interpret global climate and satellite products at museums using the *Science On a Sphere (SOS)*. This project involves close collaboration with the Maryland Science Center in Baltimore to understand public perception of stories displayed on SOS and how to improve the effectiveness of this tool. Museum staff and their public audience often need background information to provide context. To address this, CICS-MD has launched a new website (climatebits.umd.edu) to serve as a tool for SOS museums as well as a resource for anybody interested in minute-long videos on Earth Science concepts. Over the next five years, we will grow this resource and increase our collaboration with related outreach efforts.

ClimateBits will serve as the focus of CICS outreach efforts to the general public, including its website, online videos, twitter, and facebook accounts. These tools are tailored to the SOS community, consisting of more than 100 sites in 15 countries attended by more than 33 million visitors each year according to the NOAA SOS website. Yet this resource will have broader impact with a dynamic web and social media presence. The internet is now the top source of information world-wide, half of all Americans own a smartphone, and two thirds of these Americans use smartphones to access the internet. Social media accounts for 17% of all time spent online. Additionally, younger generations look for organizations on social media and lose interest in organizations without an active web presence. Facebook alone reaches more than 1 billion people or 72% of internet users, with 48% of users under the age of 30 using it as their primary news source. Additional distribution of this tool as resource will be accomplished through collaboration with other agencies (e.g. NASA, NOAA) and organizations (e.g., the Smithsonian), and by working more closely with UMD to increase our visibility on and off campus.

CICS-NC supports access to climate information for opportunities through its partnership with the Asheville Buncombe Sustainable Community Initiatives (ABSCI), a NC 501 (c) 3 with a mission to support and catalyze a resilient and enduring prosperity for the

community within the context of a rapidly evolving and increasingly complex world. ABSCI has a long history of projects that support sustainability of the long-term economic, environmental and cultural values that make NC vital and unique. ABSCI project portfolio includes the Collider Innovation Center, where ABSCI manages and runs The Collider, a catalyst environment for building relationships and collaborations across economic and community sector. The Collider offers small offices, co-working, conference rooms and event and workshop spaces as a platform within downtown Asheville to stimulate business and community engagement. Through the intentional creation, nurturing and maintenance of this workplace and learning environment ABSCI leverage the resources of a multitude of partners to offer activities that support business commercialization, community engagement and lifetime learning, with a specific focus on the climate and resilience sector.

Communication and Informational Updates on CICS

In 2013, CICS-NC significantly invested in improving its communications efforts for delivering institute science and program information and technical services for varied audiences and a wide range of stakeholders across public, private and academic enterprises.

CICS-NC brought on a communications specialist who elevated the presence of CICS-NC across its stakeholders to share information related to the progress of the institute's work. Starting with building a communications strategic plan for CICS-NC, the communications activities included following significant updates that have helped the general public improve their understanding of not only the research institute but also progress in climate research:

- A refined, updated CICS-NC website with content that is updated frequently of both science and engagement activities
- Development of a science fact sheets that translated the scientific content into user-friendly materials for the general public and the CICS-NC stakeholders
- Improved inter-institutional communications with NC State University across the College of Sciences, Marine, Earth and Atmospheric Sciences Department and Office or Research, Innovation and Economic Development, as well as with the University of Maryland ESSIC and CICS-MD
- Improved CICS-NC's presence across social media (e.g. through an improved and updated Facebook)_as well as issue relevant press releases with media contacts as appropriate.

In addition, CICS-NC developed a new brochure as well as an overview, science and engagement poster that is broadly used and shared across conferences, meetings and workshops.

CICS-MD and CICS-NC each distribute semiannual publications entitled *Circular* and *Trends,* respectively (**Figure 10**)*,* that report on CICS-MD / CICS-NC vision and mission,

research themes and provide brief descriptions of selected research projects at the institute. These publications are shared with the respective business communities, consortium partners, other organizations as part of the engagement effort, and university partners across the various offices to keep the department heads and faculty updated on research progress. They are also shared with participants at CICS-organized workshops or science meetings.

