COOPERATIVE INSTITUTE FOR CLIMATE and SATELLITES (CICS)

Scientific Report

VOLUME I: ACTIVITIES SUMMARY

For the period:

April 1, 2013 – March 31, 2014

NOAA Grant NA09NES4400006

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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 (UMCP) 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 (UMCP), the Joint Global Change Research Institute collocated with UMCP, 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 UMCP 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 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 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.

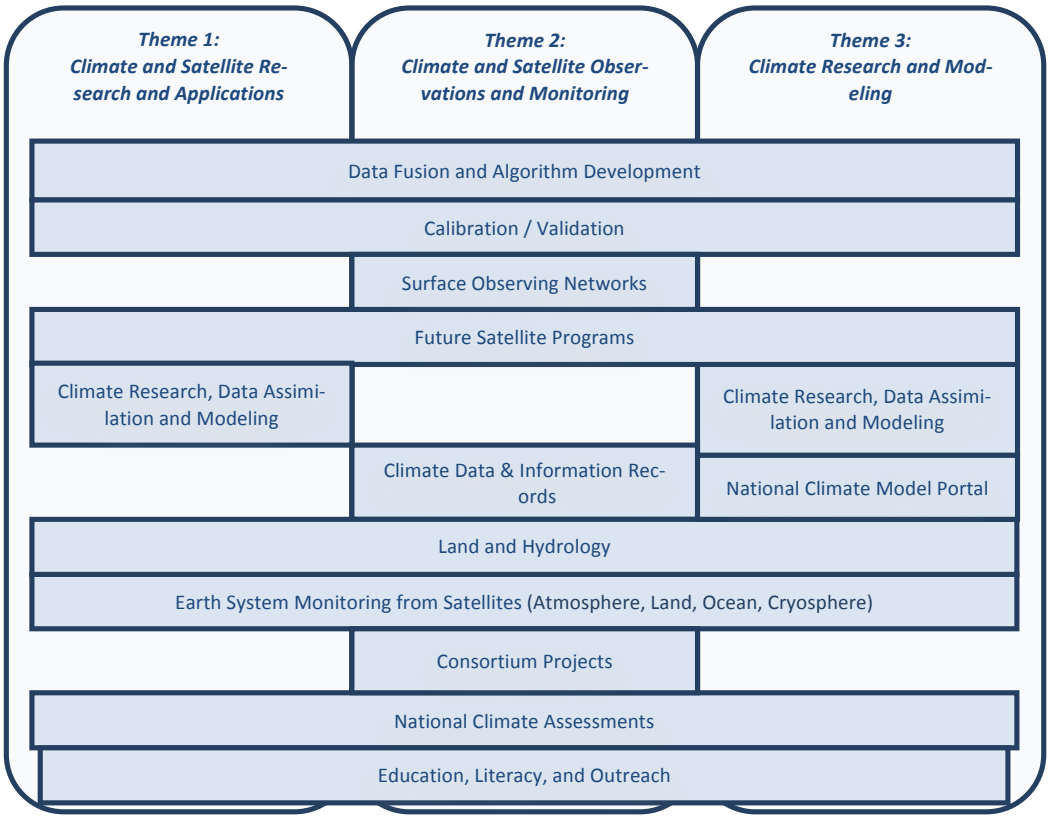

***Figure 1**: CICS Research Themes and Topic Areas*

The total task funding for CICS research is $46.5 Million, with an increase of more than $15 Million during the period of this report. In **Figure 2,** we summarize graphically the stratification of active task funding by CICS Research Theme and by NOAA Strategic Goal.

1.3 CICS-MD

CICS-MD is based upon the model and experience gained by UMCP 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.

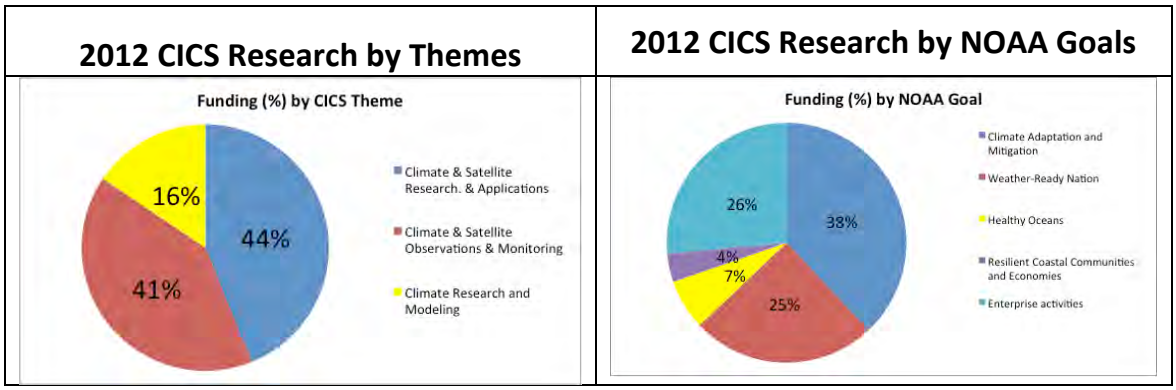

Figure 2: *Distribution of CICS funding during the reporting period.*

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 UMCP 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.

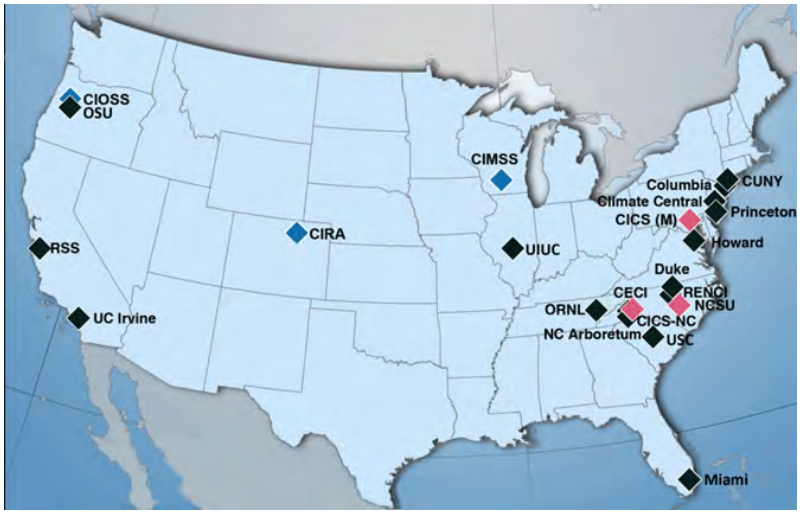

***Figure 3**: Spatial distribution of CICS Consortium institutions.*

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 UMCP and NOAA in 2011. The MOA describes the configuration and governance of CICS, and summarizes the functions of its several elements. The two principal 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 UMCP, 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 UMCP

- 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. Terri Lomax - 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

A meetings of the Executive Board was held on December 2, 2013. This meeting was held simultaneously in College Park, MD and Asheville, NC, linked by a video-conference system.

