Great Lakes Integrated Sciences and Assessments Center

2015

Annual Report on the activities of the Great Lakes Integrated Sciences and Assessments Center (GLISA) covering the period of June 2014 – May 31, 2015.
Award Title: GREAT LAKES REGIONAL INTEGRATED SCIENCES AND ASSESSMENTS CENTER - NOAA-OAR-CPO-2010-2001720

Annual Report

GLISA
A NOAA RISA TEAM

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AWARD TITLE:

GREAT LAKES REGIONAL INTEGRATED SCIENCES AND ASSESSMENTS CENTER - NOAA-OAR-CPO-2010-2001720

PERFORMANCE PERIOD

June 1, 2014 – May 30, 2015

GLISA TEAM MEMBERS 2014 – 2015

Faculty
Thomas Dietz, Co-Director
Donald Scavia, Co-Director
Jeffrey Andresen
Maria Carmen Lemos
Kenneth Frank
Richard Rood

Staff
Elizabeth Gibbons
William Baule
Laura Briley
Daniel Brown

Graduate Student Support
Samantha Basile
Meghan Charters
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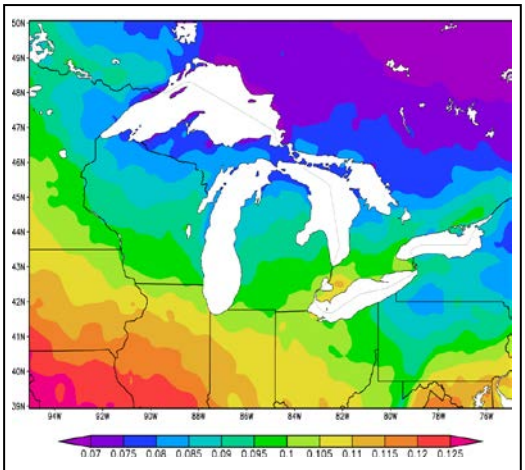
Omar Gates
Scott Kalafatis
Ian Robinson
Soner Yorgun

NEW AREAS OF FOCUS AND PARTNERSHIPS

Michigan Agribusiness Association – Team Lead: Jeffrey Andresen, William Baule
A new collaboration with the Michigan Agribusiness Association is aimed at strengthening the relationship between GLISA and the regional agricultural community as well as building a strong foundation for collaboration with the USDA Climate Hubs. The MABA represents a diverse group of businesses and associations related to regional agriculture but is also heavily engaged with farmers, so it provides a somewhat different connection with the industry e than groups such as Farm Bureau. Through this emerging partnership GLISA has developed new data information resources including updated localized climatologies, tailored for agricultural needs, and potential evapotranspiration (PET), which will be delivered to the agricultural community via the Michigan Agribusiness Association. PET describes the potential water demand by a vegetated surface under a given set of atmospheric conditions (typically an irrigated agricultural crop). This variable was chosen for a number of reasons, including its critical importance in agricultural water management as well as current major agronomic trends in the region towards the increasing use of field tile drainage and irrigation (both adaptive strategies to climate variability and change that require detailed water use information). Over the next several years we will continue to expand our work to increase public access to these resources and deliver an increasing number of useable climate information to the agricultural community. One unique aspect of the work the GLISA team is undertaking with MABA is an exploration of the impact of climate variability and



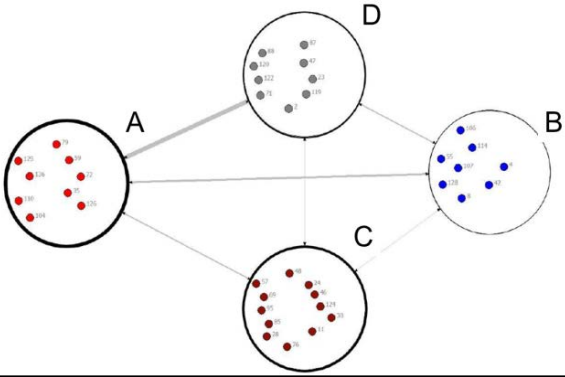
1983-1992 mean PET (mm/hr): Mean hourly references PET (Et_o, mm/hr) across the Great Lakes region, 1983-1992, generated as a part of the new GLISA regional agro-climatic models.