***Figure 10**: Recent CICS-MD and CICS-NC Newsletter issues*

CICS web sites continue to be developed to enhance CICS outreach to all interested sectors. CICS has a dedicated web page that serves as a focused presentation of CICS-specific research projects and results. An independent website, climateandsatellites.org, intended to provide a comprehensive description of the CICS Consortium, has been established and is in the process of being enhanced. This site provides the background, mission, and vision statements for CICS, as well as links to Consortium participants.

Both CICS-MD and CICS-NC maintain dedicated sites for their own activities that also include cross-links with other CICS sites using a consistent "look and feel.

CICS website: http://climateandsatellites.org

CICS-MD website: www.essic.umd.edu/cics-md/

CICS-NC website: www.cicsnc.org

In addition, CICS contributes news items to the ESSIC and AOSC web pages and blogs, where significant research accomplishments are described.

A new blog created by CICS-MD and SCSB scientists titled “It’s Severe – Unique Perspectives on Extreme Weather” was recently launched on the ESSIC website. This outreach effort aims to introduce the public to the unique methods and datasets that CICS/ESSIC scientists use to examine extreme weather events (thunderstorms, fires, floods, blizzards, etc.). The blog also serves as a seed for NESDIS, CICS, and ESSIC scientists to begin exploring new multi-sensor, multi-platform applications.

The College of Computer, Mathematical, and Natural Sciences (CMNS), of which CICS is a part, issues a quarterly newsletter to a wide audience, and CICS, when appropriate, contributes items describing notable accomplishments and events.

Additional outreach through communication occurs through seminar participation. CICS scientists participate in the AOSC, ESSIC, and NCSU MEAS seminar series, as well as give seminars and presentations at other institutions. Volume 2 of this Annual Report contains a sampling of CICS Researchers’ invited talks and their participation in giving seminars.

Appendix 1: Acronym List

AAAS	American Association for the Advancement of Science
(A)ATSR	(Advanced) Along Track Scanning Radiometer
ABI	Advanced Baseline Imager
AC4	Atmospheric Chemistry, Carbon Cycle, & Climate (CPO)
AERONET-OC	Aerosol Robotic Network-Ocean Color data
AF-ARP	Active Fire Application-Related Product
AFWA	Air Force Weather Agency
ALEXI	Atmosphere-Land Exchange Inverse model
AMSC	Applied Mathematics & Statistics, & Scientific Computation (UMD)
AMSR-2	Advanced Microwave Scanning Radiometer 2
AMSR-E	Advanced Microwave Scanning Radiometer - EOS
AMSU	Advanced Microwave Sounding Unit
AMSU-A	Advanced Microwave Sounding Unit-A
AMSU-B	Advanced Microwave Sounding Unit B
AOSC	Department of Atmospheric and Oceanic Science (UMD)
AOT	Aerosol Optical Thickness
APSP	Aerosol Particle Size Parameter
AR5	Fifth Assessment Report (IPCC)
ARL	Air Resources Laboratory
ASTR	Department of Astronomy (UMD)
ATDD	Atmospheric Turbulence and Diffusion Division
ATMS	Advanced Technology Microwave Sounder
AVHRR	Advanced Very High Resolution Radiometer
BAMS	Bulletin of the American Meteorological Society
CAS	Chinese Academy of Sciences
Cal/Val	Calibration/Validation
CalTech	California Institute of Technology
CCGG	Carbon Cycle Greenhouse Gases
CDOM	Chromophoric/Colored Dissolved Organic Matter
CDR	Climate Data Record
CHRS	Center for Hydrometeorology and Remote Sensing
CICS	Cooperative Institute for Climate and Satellites
CICS-MD	Cooperative Institute for Climate and Satellites-Maryland
CICS-NC	Cooperative Institute for Climate and Satellites-North Carolina
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies
CIRUN	Climate Information Responding to User Needs
CLASS	Comprehensive Large Array-data Stewardship System
CMAQ	Community Multi-scale Air Quality model
CMIP	Coupled Model Intercomparison Project, Phase 5
CMNS	College of Computer, Mathematical and Natural Sciences
CONUS	Continental United States
COOP	Cooperative Observer Program (NWS)