2 HIGHLIGHTS OF THIS YEAR'S RESEARCH

2.1 Summary of Achievements

This year we added new metrics to reflect the large involvement of CICS in the transfer of research to operations, including both the number of new and improved products that were developed. 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	**FY13**
# of new or improved products developed following NOAA guidance	187
# of products or techniques transitioned from research to ops following NOAA guidance	42
# of new or improved products developed without NOAA guidance	12
# of products or techniques transitioned from research to ops without NOAA guidance	7
# of peer reviewed papers	173
# of non-peered reviewed papers	50
# of invited presentations	268
# of graduate students supported by a CICS task	21
# of graduate students formally advised	36
# of undergraduate students mentored during the year	56

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. No auditing or verification of the results was performed. The CICS directors are currently evaluating, clarifying, and developing these metrics to better meet the needs of NOAA funders for budget accountability. Performance metrics broken out for CICS-MD, CICS-NC, and CUNY-CREST are included in Appendix 5. Each task report in Volume 2 of this report also has a performance metrics table.

2.2 Research Highlights

In the following sections we summarize the research highlights from the past twelve months of this agreement.

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: Code has been written and tested for AMSR-2 validation and datasets have been procured for a designated test period. Initial results indicate the performance of GAASP processing chain is meeting requirements. Interesting features are noted in data that illustrate the importance of understanding real SST signals from underlying geophysical processes that might be incorrectly interpreted as algorithm error. [**STAR**]

GOES-R Risk Reduction – Ocean Dynamics: The 4D-Var regional modeling and data assimilation system has been successfully ported from Oregon State University to the S4 supercomputer hosted at UW-Madison. A graduate student has been retained and is being trained in the use of the S4 and other NOAA computing systems, and in running the ocean model. [**STAR**]

Microwave and Diurnally Corrected Blended SST: Metop FRAC processing has been incorporated into operations. A state-of-the-art diurnal correction scheme including Stokes Drift parameterization has been developed and tested. [**NESDIS/OSD**]

Assimilation of VIIRS SSTs and Radiances into Level 4 Analyses: Code has been written and tested to ingest all three variants of the ACSPO VIIRS SST data format. Trial runs have shown a significant increase in data coverage obtained from VIIRS, although biases are somewhat characteristic of previous AVHRR products. This is not surprising since the current ACSPO algorithms are essentially identical to those developed for AVHRR, i.e. they do not take advantage of additional channels in the retrieval. [**STAR**]

Evapotranspiration and Drought Monitoring Using GOES-R Products for NIDIS: ALEXI ET and ESI products were tested using MSG and MODIS as a proxy for current GOES-R products over Africa, Europe and CONUS. The new proxy-based products were shown to provide much higher resolution while providing similar accuracy as current GOES-based products. Findings from this project will help motivate development of operational ALEXI products in the GET-D product system as GOES-R products become available. [**STAR**]

Enhancing Soil Moisture Data and their Applications for Agricultural and Numerical Weather Forecasts: As part of the NASA project team, we are tasked to provide global soil moisture data product to USDA Foreign Agricultural Service (FAS) and NOAA NWS-NCEP weather forecast models. In the past years, we continuously provided daily satellite soil moisture data product from European Space Agency's Soil Moisture Ocean Salinity (SMOS) satellite to the USDA-FAS for their world crop forecast analysts. [**STAR**]

Development of Global Soil Moisture Product System (SMOPS): We have upgraded SMOPS to ingest soil moisture retrievals from Metop-B ASCAT. To prepare the upgrade, Metop-B ASCAT soil moisture data are evaluated against Metop-A ASCAT data. SMOPS is the NOAA-NESDIS Global Soil Moisture Operational Product System. It provides soil moisture observations from microwave satellite for use in NWS-NCEP weather and climate prediction models. [**STAR**]

Development and Validation of AMSR-2 Environmental Data Records (EDR's): The AMSR2 EDR algorithms for precipitation and ocean retrievals were delivered to NOAA/OSPO Fall 2013 and transitioned into operations. The EDRs will be operationally available in spring 2014. [**STAR**]

Enhancements for Geo-SST Products: Code is being written to change outputs to netCDF4. It is important to integrate this effort with the CICS reprocessing project, which has required significant extra effort to overcome data format issues. [**NESDIS/OSD**]

Development of a Bayesian Cloud Mask: A method for rapid generation of cloudy probability distribution functions has been adapted for use over ocean surfaces. New parameter-dependent probability distribution functions are being generated for a number of different instrument parameters. Final selection of optimal parameter/channel sets will commence soon. [**STAR**]

Sea Surface Temperature Continuity for MSG: All necessary upgrades have been made to the Geo-SST processing system and successfully transitioned to operations. New Single Sensor Error Statistics have been generated and incorporated to facilitate operational generation of GHRSST L2P SST data for Meteosat-10 (MSG-3). [**NESDIS/OSD**]

Reprocessing Geo-Polar Blended SST analyses in support of NOAA Coral Reef Watch: All required major script and code changes have been made and data procured for all geostationary sensors for 2004 – present (~150 TB). Extensive testing has been performed on a sample month (August 2013) which has had the added benefit of repopulating the archive with correct data, since the upgrade to physical retrieval within NOAA Operations contained a minor implementation bug which had caused errors in the gridded output files for that month. All code changes are being coordinated with other tasks to ensure that the reprocessing methodology is as up-to-date as possible. [**STAR**]

Contributions to the Microwave-Radar Enhanced (MW-RE) Precipitation Over Land Algorithm: The before-launch GPM GPROF database for over land was constructed. [**STAR**]

Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates: CICS scientists developed and tested a new satellite rainfall retrieval technique for the use with GOES-R, which uses a combination of IR data and lightning information. The new technique innovatively incorporates the lightning information and significantly reduces biases and uncertainties compared to the infrared alone technique. Comparison with the current NOAA operational technique shows large possibilities for improvement. [**STAR**]

Improving GOES-R Cloud Precipitation Products Associated with Deep Convective Systems by using NEXRAD Radar Network over Continental U.S.: By integrating the space-borne and ground-based radar classification technique with satellite cloud property retrievals, we are developing a satellite-microphysics-based cloud classification to improve the current IR-based precipitation retrieval algorithm. Satellite-microphysics-based cloud classifications are evaluated against aircraft in situ data and ground-based retrievals, while IR-based precipitation retrievals are evaluated with ground-based radar estimates. [**STAR**]

Calibration/Validation

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: GEOG Task 1. Surface Reflectance: CICS scientists have made great progress in the evaluation of the VIIRS cloud Mask (VCM) and VIIRS surface reflectance. The VIIRS surface reflectance has recently been promoted to provisional status on March 17, 2014 and VCM is now at validation stage 2. The methods and metrics for evaluation are well in place and a paper in press in RSE that summarized our evaluation. [**STAR**]

A Rapid Delivery System of Enhanced VIIRS Active Fire Data for Fire Management and Fire Weather Applications: The VIIRS AF Proving Ground project made great strides towards our goals in 2013. Outreach continued via conference presentations, workshop training, and on-site visits to two major wildfire incidents. We enhanced our website to offer additional datasets and provide data in formats that were directly based on user feedback. Evaluation proceeded with the standard data portal (CLASS) and direct broadcast (DB) data. Webpage: http://viirsfire.geog.umd.edu/ [**STAR**]

