Trends

Cooperative Institute for Climate and Satellites–North Carolina
Inspire. Advance. Engage.
Fall 2015

Who We Are

Hosted by North Carolina State University, CICS-NC is a unique center of excellence showcasing a partnership between universities, the private sector, non-profit organizations, community groups, and the federal government. CICS-NC is a multidisciplinary team of experts who collaborate in climate and satellite research to support NOAA NCEI's "research to operations" strategy.

Our Vision

- CICS-NC ***inspires*** cutting-edge research and collaboration.
- CICS-NC ***advances*** NOAA's mission to understand and communicate the current and future state of the climate.
- CICS-NC ***engages*** with business, industry, academia, and the public to enhance decision making.

more info

Main Research Activities

Access and Services Development

Climate Assessments

Climate Data Records and Scientific Data Stewardship

Climate Literacy, Outreach, Engagement, and Communications

Surface Observing Networks

Workforce Development

Consortium Projects

Welcome to the Fall 2015 Trends! A lot has happened since our last issue. NOAA's National Climatic Data Center merged with NOAA's other data centers to form the National Centers for Environmental Information (NCEI), which provides a focal point for all of NOAA's archived environmental information, ranging from paleo to present, including the solid Earth, the oceans, and the atmosphere. The merger provides an Earth-based framework for public information dissemination and many new opportunities for NCEI's partners. See page 2 for more on this transition.

The Institute partnered with the UNC Center for Law, Environment, Adaptation, and Resources (CLEAR) to host our third Executive Forum on Business and Climate. This Forum, held March 19–20, focused on insurance climate information disclosure. It brought together industry, government regulators, academics, and stakeholders to discuss how to address impacts of change on the built infrastructure. I think everyone came away with new appreciation for the complexity of this challenge and new ideas on how to approach it.

We are also working with the American Association of State Climatologists (AASC) to host their new Executive Director in Asheville—Glenn Kerr is now in residence at the Institute. We worked with the Asheville Buncombe Economic Development Coalition (EDC) and the Asheville–Buncombe Sustainability Community Initiatives (ABSCI) to bring the AASC to Asheville and look forward to working with Glenn and his state partners. We are also a partner with ABSCI and others in the formation of a new downtown Asheville workspace called the Collider. The Collider will be a site for climate change discussions and business development and is expected to open in January 2016.

We recently completed an upgrade of our high-performance computing cluster, more than doubling its computing and storage capacities. A decade of NEXRAD observations have been reprocessed for NCEI using these resources. These new high-resolution precipitation and severe weather observations should be available to the public this fall through NCEI and several NOAA cooperative research and development (CRADA) partners (see "Big Data" on page 2). The data provide 5-minute, 1 km, research-quality maps for the continental U.S. for the first ten years of NOAA's National Weather Service NEXRAD observations.

The Institute's Technical Support Unit is finalizing a U.S. Global Change Research Program/ Environmental Protection Agency-led National Climate and Health Assessment, which is expected to be released next spring. This assessment documents connections between climate change and health in the United States.

We continue to aggressively push workforce development, including undergraduate, graduate, and post-doctoral training. Drs. Steve Stegall and Elsa Nickl are currently in residence working with Institute and NCEI mentors. Two Institute staff, Brooke Stewart and Sarah Champion, have started their Ph.D. programs at NC State. And we congratulate our undergraduate student employees Tiffany Maupin and Bobby Taylor, who have moved to working in industry, and Kelly Gassert, who is continuing her education. I would be remiss if I didn't note the scholarly productivity of the Institute's staff, who have published 27 peer-reviewed papers so far this year. It is a privilege to be associated with such a productive group.

Thank you for your interest in the Institute. We look forward to helping you and your stakeholders address the impacts of environmental change. Finally, we've redesigned our newsletter to more clearly reflect our identity as part of NC State University. Let us know what you think of our new look: info@cicsnc.org.