CoRP	Cooperative Research Program
CPC	Climate Prediction Center
CPO	Climate Program Office
CREST	Cooperative Remote Sensing Science and Technology Center
CrIMSS	Cross-track Infrared Microwave Sounder Suite
CrIS	Cross-Track Infrared Sounder
CRM	Cloud Resolving Model
CRTM	Community Radiative Transfer Model
CTD	Conductivity-Temperature-Depth probe
CUNY	City University of New York
CWG	Calibration Working Group (GOES-R)
DMSP	Defense Meteorological Satellite Program
DYNAMO	Dynamics of the MJO
EDR	Environmental Data Record
EFSO	Ensemble Forecast Sensitivity to Observations
ENSO	El Niño Southern Oscillation
ERB	Earth Radiation Budget
ESRL	Earth System Research Laboratory
ESSIC	Earth System Science Interdisciplinary Center
ETC	Extratropical Cyclone
EUMETSAT	European Organisation for Exploitation of Meteorological Satellites
FAR	Fourth Assessment Report (IPCC)
FCDR	Fundamental Climate Data Record
FDC	Fire Detection and Characterization
FOC	Full Operational Capability
GCOM	Global Change Observation Mission (JAXA)
GCOM-W1	Global Change Observation Mission 1st - Water
GCOS	Global Climate Observing System
GEO	Geostationary Orbits
GEOG	Department of Geographical Sciences (UMD)
GERB	Geostationary Earth Radiation Budget
GFS	Global Forecast System
GHCN-M	Global Historical Climate Network Monthly
GLM	Geostationary Lightning Mapper
GOCART	Goddard Chemistry Aerosol Radiation and Transport module
GOES	Geostationary Orbiting Environmental Satellite
GOESPO	GOES-R Program Office (NOAA)
GOES-R	Geostationary Orbiting Environmental Satellite – R-Series
GPCP	Global Precipitation Climatology Project
GPM	Global Precipitation Measurement Mission
GPROF	Goddard Profiling Algorithm
GPS	Global Positioning System
GPSRO	Global Positioning System Radio Occultation
GridSat	Gridded Satellite Data

GRUAN	GCOS Reference Upper Air Network
GSA	Geostationary Surface Albedo
GSFC	Goddard Space Flight Center
GSICS	Global Space-based Inter-Calibration System
GVAR	GOES Variable Format
HDSS	Hierarchical Data Storage System
HIRS	High-Resolution Infrared Radiation Sounder
IASI	Infrared Atmospheric Sounding Interferometer
IBTrACS	International Best Track Archive for Climate Stewardship
ICESat	Ice, Cloud and Land Elevation Satellite
IDPS	Integrated Data Processing Segment
IGES	Institute for Global Environmental Strategies
IMSG	I. M. Systems Group, Inc.
IMS-V3	Interactive Multi-Sensor Snow and Ice System, Version 3
IOC	Initial Operational Capability
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
ISCCP	International Satellite Cloud Climatology Project
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JPSS	Joint Polar Satellite System
JPSSO	JPSS Office (NOAA)
LAI	Leaf Area Index
LETKF	Local Ensemble Transform Kalman Filter
LIS	Land Information System
LISCO	Long Island Sound Coastal Observatory
LMA	Lightning Mapping Arrays
LST	Land Surface Temperature
MADRAS	Multi-Frequency Microwave Scanning Radiometer
MEAS	Department of Marine, Earth, and Atmospheric Sciences (NCSU)
METEOSAT	Meteorological Satellite operated by EUMETSAT
Metop-B	Meteorological Operational Polar Satellite-B
MHS	Microwave Humidity Sounder
MiRS	Microwave Integrated Retrieval System
MJO	Madden-Julian Oscillation
MLD	Mixed Layer Depth
MMF	Multi-Scale Modeling Framework (NASA)
MOA	Memorandum of Agreement
MODIS	Moderate Resolution Imaging Spectroradiometer
MSC	Maryland Science Center
MSG	METEOSTAT Second Generation
MSPPS	Microwave Surface and Precipitation Products System
MSU	Microwave Sounding Unit
M-T	Megha-Tropiques satellite