A Terrestrial Surface Climate Data Record for Global Change Studies: A 30+ years of daily surface reflectance and vegetation index data processed in a consistent way is now available from this project. It is generated from data of several AVHRR instruments from 1981 to 2013 and of the MODIS instruments on-board Terra and Aqua from 2000 to 2013. Inter-comparison of the MODIS aqua and AVHRR for the 2000-2013 period has enable to further refine the AVHRR record. It uses state of the art algorithms for geolocation, calibration, cloud screening, atmospheric and surface directional effect correction to achieve the most consistent data record possible. This dataset is a daily global

dataset at the resolution of 0.05 degree of latitude and longitude. This dataset has also been tested prior to release in practical applications of societal benefits such as forest cover change detection over the long term as well as drought monitoring or yield prediction in the context of agricultural production and food security. [**NCDC**]

Evaluation of Megha-Tropiques (M-T) Products: This research evaluated quality of the observations from SAPHIR instruments aboard Megha-Tropiques satellite versus ATMS onboard S-NPP as well as *in-situ* measurements. [**STAR**]

Satellite Calibration and Validation (Cal/Val) efforts for STAR Precipitation Products: Daily and seasonal validations of several operational rainfall products generated by NESDIS are conducted over the contiguous United States, and the results are disseminated via a CICS web page. [**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**]

Extension of Global Space-based Inter-Calibration System (GSICS) Framework using CrIS Sensor DataRecords (SDR): CICS scientists have developed a novel method of employing inter-sensor comparison to evaluate and improve radiometric, spectral, and geolocation accuracy of Cross-track Infrared Sounder (CrIS) Sensor Data Records (SDR), which are fundamental for Global Space-based Inter-Calibration System (GSICS) Framework. [**STAR**]

Science and Management Support for NPP VIIRS Aerosol Optical Thickness (AOT), Aerosol Particle Size Parameter (APSP), and Suspended Matter (SM): CICS scientists at NOAA NESDIS STAR (Drs. Jingfeng Huang and Ho-Chun Huang) maintained, evaluated, and improved the current operational Suomi-National Polar-orbiting Partnership (S-NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) aerosol products. The Intensive Calibration and Validation (ICV) of the products were conducted through closely monitoring global aerosol observations and evaluating data maturity against ground measurements. New aerosol retrieval and quality assurance schemes were developed and implemented to improve global aerosol retrievals. Data usage support to research and application communities were provided. [**STAR**]

NPP/VIIRS Land Surface Albedo Validation Research and Algorithm Refinement: We evaluated the quality of the current surface albedo EDR data and compare them with the existing products. We updated the BPSA LUT, and the new LUT generated better results. We investigated the angular dependency of BPSA retrievals and proposed methods to reduce the temporal variations. [**STAR**]

GOES-R Calibration Working Group (CWG) Support at the University of Maryland: CICS scientists support Calibration and Validation work for GOES-R Advanced Baseline Imager

(ABI) instrument through lunar calibration, long-term monitoring of radiometric parameters at desert areas and field measurement. [**STAR**]

Developing Calibration Data Quality Monitoring Tools for GOES-R Advanced Baseline Imager (ABI) L1B in support of the Calibration Working Group: CICS scientists are developing calibration data quality monitoring tool to support Calibration and Validation work for GOES-R Advanced Baseline Imager (ABI) instrument, to facilitate the diagnosis of instrument problems, and to better serve the user community. [**STAR**]

Analyzing AVIRIS Data to Support GOES-R Calibration Working Group (CWG): A graduate student, Scott Ozog, from Department of Atmospheric and Oceanic Science of UMD is supported to develop tools to perform accurate retrieval of surface reflectance in AVIRIS scene and validation and calibration of the reflectance products with ground measurements. This supports the post-launch vicarious calibration of GOES-R ABI instrument. [**GOESPO**]

HIRS Calibration: Developing HIRS adjusted spectral response functions (ASRFs) for satellites NOAA 6, 7 and 8: Calibration methods such as double differencing, global mean and SNO are used process radiance data over land/ocean sites and those from GOES 6, to calculate inter-satellite bias for HIRS channel 4,5,7 of NOAA -6, -7,-8 and -9. [**STAR**]

NPP VIIRS Cal/Val Support at the University of Maryland: CICS scientists support calibration and validation work for NPP VIIRS instrument through developing routine SNO/lunar appearance/vicarious sites overpassing predictions web services, performing sensor data record verification, validation, and long-term performance monitoring with lunar, vicarious and deep convective cloud calibration. [**STAR**]

The Ozone Mapping and Profiler Suite Sensor Data Record Calibration and Validation: CICS Scientists: have developed new comprehensive data analysis algorithms to evaluate entire sensor orbital performance in accordance to the NASA newly established calibration measurement sequences. The algorithms have been used by me to have performed sensor end-to-end data analysis to evaluate sensor orbital performance and calibration results, as well as to validate SDR products. Sensor anomalies are identified based on my results and solutions were proposed. I presented a comprehensive sensor performance review to the JPSS program in SNPP Products Review on Dec. 19, 2014. [**STAR**]

Surface Observation Networks

Assessment of Global Oceanic Net Freshwater Flux Products Using Argo Salinity Observations: We attempted to evaluate ten E-P sets employing the ocean rain gauge as a valid reference. For the annual mean spatial distribution, the combination of E-P from OAFlux/TRMM has the best agreement with the indirect estimate of E-P according to their spatial pattern correlations and the RMSD. Thus, we recommend this combination for ocean modeling studies. The zonal averaged analysis indicates that direct estimate

products likely overestimate in their high value regions. This NSF-funded project was completed this year. [**NSF**]

Future Satellite Programs: GOES-R

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 for the last three years. These proving grounds allow forecasters and researchers the opportunity to evaluate new satellite technologies in every day operations. [**GOESPO** & **JPSSPO**]

Application of the GOES-R Land Surface Temperature Product for Snowmelt Mapping: A snowmelt detection technique for the future GOES-R ABI sensor has been developed using GOES-13 and VIIRS data as proxy. The NOAA's Snow Data Assimilation System (SNOWDAS) was used as reference to develop and test the algorithm. [**STAR**]

Science and Management Support for GOES-R ABI Land Surface Temperature Algorithm and Validation: We have developed a new validation tool for GOES-R LST product. It validates the ABI LST split-window retrieval algorithm with SURFRAD ground networks and multiple ABI proxy sensors. [**STAR**]

Land Surface Temperature Diurnal Analysis to Validate the Performance of GOES-R Advance Baseline Imager: : Two journal articles were published on angular anisotropy of satellite observed land surface temperature and a presentation was given at the NOAA 2013 Satellite Conference for Direct Readout, GOES/POES, and GOES-R/JPSS Users. [**STAR**]

Development of Algorithms for Shortwave Radiation Budget from GOES-R: This year's effort has focused on making refinements to the original delivery of the narrow-to-broadband (NTB) transformation coefficients used in the indirect path shortwave radiative flux algorithm. Additional simulations of radiative transfer based on the Atmospheric Infrared Sounder (AIRS) are being used to increase the robustness of cases used to calculate the coefficients. New spectral response functions for ABI are now available, and the coefficients are being reprocessed with these inputs as well. [**STAR**]

Future Satellite Programs: JPSS

Enhanced Agricultural Drought Monitoring Using NPP/JPSS Land EDRs for NIDIS: We have implemented data assimilation algorithms in NLDAS and GLDAS. We also generated long term data base of NLDAS/GLDAS climatology from 2002 to present, using the best available forcing data and best initialization. [**STAR**]