— Otis Brown, CICS-NC Director

Introducing NOAA's National Centers for Environmental Information

As you may know, our NOAA partner, the National Climatic Data Center (NCDC), recently merged with NOAA's two other data centers—the National Geophysical Data Center and the National Oceanographic Data Center (which included the National Coastal Data Development Center)—to form a new organization known as the National Centers for Environmental Information, or NCEI.

This consolidation is intended to help NOAA better meet the growing demand for environmental data and to enhance the value of NOAA's full suite of environmental data sets through more standardized data stewardship practices and coordination.

For the most part, this is an organizational change and does not involve physical relocations. NCEI headquarters are here in Asheville, NC, at the home of the former NCDC. In addition to Asheville, NCEI staff are located at the former homes of other data centers in Silver Spring, MD, Boulder, CO, and Stennis Space Center, MS, and at several other locations around the country. The new organization is led by Tom Karl, who was previously the director of NCDC. The existing center websites will remain active for some time, but are now also accessible through an umbrella NCEI website: https://www.ncei.noaa.gov/

What does this change mean for the Institute? The immediate impacts are fairly minimal. For a few of us, our desks moved into a new part of the building and some roles have changed slightly, but our mission and activities remain unchanged.

However, in the coming months and years, the transition to NCEI will present us with new opportunities to help understand, project, and communicate the state of the full Earth system, advance NOAA's data holdings and data stewardship practices, and improve our ability to engage with stakeholders—who can benefit from access to the expanded spectrum of climate, weather, space weather, geophysics, and coastal data available through NCEI.

Climate Literacy, Outreach, Engagement, and Communications

The Institute's scientists and our engagement team have been quite active in the past several months in an effort to advance our connection with the general public and across business, industry, and other organizations. Partnering with NCEI, our collective engagement activities build an improved understanding of our data and our research and expand awareness of how these resources can advance activities in climate adaptation and resilience among our various stakeholders.

In early August, Institute staff engaged with over 100 scientists and practitioners as part of the Climate Data Records Program meeting that highlighted the value, usefulness, and applications of satellite observations. Two of our scientists, Dr. Ken Kunkel and Jared Rennie, have developed an innovative "warming index" in collaboration with NBC Universal and UNC Chapel Hill. This index is designed to put the current state of the climate in context by providing comparisons to historical time periods, similar to the pollen index. We also partnered with the Brattle Group to do a presentation for the National Association of Regulatory Utility Commissioners and recently became members of Utility Analytics. Both activities are part of a broader effort to encourage the use and application of environmental information for the energy industry.

This spring, members of our engagement team were particularly active in supporting local and regional K–12 outreach at climate literacy events: WeatherFest at UNC Charlotte; the Entrepreneurship, Science, Technology, Engineering, Art, & Math (ESTEAM) Expo in Asheville; and several activities associated with the larger NC Science Festival, including the Mountain Science Expo at the NC Arboretum (which reached approximately 2,600 K–12 students, families, and area educators) and the Science and Technology Expo at Isothermal Community College. Staff involved in these educational outreach events included Jim Biard, Ronnie Leeper, Tom Maycock, Jared Rennie, Laura Stevens, Scott Stevens, and Theresa Stone.

Please visit our website under Events to learn more about upcoming engagement efforts.

Big Data — Pushing Climate Data to the Cloud

With more than 18 petabytes of data stored at NCEI alone, NOAA was doing "big data" long before that term became trendy. But in April of this year, NOAA (and the Institute) took a leap into the wider world of big data and cloud computing with the announcement of NOAA's Big Data Project. This project establishes a partnership between NOAA, Amazon Web Services, Google Cloud Platform, IBM, Microsoft, and the not-for-profit Open Cloud Consortium. The goals include providing the public and private sectors with unprecedented access to environmental data and positioning data in close proximity to cloud-based high-performance computing resources, which will expand opportunities for both research and economic development.