NASA	National Aeronautics and Space Administration
NCA	Draft National Climate Assessment
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NCICS	North Carolina Institute for Climate Studies
NCSU	North Carolina State University
NCWCP	NOAA Center for Weather and Climate Prediction
NEMAC	National Environmental Modeling and Analysis Center
NEMS	National Environmental Modeling System
NEON	National Ecological Observatory Network
NESDIS	National Environmental Satellite, Data and Information Service
NIDIS	National Integrated Drought Information System
NIFA	National Institute of Food and Agriculture (USDA)
NMME	National Multi-Model Ensemble
NMQ	National Mosaic and Multi-Sensor QPE
NN	Neural Network
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOS	National Ocean Service (NOAA)
NPOESS	National Polar Orbiter Environmental Satellite System
NPP	NPOESS Preparatory Project
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
NWP	Observing Systems Simulation Experiment
NWRI	National Water Research Institute
NWS	National Weather Service
OAFlux	Objectively Analyzed Air-Sea Fluxes for Global Oceans (WHOI)
OAR	Office of Oceanic and Atmospheric Research (NOAA)
OESD	Office of Education and Sustainability (NOAA)
OISST	Optimum Interpolation Sea Surface Temperature
OLR	Outgoing Longwave Radiation
OpeNDAP	Open-Source Project for a Network Data Access Protocol
OS	Operating System
OSD	Office of Systems Development (NESDIS)
OSPO	Office of Satellite and Product Operations (NESDIS)
OSSE	Observing Systems Simulation Experiment
OST	Office of Science and Technology
OSU	Oregon State University
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
POES	Polar Orbiting Environmental Satellites
Q2	Next Generation QPE
QA	Quality Assurance
QC	Quality Control
QIR	Quadratic Interval Refinement

QPE	Quantitative Precipitation Estimates
SAFE	Snow Analysis and Field Experiment
SAPHIR	Spectrometer Arrangement for Photon Induced Reactions
SCSB	Satellite Climate Studies Branch
SDR	Sensor Data Record
SeaWiFS	Sea-viewing Wide Field of View Sensor
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SIP	Standardized Precipitation Index
SM	Suspended Matter
SMOS	Soil Moisture and Ocean Salinity satellite
S-NPP	Suomi-National Polar-Orbiting Partnership
SOS	Science on a Sphere network (NOAA)
SPEC	Satellite Product Evaluation Center
SSH	Sea Surface Height
SSM/I	Special Sensor Microwave Imager
SSMIS	Special Sensor Microwave Imager/Sounder
SST	Sea Surface Temperature
STAR	Center for Satellite Applications and Research
STEM	Science, Technology, Engineering and Mathematics
SW	Shortwave
SWE	Snow Water Equivalent
TAR	Third Assessment Report (IPCC)
TC	Tropical Cyclones
THREDDS	Thematic Real-Time Environmental Distributed Data Services
TMPA	TRMM Multisatellite Precipitation Analysis
TOA	Top of the Atmosphere
TPW	Total Precipitable Water
TRMM	Tropical Rainfall Measuring Mission
TSU	Technical Support Unit (National Climate Assessment)
UCI	University of California, Irvine
UMCES	University of Maryland Center for Environmental Science
UMD	University of Maryland, College Park
UMUC	University of Maryland University College
UNC	University of North Carolina
USCRN	United States Climate Reference Network
USDA	United States Department of Agriculture
USGCRP	United States Global Change Research Program
VCM	VIIRS Cloud Mask
VEGAS	Vegetation Global Atmosphere and Soil model
VIIRS	Visible/Infrared Imager Radiometer Suite
WERF	Water Environment Research Foundation
WHOI	Woods Hole Oceanographic Institution
WRF	Weather Research and Forecasting model
XBT	eXpendable BathyThermograph