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: GEOG Task 3 Land Surface Type EDR: A whole year's VIIRS data (February 2012 to January 2013) were

gridded to create 32-day composites and annual metrics, which was used to produce the first VIIRS QST IP. [**STAR**]

NPP/VIIRS Land Product Validation Research and Algorithm Refinement: GEOG Task 4 Active Fire Ap-plication Related Product: We completed a MODIS-Collection 6 equivalent version of the VIIRS fire code. [**STAR**]

Improvement of ATMS Snowfall Rate Algorithm: A prototype ATMS Snowfall Rate algorithm has been developed in a JPSS Proving Ground (PG) and STAR End of Year (EOY) co-sponsored project. The focus of this project is to investigate the possibility to improve the assumptions in the algorithm about Ice Water Content based on better understanding of cloud physics and its relationships with the environmental conditions. [**STAR**]

Validation of Cryospheric EDRs from GCOM: 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. [**STAR**]

Extension of ATMS Snowfall Detection Algorithm to Colder Regions: AMSR2 for IMS V3 Snow Depth: A new statistical algorithm for detection of snowfall over land from ATMS has been developed. The new algorithm computes the probability of snowfall using logistic regression from principal components of high frequency brightness temperatures at 89 GHz and above. Evaluation of the algorithm shows significant skill in capturing snowfall in colder weather. The IMS V3 Blended Snow Depth Analysis is being transitioned to operations. Work is on-going to ingest AMSR2 snow depth into the analysis for blending microwave with in-situ snow depth. [**STAR**]

Technical Support of JPSS Land Surface Temperature and Albedo EDR Evaluation and Improvement: Our focus is on providing scientific and technical support on evaluation and improvement of VIIRS Land Surface Temperature and Albedo EDR product to meet the NPP/JPSS mission requirement. It is also a continuous effort toward the readiness of the LST/Albedo EDR product for future satellite after SNPP. [**NESDIS/OSD**]

CrIMSS Rain Flag: More extensive validation work has been carried out to confirm the improvement of the new algorithm. The offline rain flag system has been incorporated into the CrIMSS system by introducing fixed and climatological wind speed. [**STAR**]

Scientific Support for JPSS Instrument Calibration: CICS Scientist Hu Yang used the Backus-Gilbert (B-G) method as an optimal remapping algorithm, which converts ATMS observations at K, V and W bands from 5.2° and 2.2° FOV size to a consistent AMSU-A 3.3° FOV size. A physical model was developed for ATMS lunar contamination correction, this model has been implemented as operational algorithm of ATMS on-orbit calibration and shows a successful removal of all the lunar contamination on the earth-scene brightness temperature. CICS Scientist Slawomir Blonski has also conducted long-term testing of a new automated procedure for deriving radiometric calibration coefficients for the VIIRS

reflective solar bands. The tests not only helped in debugging the revised code, but also enabled improvements of processing coefficients contained in the lookup tables. [**STAR**]

Climate Research, Data Assimilation and Modeling

Support for Diagnostic, Monitoring and Forecast Activities at CPC: We developed and transitioned to operations several products as part of a new tool being used in real-time by forecasters of the Global Tropics Hazards and Benefits Outlook (GTH). We continued research on the physics of the MJO and the importance of air – sea coupling. We are evaluating links between climate and health and the capacity of models to predict hazardous atmospheric conditions at subseasonal lead times. [**CPC**]

Support for the 6th WMO International Symposium on Data Assimilation: In support of organization and hosting of the prestigious WMO Conference, we have successfully provided the Local Organizing Committee with the necessary access to UMD Conference and Visitor Services that NOAA does not have. [**CPC**]

Student Support for the NOAA Climate Prediction Center: This year, graduate student Katherine Lukens, under the advisement of Dr. E. Hugo Berbery, focused 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**]

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 have implemented a new ensemble-based formulation of forecast sensitivity to observation (EFSO) to a lower-resolution version of the operational hybrid GSI. We have found that the EFSO results are insensitive to the choice verification and evaluation lead-time. [**JPSSPO**]

Comparison of 4DVAR and LETKF in Assimilating JPSS-Derived Sea-Surface Temperature in the Chesapeake Bay Operational Forecasting System: We have configured and adapted 4D-Var data assimilation to the Chesapeake Bay Operational Forecasting System. Assimilation of daily composite AVHRR SST into CBOFS successfully lowers the model bias. [**STAR**]

Graduate Student Support: ENSO Representation In CMIP5 Models: We found that most CMIP5 models exhibit phenomena that resemble ENSO in their spatial and spectral signatures, with impressive consistency across ensemble members. There might also be an amplification of ENSO-related precipitation in the last century. [**STAR**]

Support for Community Radiative Transfer Model Development at the JCSDA: CICS scientists are supporting Community Radiative Transfer Model development at the Joint Center for Satellite Data Assimilation. CRTM is a core component of the satellite radiance assimilation system in supporting of daily weather forecasting and satellite product generations. [**JCSDA**]

Participation in Climate Research Activities at the Air Resources Laboratory NOAA: In 2013, the six CICS research scientists working with NOAA's ARL are made air quality measurements and forecasts to complement ongoing atmospheric chemistry studies at UMD: http://www.arl.noaa.gov/. [**ARL**]

Climate Data and Information Records/Scientific Data Stewardship

Support for the National Oceanographic Data Center: In 2013 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. [**NESDIS/NODC**]

Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record: NOAA/NCDC CDR Program has acquired the Initial Operational Capability (IOC) for HIRS OLR CDR Product and is moving toward Full Operational Capability (FOC), while CICS continues to take charge of maintaining science integrity and developing QA/QC system. We also started the development of the 1°x1° Daily HIRS OLR CDR product in response to the continued requests for an OLR CDR product with higher temporal and spatial resolution. http://www.ncdc.noaa.gov/cdr/operationalcdrs.html [**NCDC**]

The Development of AMSU Climate Data Records (CDR's) for Hydrological Applications: The inter-satellite calibration for AMSU-A window channels and for AMSU-B/MHS water vapor channels is nearly completed. [**STAR**]

Land and Hydrology

A GOES Thermal-Based Drought Early Warning Index for NIDIS and Dual Assimilation of Microwave and Thermal Infrared Satellite Observations of Soil Moisture into NLDAS for Improved Drought Monitoring: CICS scientist are developing a land data assimilation system using the NASA Land Information System (LIS) which assimilates soil moisture retrievals from a thermal infrared methodology (e.g., ALEXI) and from passive microwave sensors (e.g., AMSR-E; Windsat; AMSR2) to improve drought monitoring over the continental United States. [**STAR**]

Hydroclimatological Support for the Climate Prediction Center: CICS researcher evaluated the predictive skill of meteorological drought based on the North American Multi-Model Ensemble (NMME) forecasts and showed higher skill than that based on single-model forecasts. [**CPC**]

Improvements to the AMSR-E Rain Over Land Algorithm: A final version of GPROF2010V2 over land was completed, tested and delivered to the NASA/MSFC pro-

cessing center for AMSR-E. The entire record of AMSR-E is being reprocessed at MSFC using this vastly improved algorithm (including improvements over ocean developed by CIRA/Colorado State Univ.). [**STAR**]