As part of this initiative, the entire Level 2 Next Generation Weather Radar (NEXRAD) archive from NOAA's NCEI is being copied to both the Amazon Web Services and Microsoft Azure platforms. Institute staff, including Scott Stevens, Jonathan Brannock, and Scott Wilkins, are providing scientific and technical expertise to facilitate the transfer, while the Institute's computing infrastructure serves as a crucial waystation between NCEI and the cloud. More than 135 terabytes of data have been transferred so far. Requests have already been made for many other NCEI datasets, and we expect that our role in connecting environmental data to the cloud will continue to expand.

Research Highlight: Extra-tropical Cyclones

By Paula Hennon

About a dozen times a year a classic Nor'easter storm comes along, resulting in rain or snow along the East Coast of the United States. Two or three times a year, the rain, snowfall, winds, and extreme weather conditions are quite impressive and lead to severe coastal erosion, power outages, flooding, or blizzard conditions. These Nor'easters, Alberta Clippers, Panhandle Hooks, and Gulf of Alaska Lows—named for the origin of their formation—are large-scale low-pressure storms that develop along frontal boundaries between air masses of contrasting temperatures in the mid- and high-latitudes. Big storms make headlines, but in fact about 40 of these extra-tropical cyclones are in existence during any 6-hour period worldwide. During colder times of the year, these cyclonic storms tend to be stronger and migrate closer to the equator, making them the main driver of mid-latitude storminess.

Sometimes the absence of these storms is newsworthy as well. Heat waves, droughts, and long severe winters often occur when a phenomenon known as a "blocking high" prevents the movement of extra-tropical cyclones into an area dominated by high surface pressure. Areas affected by the collision between an extra-tropical cyclone and a blocking high can experience stagnant weather patterns for several days or even weeks, with the stalled precipitation of the low pressure system vying for position with clear skies of the high-pressure region.

Understanding trends in the frequency and location of extra-tropical cyclones, and the blocking highs restricting their movement, increases society's ability to adapt and respond to potential shifts in these patterns with a future warming climate.

A number of recent studies focused on the Northern Hemisphere show a significant shift to the North of extra-tropical storm tracks in both the Pacific and Atlantic Ocean basins, fewer extra-tropical cyclones in the mid-latitudes, and an increase in extra-tropical cyclone activity toward the polar regions for the latter half of the 20th Century. Future climate warming may also lead to a decrease in polar low activity, leading to significant changes in weather patterns in the more populated mid-latitudes.

Previous work by Institute Senior Scientist Dr. Ken Kunkel and his science team examined trends in extra-tropical cyclone activity from 1871 to 2010 and indicated strong trends toward fewer storms in the Pacific Ocean and more activity in Europe, Asia, and all of the mid-latitude areas.

The availability of a new 20th Century Reanalysis data set offered the team the opportunity to test their hypothesis that, since 1871, extra-tropical cyclone activity has increased and the typical tracks of these storms have shifted southward toward the equator. Using monthly average atmospheric pressure fields to identify and follow storm tracks, the analysis attempts to reconcile the number and locations of storms. The reanalysis data set is comprised of 56 ensembles with, sometimes, considerable differences between members. The degree of agreement—or consensus—between the reanalysis members can be used to evaluate the uncertainty and variability in the number and locations of the storms. Various regions of study demonstrated differing results with regard to the trends in the numbers and locations of storms and the degree of uncertainty across time. For North America, a mid-latitude upward trend in storm occurrence from the early 20th Century to mid-century followed by a decline seems reliable, given that the surface pressure fields and the consensus storm tracks showed high agreement. High-latitude analyses over North America showing increases in activity in the late 19th Century followed by a decline in the early 20th Century should be viewed as uncertain however, because of lack of agreement in the pressure fields.