Earth System Monitoring from Satellites

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 sensing data. [**STAR**]

Atmospheric Rivers Detection and Climatology: An approach to extract atmospheric river has been developed, and verified using topography, wind and extreme precipitation. A journal paper is in preparation. [**STAR**]

Eddies in Sea Level at High Latitude: This proposal explores the potential of a combined set of satellite altimeters (JASON2, ENVISAT, and CRY-OSAT2) to understand the variable circulation in this key region of the ocean and its contribution to the changing Arctic Ocean. [**STAR**]

Investigations over Arctic Sea Ice using Satellite and Aircraft Altimetry: We have assessed changes in Arctic sea ice thickness over the last five years (2009-13) and find the thickness of ice in the high, central Arctic has stabilized, after a precipitous decline in 2007-08. We have developed an algorithm to derive snow depth and uncertainty with respect to ice type, for application to airborne radar altimeter data. We are establishing new collaborations with members of the numerical modeling community to provide sea ice observations to help improve parameterizations of sea ice physical processes. See http://ibis.grdl.noaa.gov/SAT/SeaIce/index.php. [**STAR**]

Using Satellite Data to Improve Operational Atmospheric Constituents Forecasting Capabilities: We developed operational computer codes to produce a new global biomass burning emissions product. This product is called GBBEP-Geo-Leo, which blends polar orbiting and geostationary satellite data. The computer codes have been transferred to NOAA/NESDIS/OSPO. This operational product is expected to serve as a significant input to aerosol module (GFS-GOCART) in the next-generation operational weather forecasting system, National Environmental Modeling System (NEMS), for predicting global aerosols. [**STAR**]

Monitoring Land Surface Vegetation Phenology from VIIRS: We developed algorithm and operational computer codes to produce vegetation phenology from VIIRS data. An annual time series of VIIRS data (NDVI, EVI, and snow cover) in 2013 was investigated. Methods for smoothing annual time series of EVI were developed and tested. Algorithm for the detection of phenological metrics was further modified. [**STAR**]

National Climate Assessment

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. See http://tinyurl.com/melissakenney & http://orcid.org/0000-0002-2121-8135 [**CPO**]

National Climate Portal

CWRF Model Development for Climate Services: Regional Enhancement of ISI Products: We have developed a new CFS-CWRF real time seasonal forecast system. The products of the system showed substantial improvement over CPC' operational CFS especially for precipitation. [**ARL**].

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

Interpretation of Real-Time Weather and Climate Data for Spherical Displays: We create videos about climate science topics distributed to the Science On a Sphere network: 100 museums and visitor's centers around the world. Working closely with the Maryland Science Center and other SOS sites, we evaluate the effectiveness of these stories with the general public and tailor our products to engage people with a variety of backgrounds on many levels. [**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 Strategy: This task promotes the Cooperative Institute for Climate and Satellites (CICS-NC) to its stakeholders and advanced the National Climatic Data Center's strategic goals among its workforce. A strong communications plan was developed to reach out to CICS-NC audiences and potential partners. The approach was to understand what the key messages were and how they should be delivered by determining which channels should be used for the different audiences **[NCSU and NCDC].**

Information Technology Systems Improvement, Management, and Maintenance: CICS-NC 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

Activities in Advancing Climate Engagement, Outreach and Literacy 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 and other interdisciplinary stakeholder groups. Part-

nering with NCDC's Sectoral Engagement team, CICS-NC Outreach activities focus on user engagement workshops (called Climate Data and Applications Workshops) as well as the Executive Forum on Business and Climate, which targets business leaders from the industry. **[NCDC]**

Highlighting 150 Years of Weather Observations in Asheville: The Science House of NCSU provides K-12 educational outreach for climate and Earth System science in partnership with NOAA's NCDC and CICS-NC. The Science House is collaborating with NCDC on building curriculum and methodologies for using climate data in the classroom. **[NCDC]**

Climate Data and Information Records and Scientific Data Stewardship

Climate Data Record (CDR) Intergrated 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]**

Suomi-NPP 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]**

Optimum Interpolation Sea Surface Temperature (OISST) Transition to Operations: NCDC's Optimum Interpolation Sea Surface Temperature software was refactored in order to meet CDR Program requirements for operational readiness. **[NCDC]**

Suomi-NPP VIIRS Climate Raw Data Record System Infrastructure: The transition of the VIIRS Climate Raw Data Record into the NCDC operational environment was completed and helped define the processes for the NCDC 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]**

Validation of Land Surface Temperature (LST) from Suomi NPP VIIRS: The objective of this task is to provide the LST users community and the algorithm-working group (NOAA STAR) with uncertainty estimates associated with VIIRS LST standard products. **[NCDC/JPSSO]**

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. A comparison of the 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, by employing AVHRR channel 1 reflectance in the Pathfinder Atmospheres Extended (PATMOS-x) data and validating 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]**

Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES Data: The GSA algorithm was implemented as the U.S. contribution of an international collaboration between Europe, Japan, and the United States to produce a joint Climate Da-ta Record. **[NCDC]**

Uncertainty Quantification for Climate Data Records: Uncertainty quantification in climate research is a multidisciplinary area of increasing importance. Activity in this task has introduced CICS-NC as an entity in the mathematics/statistics for climate community network. Project topics researched by the group include: detection and attribution when comparing climate model output with observational data, uncertainty quantification for the global carbon cycle, and spatial statistics on distributed data. **[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:

CICS 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 new dataset. **[NCDC]**

Maintenance and Production of CDRs for Microwave Sounding Unit (MSU) and Advanced-MSU (AMSU) Atmospheric Temperatures and SSMIS Brightness Temperatures: MSU/AMSU brightness temperatures updated and transferred to CDR Archive at NCDC. SSM/I Version 7 brightness temperatures updated and transferred to CDR Archive at NCDC. **[NCDC]**

Evaluation and Characterization of Satellite Products: Evaluated the NOAA/NSIDC passive microwave sea ice concentration climate data record (CDR) and provided global characterization of decadal trends of sea ice extents in the Arctic and Antarctic Oceans. The NCDC blended sea surface winds product was also evaluated. **[NCDC]**

The Scope and Framework of Long-Term Scientific Stewardship for CDRs: For this task, the scope of long-term stewardship for NOAA digital climate environmental data products was drafted based on U.S. laws and expert bodies' recommendations and associated functional areas, and, a unified framework for assessing the vigor of stewardship practice applied to individual data product was defined. **[NCDC]**

Toward the Development of Climate Data Records for Precipitation: Characterization of CONUS Rainfall Using a Suite of Satellite, Radar, and Rain Gauge Quantitative Precipitation Estimates (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 in 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 examined the over-land rainfall contribution originating from tropical cyclones for basins around the world for the period 1998-2009. Using the global database International Best Track Archive for Climate Stewardship (IBTrACS) and satellite precipitation data from the TRMM Multi-satellite Precipitation Analysis (TMPA) product 3B42, the precipitation budget and extreme rainfall were determined for different tropical cyclone (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 (ZH), the differential reflectivity (ZDR), and the specific differential phase (KDP). **[NCDC]**