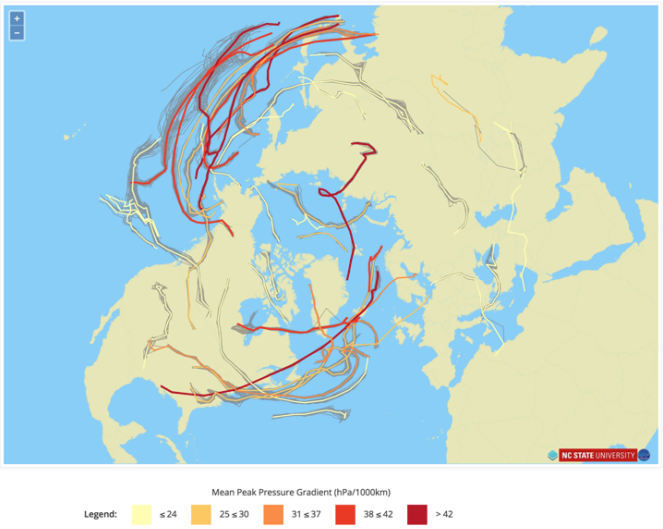

Figure: Consensus extra-tropical cyclone storm tracks from the surface pressure fields of the 20th Century Reanalysis analysis from March 1993 are shown in color. Disparity in the position of storm tracks amongst the 56 ensemble members indicating increased uncertainty shows in gray around the consensus tracks. The storm track for the 1993 "Storm of the Century," starting near the Gulf of Mexico and traveling the entire Eastern Seaboard into the Arctic (dark red), is particularly notable–there is little disagreement and therefore no uncertainty in the track and strength of this particular storm. The tool used to generate this plot will soon be available at www.cicsnc.org.

Given the varying regional results, conclusions about trends for the entire Northern Hemisphere can only be made for a shorter period, perhaps from around 1930 onward for the high latitudes and 1910 onward for the mid-latitudes. In this context, there appears to be a robust upward trend in extra-tropical cyclone numbers but little evidence for any shift in latitude. Trends in the number and location of blocking highs suggest a substantial downward trend from 1871 to the early part of the 20th Century. While it may be premature to dismiss a real downward trend, the high uncertainties in surface pressure may point to an artificial influence. Institute team member and NCSU PhD student Brooke Stewart is pursuing research on trends in these blocking highs and the associated effects of changes in their patterns on our climate.

Obs4MIPS: Connecting Models and Observations

By Jim Biard

The goal of the Observations for Model Intercomparison Projects (obs4MIPs) program is to provide a collection of well-established and documented datasets containing observational data in a form that makes it easy to compare with climate model outputs. This effort was initiated with support from the United States National Aeronautics and Space Administration and Department of Energy, and is overseen by the World Climate Research Program's Data Advisory Council.

A key part of the validation and assessment of any climate model is to start the model at some time in the past, run it up to the present day, and compare the model's outputs over that historical period with observations of the actual behavior of the Earth's climate. Most climate models produce their outputs to match the requirements of the 5th Coupled Model Intercomparison Project (CMIP5), so organizing observational data according to those same output requirements makes it much easier to compare observations with model outputs, using the same applications that are used to compare the outputs from different climate models. Each obs4MIPs dataset corresponds to a measurement field that is specified in the CMIP5 requirements.

The NOAA NCEI Climate Data Record Program is developing a suite of Climate Data Records (CDRs). Each CDR uses the netCDF-4 file format, conforms to the Climate & Forecast (CF) Metadata Conventions, and contains important climate-related measurements—many of which are global, over long time spans on the order of 30 years. Many of these measurements map directly to fields from the CMIP5 requirements, so they are good candidates for the obs4MIPs program.