Role of Kelvin Waves in Tropical Cyclogenesis: Kelvin waves are among the most prominent sources of synoptic scale rainfall variability in the tropics, but their relationship with tropical cyclogenesis remains largely unknown. The relative impacts of convection and dynamical factors in these interactions are being quantified through a novel methodology. This project uses Kelvin-filtered NASA TRMM multisatellite rainfall estimates to identify which Kelvin wave phases produce the most tropical cyclones. **[NASA]**

Reanalyzing Tropical Cyclone 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 since launching in September 2012. Preliminary research has shown that these classifications can help address uncertainties in the historical record of these storms. **[NCDC, NCSU]**

Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks Climate Data Record (PERSIANN-CDR): For this project, a new precipitation data set at 0.25^{o} and daily spatio temporal resolutions was developed. This product named PERSIANN-CDR is generated from the PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) using 3-hourly GridSat-B1 data as input. The PERSIANN estimates are adjusted using the Global Precipitation Climatology Project (GPCP) monthly product to maintain consistency of two data sets at 2.5^{o} monthly scale throughout the entire reconstruction period. The product covers from 60^{o}S to 60^{o}N and 0° to 360° longitude from 1983 to 2012. **[NCDC]**

Reanalysis of Archived NEXRAD Data Using NMQ/Q2 Algorithms to Create a High-Resolution Precipitation Dataset for the Continental US: The project team has generated four years of a high-resolution gridded precipitation product for the entire continental US at CICS-NC, with an additional seven years being produced at the National Severe Storms Laboratory/CIMMS in Norman, OK. CICS-NC 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 Scientific Support Activities: The Technical Support Unit (TSU) Science Team made substantive contributions to the completion of the Third National Climate Assessment Report (NCA3). These included lead author revisions to the

draft report in response to public comments, two rounds of NRC panel review, and two rounds of government review. In addition, numerous graphics revisions and scientific analyses were performed to support revisions by a number of the other NCA3 authors. **[CPO]**

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. **[NCDC/CPO]**

National Climate Assessment Technical Support Unit (TSU) Program Support Activities: Implementing new production processes and maintaining a supportive workforce are ongoing priorities. Coordinating TSU/USGCRP activities, especially delivering the Draft National Climate Assessment for public and expert review were primary accomplishments of the TSU in 2013. **[CPO]**

Development of Geospatial Visualizations, Online resources, and Decision Support Tools for the National Climate Assessment: Staff from UNC Asheville's National Environmental Modeling and Analysis Center (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]**

National Climate Assessment Technical Support Unit (TSU): the following efforts contributed to the National Climate Assessment (NCA) efforts:

- *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 must be 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 Spring 2014.
- *Web Development*: 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*: CICS-NC staff provided editorial, production, and project management 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 10% 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 National Climate Assessment (NCA3) report, along with the compilation of associated metadata.
- *Science Editor/Publication Support*: CICS-NC staff provided editorial, graphics, and production support for NOAA's Technical Support Unit to the National Climate Assessment, making significant contributions to the development 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 US Climate Reference Network (USCRN) Soil Moisture and Temperature: This research is an analysis of USCRN soil observations for developing an under-standing 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/CPO]**

*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. In order to develop projects dealing with climate and health, Jesse Bell became a Guest Researcher in the Climate and Health Program (located in CDC's National Center for Environmental Health (NCEH)). His role is to serve as a conduit between NOAA's National Climatic Data Center and CDC's NCEH to assist CDC researchers in accessing climate data and better understanding ways of applying these data. **[NCDC]**

Climate Monitoring and Research Services to the Atmospheric Turbulence and Diffusion Division (ATDD) of NOAA's Air Resources Laboratory: Installed a USCRN site near Paxson, Alaska in August 2013. **[ATDD]**

Investigating the hydrological effects of Tropical Cyclones over the Carolinas from observational and modeling based perspectives: Five Tropical cyclones (Floyd 1999, Isabel

2003, Frances 2004, Alberto 2006, 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 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. Preliminary results indicate that evaporative losses had little impact on total precipitation. A website was developed to both improve 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 Program (COOP) Comparisons: This study compares USCRN and COOP temperature and precipitation measurements and attributes observational discrepancies to station architecture. 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: Sea Surface Temperature Analysis-ERSST: This project analyzed the parametric uncertainty quantification for monthly Extended Reconstructed Sea Surface Temperature (ERSST) version 4 (v4) by adopting a Monte Carlo ensemble approach. **[NCDC]**

Consortium Projects

Maps, Marshes, and Management Application: Ecological Effects of Sea-Level Rise in North Carolina: This project developed and implemented web-based geospatial decision support information for managing coastal marshes. Results from prior funded mapping

and modeling efforts have been assimilated on the new NC Coastal Atlas in collaboration with coastal resource management stakeholders. **[NOS]**

Radar-based SPI to Support NIDIS: This project group has transitioned an experimental high-resolution drought-monitoring product into an operational service now used routinely by authors and a contributor to the weekly US Drought Monitor. **[CPO]**

Programming and Applications Development for NOAA's Climate Services Portal: Staff from UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) assisted with the enhancement of data visualization capabilities with the Global Climate Dashboard, specifically with the development of Multigraph, the Climate Explorer prototype, and Data Snapshots. These new 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: The main objective of this study is to understand and quantify the potential impacts of near-term climate change and population growth on freshwater sustainability-defined here as integrating daily to annual flows required to minimize human vulnerability and maximize ecosystem needs (including native biodiversity) for freshwater-by explicitly incorporating the feedbacks from human-environmental systems on water supply and demand. Model simulations from the CMIP5 hindcast experiment were found to reproduce observed temperature trends for the southeast and southwest U.S. for the period 1981-2004. Precipitation trends for the southeast U.S. were simulated well also. However, the downward trend in precipitation for the southwest U.S. was not simulated well. **[NSF]**

Identifying Tropical Variability with CDRs: Climate Data Records are being leveraged to develop new diagnostics for tracking and predicting the Madden-Julian Oscillation (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 UMCP. 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 UMCP 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 Parmar 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.

CICS scientists' activities include mentoring at local elementary schools, serving either as guest or regular scientists to discuss weather and oceanography lessons, and using the Magic Planet (animated globe for environmental data display) spherical display. One scientist (Stephanie Scholaert-Uz of CICS-MD) supported building and maintaining the McKinley Elementary School rain garden, where she conducts semi-annual outdoor lessons with K-5 students. An honors student at the Montgomery County MD science and technology magnet high school completed a summer internship at CICS-MD and used the work accomplished as his senior thesis.

Opportunities exist to expand CICS-MD outreach to local high school students. For instance, Eleanor Roosevelt High School in Greenbelt, MD is home to Prince George County's science and technology magnet program. All students are required to complete a research project during his or her senior year. Students on the Physical Science track would be well suited to learn and make contributions to CICS projects. These students often have extensive math and computer science backgrounds, even compared to many undergraduates. The internship runs the length of the school year, and the students are expected to work approximately 15 hours per week culminating in a presentation and written report. Other departments in the University of Maryland system are already taking advantage of this potential partnership.

CICS partners with NOAA's NCDC and the NC State University Science House to provide K-12 educational outreach for climate and Earth system science. The Science House serves over 5,000 teachers and over 36,000 students annually from six offices spread across the state of North Carolina. The Science House leads teacher professional development sessions that focus on understanding the Earth System, the changing nature of the climate and its impacts, resource management, and sustainability. The Science House supports students and teachers by providing climate materials and teaching techniques, and by sharing cutting edge research from climate scientists. Laboratory equipment is loaned out to participating teachers at no cost. Students can use this equipment to collect local data, which can then be compared with various data from the National Climatic Data Center.