A team here at the Institute has developed an application that will take a CDR dataset and repackage a measurement from it as an obs4MIPs dataset. The application is capable of doing temporal averaging of the input data, so both daily and monthly obs4MIPs datasets can be produced from a daily CDR. To date, we have produced daily and monthly obs4MIPs datasets for:

- Sea surface temperature from the daily Optimal Interpolation Sea Surface Temperature (OISST) CDR
- Outgoing Long-wave Radiation (OLR) from the High resolution Infrared Radiation Sounder (HIRS) OLR-Daily CDR
- Sea ice area fraction from the daily and monthly Sea Ice Concentration CDR

These data sets and additional information are available on the experimental obs4MIPS page on the CICS-NC website. We plan to produce additional data sets in the near future.

National Climate Assessment Update: Comparing CMIP5 and CMIP3

A new NOAA Technical Report entitled "Regional Surface Climate Conditions in CMIP3 and CMIP5 for the United States: Differences, Similarities, and Implications for the U.S. National Climate Assessment," compares simulations of historical and future U.S. climate produced by Phases 3 and 5 of the Coupled-Model Intercomparison Project (CMIP3 and CMIP5, respectively).

The report provides important insights into similarities and differences between the two generations of model simulations and underlying scenarios. It concludes that the differences between the two are generally very small, both in magnitude and in spatial distribution. Because many of the findings of the Third National Climate Assessment (NCA3) were based on CMIP3 simulations, the finding that CMIP5 simulations produce very similar results serves as further validation of the findings of NCA3.

Both sets of simulations indicate that future warming will increase temperatures well beyond the envelope of historical occurrences for the moderate to high emissions scenarios. Along with average temperatures, changes are also projected for a variety of climate extremes, including maximum temperatures, which are projected to increase. Most of the differences between the CMIP3 and CMIP5 projections are likely due to the fact that the CMIP5 scenarios cover a larger range of possible future greenhouse gas concentrations, resulting in a wider range of climate outcomes in the CMIP5 simulations.

In both sets of simulations, projections for precipitation changes indicate that the United States straddles the transition zone between wetter conditions across the north to drier conditions in the southwest in the winter and spring. Regional patterns of projected precipitation changes do vary somewhat between CMIP3 and CMIP5, reflecting both differences in scenarios and the fact that precipitation projections tend to vary more widely among different climate models.

The new report, which underwent extensive peer review, was authored by Liqiang Sun, Kenneth Kunkel, Laura Stevens, and Andrew Buddenberg of CICS-NC; J. Greg Dobson of the National Environmental Modeling and Analysis Center at the University of North Carolina–Asheville; and David Easterling of NOAA's NCEI.

The report serves as an update to the detailed CMIP3 simulations presented in an earlier set of NOAA Technical Reports produced by the many of the same authors. This new report, along with another produced by the NOAA CMIP5 Task Force, serves as an update to the earlier NOAA Technical Reports. These new reports should inform the science and projections in the next National Climate Assessment report.

Publications

This has been a productive year for research, with 27 peer-reviewed papers and reports published in the first three quarters of 2015 (some appeared online in late 2014). The topics reflect the full breadth of Institute activities, including satellite calibration/validation, temperature data, surface observation networks, climate dynamics, data stewardship, and modeling and assessment activities. Many of these have been highlighted in press releases and/or on the NCEI web site (links provided where available). Institute staff in **bold**.

Ashouri, H., K.-L. Hsu, **S. Sorooshian**, D. K. Braithwaite, K. R. Knapp, L. D. Cecil, B. R. Nelson, and **O. P. Prat**, 2015: PERSIANN-CDR: daily precipitation Climate Data Record from multi-satellite observations for hydrological and climate studies. *Bulletin of the American Meteorological Society*, **96,** 69-83. [paper] [CICS-NC Press Release]

Bilotta, R., **J. E. Bell**, E. Shepherd, and A. Arguez, 2015: Calculation and evaluation of an air-freezing index for the 1981–2010 climate normals period in the coterminous United States. *Journal of Applied Meteorology and Climatology*, **54,** 69-76. [paper] [CICS-NC Release] [NCEI Story]