The Science House has engaged in two educational activities in partnerships with CICS-NC and NCDC. The first one is targeted at developing educational materials to enhance the exhibit *"Highlighting 150 Years of Weather Observations in Asheville"* at Asheville's Colburn Earth Science Museum. In a recent activity, CICS-NC's Jenny Dissen, NCDC's Greg Hammer and the Science House team developed an educational curriculum using NCDC's climate data, where a specific climate datasets (climate normals) were used for teaching exercises for teachers in Western North Carolina counties. Teachers use a pro-

tocol developed by NCDC, CICS-NC and the Science House, to access climatic data from NOAA in order to investigate microclimates using real-world data. This pilot effort to bring climate data to the classroom is planned to be available to all teachers across the U.S. through the NOAA website. Through this educational engagement, CICS hopes to increase their understanding of teachers' needs for climate information so they can effectively teach climate science to their students (Figure XX).

Group of CICS-NC scientist Jim Biard organized lead "Wave Day" an event designed to give 6th Grade students at Asheville Middle School a chance to learn about waves in various ways through direct hands-on experimentation. Seven unique wave examples stations were (with up to four instances of each station) set up around the Asheville Middle School auxiliary gym, and small groups (2-6) of children navigated through the stations, discovering learning experiments about transverse, latitude, water and other types of waves and physics principles (**Figure 4**).

Figure 4*: Students engaging in hands-on physics activity to learn about longitudinal and transverse waves at the Asheville Middle School, as part of the Wave Day, December 2013.*

Each summer since 2009, CICS member CUNY-CREST has organized a Weather Camp (partially funded by CICS) where 8-10 high school students spend one week on the campus of CCNY and 1 week at the NWS office on Long Island learning about weather concepts, operations, and future college and job careers in STEM fields (**Figure 5**).

Other activities in advancing literacy for K-12 audience includes giving presentations on climate science and change to the 8th grade students at Asheville Middle School, as well as to the local Boy Scouts Troop (Troop 8), where scouts learned information to achieve their Weather and Environmental Merit Badge. CICS-NC Scott Stevens served as an expert mentor to a group of 5th grade students at the local Isaac Dickson Elementary school tasked with a project on how they could help the community or the world; one student's project focused on climate change and collaborated with Scott Stevens for information.

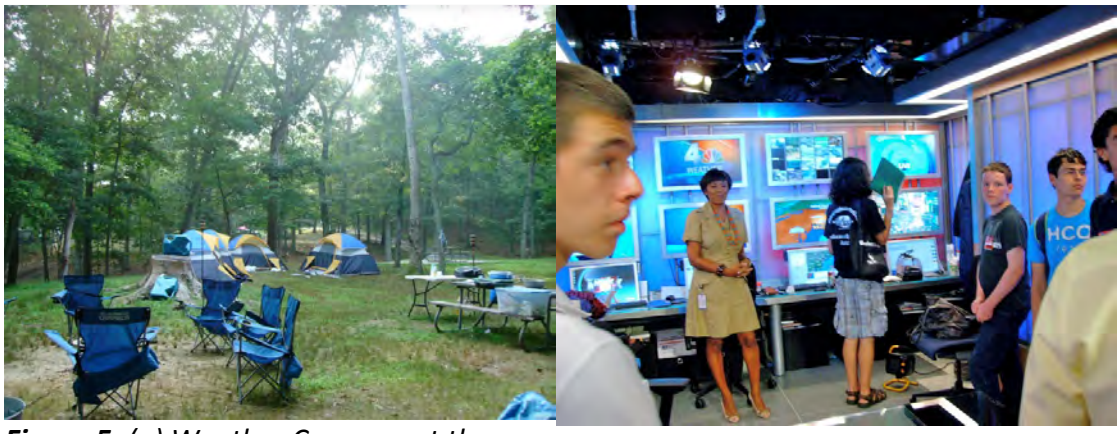

***Figure 5**: (a) Weather Campers at the Camp Site near NWS/Weather Forecast Office, Brookhaven National Lab region, Long Island, NY. (b) Place-based learning experience for the High School students at the Weather Forecast Office in NWS/WFO, Long Island, NY.*

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 train her 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 2013 CSI, and lessons learned will be applied to future summer initiatives.

Figure 7: *The CICS-MD Summer Initiative*

CICS-NC is closely linked to the North Carolina State University ‘s Marine Earth and Atmospheric Sciences department, as well as UNC Asheville Atmospheric Sciences and Applied Mathematics Department. CICS-NC has undergraduate student internship programs where total of five students from the UNC System have been engaged in supporting CICS staff since 2011 for various research activities.

An undergraduate student, Jennifer Meyer, from UNC Asheville Applied Mathematics Program received guidance and research advisory support from CICS scientist. Jennifer then later became an intern at CICS-NC. Under the guidance of CICS-NC Dr. Jessica Matthews, Jennifer Meyer, while an undergraduate in UNC-A's Applied Mathematics program, contributed to a CICS-NC research project using satellite-based vegetation time series data to derive the date of the onset of growing season. This was compared to ground-based temperature data to understand which of soil temperatures or air temperatures the growing season onset was more closely related. Jennifer applied the methodologies as developed by CICS-NC scientists Jessica Matthews and Jesse Bell. The results of this work are currently being compiled to submit as a manuscript in the peer-reviewed scientific literature.

Andrew Rogers, aspiring graduate student from UNC Charlotte, worked with CICS-NC and NCDC staff to further the development of the International Surface Temperature Initiative's (ISTI's) Global Land Surface Databank. Research included in depth analysis of a recently developed algorithm to merge temperature stations using advanced statisti-

cal measures. This also included classifying problematic stations and working on optimized solutions using both qualitative analysis and software development.

During summer of 2013, three students worked closely with Jenny Dissen, Ken Kunkel and Andrew Buddenburg on to analyze precipitation trends for southeastern (SE) states (South Carolina, Georgia, Alabama, Florida, Louisiana, and Mississippi) and analyze precipitation trends across various regions of Brazil using GHCN Daily and monthly datasets. Through this process, the interns learned the challenges of data management, climatology, and best practices uses by scientists to manage missing station data.

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 UMCP 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 climate 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 satel-

lite 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.

Outreach and Engagement with Private Sector through Interdisciplinary Activities

Improved understanding and communication of uses and applications of climate information is essential in building capacity for adaptation and resilience. As the understanding of climate risks grows for public and private companies, the dissemination of meaningful climate data becomes important for improved risk management practices. As a NOAA academic partner, we have been exploring ways to: 1) identify opportunities in the corporate value chain that can make best use of detailed climate data, and 2) deepen the scientific understanding of business processes and methodologies for using climate data in managing various business functions. This level of engagement occurs both through formal and informal mechanisms. Formal mechanisms include workshop series and forums, whereas informal mechanisms include one-on-one conversations and relationships with various industry and private sector companies.