Coopersmith, E. J., **J. E. Bell**, and M. H. Cosh, 2015: Extending the soil moisture data record of the U.S. Climate Reference Network (USCRN) and Soil Climate Analysis Network (SCAN). *Advances in Water Resources*, **79,** 80-90. [paper] [CICS-NC Press Release]

Frei, A., **K. E. Kunkel**, and A. Matonse, 2015: The seasonal nature of extreme hydrological events in the Northeastern United States. *Journal of Hydrometeorology*, **In press**. [paper]

Hennon, C. C., K. R. Knapp, **C. J. Schreck, III**, **S. E. Stevens**, J. P. Kossin, P. W. Thorne, **P. A. Hennon**, M. C. Kruk, **J. Rennie**, J.-M. Gadéa, M. Striegl, and I. Carley, 2015: Cyclone Center: Can citizen scientists improve tropical cyclone intensity records? *Bulletin of the American Meteorological Society*, 96, 591-607. [paper] [CICS-NC Press Release]

Huang, B., V. F. Banzon, E. Freeman, J. Lawrimore, **W. Liu**, T. C. Peterson, T. M. Smith, P. W. Thorne, S. D. Woodruff, and H.-M. Zhang, 2015: Extended Reconstructed Sea Surface Temperature Version 4 (ERSST.v4). Part I: Upgrades and intercomparisons. *J. of Climate*, **28,** 911-930. [paper]

Inamdar, A., and P. Guillevic, 2015: Net surface shortwave radiation from GOES imagery—product evaluation using ground-based measurements from SURFRAD. *Remote Sensing*, **7,** 10788. [paper]

Inamdar, A., and K. R. Knapp, 2015: Inter-comparison of independent calibration techniques applied to the visible channel of the ISCCP B1 data. *Journal of Atmospheric and Oceanic Sciences*, **32,** 1225-1240. [paper] [CICS-NC Press Release]

Jacobs, J., S. K. Moore, **K. E. Kunkel**, and **L. Sun**, 2015: A framework for examining climate-driven changes to the seasonality and geographical range of coastal pathogens and harmful algae. *Climate Risk Management*, **8,** 16-27. [paper]

Kibler, S. R., P. A. Tester, **K. E. Kunkel**, S. K. Moore, and R. W. Litaker, 2015: Effects of ocean warming on growth and distribution of dinoflagellates associated with ciguatera fish poisoning in the Caribbean. *Ecological Modelling*, **316,** 194-210. [paper]

Kilpatrick, K. A., G. Podestá, S. Walsh, E. Williams, V. Halliwell, M. Szczodrak, **O. B. Brown**, P. J. Minnett, and R. Evans, 2015: A decade of sea surface temperature from MODIS. *Remote Sensing of Environment*, **165,** 27-41. [paper] [CICS-NC Press Release]

Kossin, J. P., T. R. Knutson, K. A. Emanuel, T. R. Karl, **K. E. Kunkel**, and J. J. O'Brien, 2015: Reply to 'Comment on "Monitoring and Understanding Trends in Extreme Storms - State of Knowledge"'. *Bulletin of the American Meteorological Society*, **In press**. [paper]

Kunkel, K. E., R. Moss, and A. Parris, 2015: Innovations in science and scenarios for assessment. *Climatic Change*, **In press,** 1-14. [paper]

Kunkel, K. E., R. S. Vose, **L. E. Stevens**, and R. W. Knight, 2015: Is the monthly temperature climate of the United States becoming more extreme? *Geophysical Research Letters*, **42,** 2014GL062035. [paper] [CICS-NC Press Release]

Leeper, R. D., and J. Kochendorfer, 2015: Evaporation from weighing precipitation gauges: Impacts on automated gauge measurements and quality assurance methods. *Atmospheric Measurement Techniques*, **8,** 2291-2300. [paper]

Leeper, R. D., M. A. Palecki, and E. Davis, 2015: Methods to calculate precipitation from weighing bucket gauges with redundant depth measurements. *Journal of Atmospheric and Oceanic Technology*, **32,** 1179-1190. [paper] [NCEI Web Story]

Leeper, R. D., **J. Rennie**, and M. A. Palecki, 2015: Observational perspectives from U.S. Climate Reference Network (USCRN) and Cooperative Observer Program (COOP) Network: Temperature and precipitation comparison. *Journal of Atmos. and Oceanic Tech.*, **32,** 703-721. [paper]

Liu, W., B. Huang, P. W. Thorne, V. F. Banzon, H.-M. Zhang, E. Freeman, J. Lawrimore, T. C. Peterson, T. M. Smith, and S. D. Woodruff, 2015: Extended Reconstructed Sea Surface Temperature Version 4 (ERSST.v4): Part II. Parametric and Structural Uncertainty Estimations. *Journal of Climate*, **28,** 931-951. [paper]

Liu, W., Z. Liu, J. Cheng, and H. Hu, 2015: On the stability of the Atlantic meridional overturning circulation during the last deglaciation. *Climate Dynamics*, **44,** 1257-1275. [paper]

Miao, C., H. Ashouri, K.-L. Hsu, **S. Sorooshian**, and Q. Duan, 2015: Evaluation of the PERSIANN-CDR daily rainfall estimates in capturing the behavior of extreme precipitation events over China. *Journal of Hydrometeorology*. [paper]

Peng, G., J. L. Privette, E. J. Kearns, N. A. Ritchey, and S. Ansari, 2015: A unified framework for measuring stewardship practices applied to digital environmental datasets. *Data Science Journal*, **13**. [paper] [CICS-NC Press Release] [NCEI Web Story]

Prat, O. P., and B. R. Nelson, 2015: Evaluation of precipitation estimates over CONUS derived from satellite, radar, and rain gauge data sets at daily to annual scales (2002–2012). *Hydrology and Earth System Sciences*, **19,** 2037-2056. [paper]

Santer, B. D., S. Solomon, C. Bonfils, M. D. Zelinka, J. F. Painter, F. Beltran, J. C. Fyfe, G. Johannesson, **C. Mears**, D. A. Ridley, J.-P. Vernier, and F. J. Wentz, 2015: Observed multivariable signals of late 20th and early 21st century volcanic activity. *Geophysical Research Letters*, **42,** 500-509. [paper]

Schreck, C. J., III, 2015: Kelvin waves and tropical cyclogenesis: A global survey. *Monthly Weather Review*, **In press**. [paper]

Schreck, C. J., III, S. Bennett, J. M. Cordeira, J. Crouch, **J. Dissen**, A. L. Lang, D. Margolin, A. O'Shay, **J. Rennie**, and M. J. Ventrice, 2015: Natural gas prices and the extreme winters of 2011/12 and 2013/14: Causes, indicators, and interactions. *Bulletin of the American Meteorological Society*, **In press**. [paper] [NCEI Web Story]

Smith, A. B., and **J. L. Matthews**, 2015: Quantifying uncertainty and variable sensitivity within the US billion-dollar weather and climate disaster cost estimates. *Natural Hazards*, **77,** 1829-1851. [paper]

Sun, L., **K. E. Kunkel**, **L. E. Stevens**, **A. Buddenberg**, J. G. Dobson, and D. R. Easterling, 2015: Regional Surface Climate Conditions in CMIP3 and CMIP5 for the United States: Differences, Similarities, and Implications for the U.S. National Climate Assessment. NOAA Technical Report, NESDIS 144, 111 pp. [report]

Cooperative Institute for Climate and Satellites–North Carolina
NOAA's National Centers for Environmental Information
151 Patton Avenue Asheville, NC 28801 • USA

www.cicsnc.org
info@cicsnc.org

facebook.com/cicsnc
twitter.com/cicsnc