In collaboration and partnership with NCDC's Climate Services and Monitoring Branch, Jenny Dissen has lead the development of an ongoing framework and approach for advancing climate data applications through a new activity called Climate Data and Applications Workshops (formerly referred to as Dataset Discovery Day). This two-day workshop allows NCDC staff to discuss their data products, CICS-NC staff to discuss research and application opportunities in various sectors, and users from public and private sector on applications and their requirements. In addition, the objectives are to discuss updates and trends in research of various data products, determine knowledge gaps, assess current and future uses and applications of the climate data, and build engagement with industry, academia, and solution providers interested in managing their risks, particularly with respect to climate adaptation.

Over the past year, CICS-NC, in collaboration with NCDC, held 2 workshops where the outcomes have resulted in new science research, new methodology for calculating the "Billion Dollar Disaster Chart," requirements for updating various data sets, feedback to NCDC, and opportunities for private sector for innovation:

- Frost and Freeze Data (March 20 – 21st, 2013)
- A Focus on Precipitation (December 3 - 4, 2013)

Information and presentations on these workshops can be found on the CICS-NC website: http://cicsnc.org/events.

Formally, CICS-NC has engaged with business leaders through a program called the Executive Forum on Business and Climate, a new and groundbreaking approach to bringing together academic researchers, business leaders and federal science experts to examine how recent weather and climate trends are impacting the industry, and how the information is used by business decision-makers in their strategy and operations. In 2013, CICS-NC led two forum discussions. The first focused on a 4-day sessions focused on the energy industry with keynote messages from U.S. Senator Kay Hagan and Southern Company President, CEO and Chairman Thomas Fanning. With nearly 35 participants ranging from CEO's to business leaders, scientists and CICS-NC academics, participants learned examples through case-based learning on how climate information is used today to establish competitive advantage and drive market behavior and decisions. More information and the summary report can found at: www.cicsnc.org/events/forum.

The second Executive Forum on Business and Climate was a 2-day knowledge exchange forum, co-convened by Climate and Energy Solutions (C2ES) and the Cooperative Institute for Climate and Satellites – North Carolina (CICS-NC), focused on climate-related risks and opportunities for private sector businesses and investments made today in business resilience by companies.

The Executive Forum on Business and Climate (**Figure 8**) took place on November 4 and 5, 2013 in Washington, DC. The event explored industry's needs related to climate data, information, and decision-support tools, as well as the avenues for engaging with government agencies such as NOAA's National Climatic Data Center. The workshop aimed to strengthen the relationship between business and industry leaders and NOAA's climate science team, identifying ways to access technical expertise. In total, the workshop hosted 44 attendees over the two-day period, including 21 representatives of private-sector organizations. Keynote messages were given by John Firth (CEO and Founder of Acclimatise), Jim Chelius (Engineering Director - Corporate Planning, American Water), Jeff Williams (Director, Climate Consulting, Entergy), Jeff Hopkins (Principal Adviser, International Energy and Climate Policy, Rio Tinto) and Thomas Karl (Director of NOAA's NCDC. More information and the summary report can found at: www.cicsnc.org/events/forum2.

***Figure 8**: Interactions between business leaders, government, scientists and members from C2ES at the recent Executive Forum on Business and Climate – Business Resilience, November 2013*

Informal mechanisms include conversations with various public and private companies in an effort to understand their vulnerability to changing climate and their climate information needs. CICS-NC has established a relationship with *Duke Energy* to help them understand the impacts of changing climate normals on their energy load forecast. This spurred a research activity in developing profiles of optimal climate normals for each climate division in North Carolina, which has enabled further dialogue with the company on impacts to their operational activities.

CICS-NC's Otis Brown and Jenny Dissen are currently engaging with Facebook, particularly the data center located in Forest City, North Carolina, on the development case study related to their experience of using NCDC climate data for the siting and operations of their data farm. Facebook uses an innovative evaporative cooling system instead of a chiller system, and often concerned with maintain certain temperature and humidity conditions to maintain an efficient and effective power utilization effectiveness ratio. The location in Forest City is deemed as one of the most energy efficient data centers in the world, which relies and depends on climate information. The case study intends to elaborate how the engineering and system designers use climate as a key decision driver in the siting and operations of this data center.

Engagement with Facebook has also led to collaborations with NC State Office and Isothermal Community College (ICC) to install and maintain a ECONet climate station in Rutherford County. CICS-NC Jenny Dissen is collaborating with ICC and NC State University to provide teacher training to find innovative ways to incorporate climate data into the community college curriculum.

CICS-NC is currently in collaborating with Google specifically their Earth Engine team, which brings together world's satellite imagery, including climate observations, to make it available as a useful took for scientists and researchers. Google Earth Engine has numerous opportunities in applications such as detecting deforestation, estimating biomass, etc. CICS-NC and the Earth Engine team are in the process of sharing the capabilities as a research opportunity for NCDC and other CICS scientists. Examples where Earth Engine has been useful includes providing cloud-free global landsat imagery in maps and in animations, forest extent and change, using MODIS data for NDVI, etc.

Informally, CICS-NC presents and leads various webinar sessions to advance access to climate data and information to different solutions providers and to associations, such as:

- Booz Allen Hamilton Climate Change Community of Practice
- Booz Allen Hamilton Sustainability Community of Practice
- StatWeather Energy Summit (Spring 2013, Fall 2013)
- Asheville Leadership
- Asheville HUB and Economic Development Coalition
- Air and Waste Management Association (Regulatory Update - George Regional Meeting)

- Air and Waste Management Association – Climate Change Conference
- Tokio Marine Technology Insurance Conference
- Fortune Brainstorm Green
- Facebook Data Center
- CDM Smith (Environmental Engineering Company) – Webinar
- Leadership Asheville Presentation

Engagement and Outreach to the General Public

Figure 9*: Images of Maryland Da*y

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 9**; 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.

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).

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 UMCP 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**: CICS-MD and CICS-NC Newsletter from Fall 2013*

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 (UMCP)
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 (UMCP)
AOT	Aerosol Optical Thickness
APSP	Aerosol Particle Size Parameter
AR5	Fifth Assessment Report (IPCC)
ARL	Air Resources Laboratory
ASTR	Department of Astronomy (UMCP)
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 (UMCP)
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
UMCP	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

Appendix 2: Personnel Statistics

CICS-MD

Category	Total	BS	MS	PhD
Research Scientist	64		24	40
Visiting Scientist	13			13
Postdoctoral Fellow	37			37
Research Support Staff	18	11		
Administrative	9	4	2	3
Total (> 50% support)	122	19	24	79
Undergraduate Students	7			
Graduate Students	11	11		
Employees that receive < 50% NOAA funding	19*	1	1	10
Located at NOAA facility (NCWCP, Silver Spring or NCDC)	63	1	12	50
Obtained NOAA employment within the last year	2			2

*7 are undergraduate research assistants

CICS-NC

Category	Total	AA or less	BS	MS	PhD
Research Scientist	7		2	2	3
Visiting Scientist	0				
Postdoctoral Fellow	1				
Research Support Staff	18	3	3	7	5
Administrative	3			2	1
Total (> 50% support)	**29**				
Undergraduate Students	**5**	4	1		
Graduate Students	0				
Employees that receive < 50% NOAA funding (not including students)	**2**			2	
TOTAL CICS-NC EMPLOYEES	**36**				
Located at NOAA facility (National Climatic Data Center)	33				
Obtained NOAA employment within the last year	4				