UNIVERSITY OF MICHIGAN
MICHIGAN STATE UNIVERSITY

change on nutrient run-off from agricultural landscapes with producers. Due to environmental impacts from nutrient loading in streams and lakes in the region, discussions about the issue of run-off are often driven by environmental concerns, rather than by the concerns facing the producers. For producers, increased run-off means lower nutrient content, crop yields, and economic returns, and depleted soil quality on agricultural lands. By partnering with MABA this relationship will provide an opportunity for our team to A) provide resources directed at the producer side of the agricultural community in terms of this nutrient and soil quality depletion and B) facilitate discussion and collaboration between the agricultural community and communities concerned with environmental impacts. The goal is that by working together with the producers to create resources aimed at helping them improve their production efficiency and reduce their enviromental impacts, we will build trust in that community and increase the collaboration space between both the practitioners and researchers, but also between the varied stakeholder groups.

Alliance for the Great Lakes – Expanding the Great Lakes Network Analysis – Team Lead: Kenneth Frank

Following the GLISA 2013 – 2014 Great Lakes Climate Assessments Award to The Alliance for the Great Lakes, an organization comprised of scientists, policy makers, businesses, and community members dedicated to the health of the Great Lakes, a strong relationship was formed between the Alliance and Frank's research team. This relationship has led to Frank working with the Alliance for the Great Lakes to develop, implement and begin analysis on their own network of stakeholders. This analysis is seeking to identify how network members access climate information and who within the network are information providers. This analysis marks the first time we have had the opportunity to see how the broader GLISA network analysis relates to a particular stakeholder group's network and from this analysis we can begin to see people who play key roles in both networks and how information passes from the regional network into this local, sector specific network.



The diagram shows that use of climate change in management is highest in subgroups A and C, and that there is a gap or structural hole in the network because B has relatively few interactions with those who most integrate information about climate change in their decisions.

These findings can, for example, be used by the leaders of the AGL to cultivate flows that will direct knowledge towards subgroup B by raising the awareness of network members of the structural gap, creating venues that increase the probability of interaction between members of

With this information, we developed a network analysis where each small dot represents a stakeholder and stakeholders are organized into subgroups based on application of Frank's (1995,1996) *KliqueFinder* algorithm; the algorithm insures a concentration of close colleagial ties within subgroups. The thickness of the line around each subgroup indicates the extent to which members of the subgroup use information about climate change in their management of storm water.

National and Regional Engagement with Native American Tribes – Team Lead: Kenneth Frank, Richard Rood, Thomas Dietz, Elizabeth Gibbons, and William Baule, Non-GLISA Partners: Kyle Powys Whyte, Frank Marsik

Partnerships between a number of GLISA team members and Native American tribes both regionally and nationally strengthened over the past year. We developed two strands of research. The first concerns the networks within Great Lakes tribes and how those relate to decision-making concerning natural resources. The second concerns the participation of Great Lakes tribal members in the national group Rising Voices, focusing on which actors become integrated into the national group and why.

Regional Engagement and Decision Support - GLISA staff provided opening remarks at the Shifting Seasons Summit. This event was designed to bring together tribal decision makers, federal agencies, indigenous practitioners, and climate change scientists to benefit both tribal and non-tribal decision making in the face of climate change for the Northeast Region. Participation in this event has led to collaborations with collaboration with The Nottawaseppi Huron Band of the Potawatomi to providing applied climate training to a summer intern working with the tribe identifying critical climate impacts and building educational programs for younger tribal members in the sciences. As the host institution, College of Menominee Nation Sustainable Development Institute, is a formal partner with the Northeast Climate Science Center, which also co-sponsored the Shifting Seasons Summit, GLISA staff had an opportunity to collaborate with NECSC scientists on presentations and continue to build the partnership between our climate programs.

National Network Analysis with Rising Voices and USGCRP - Coordination between Frank's team and Dr. Julie Muldano at USGCRP and Dr. Kyle Whyte at Michigan State University….the team will use participation in shifting seasons and other forms of contact and collaboration among the tribes and between the tribes and others to better understand how specific tribal members become integrated into the national organization and the roles they play within the national organization. Additionally, this engagement will track the flow of information and find strategies to aid in effective communication and sharing of perspectives and approaches across national networks.

GLISA co-investigator Richard Rood with working with an interdisciplinary team including Dr. Kyle Whyte and Dr. Frank Marsik is leading a team working with two tribes located in northern Michigan to identify how variable lake levels and related climate change impacts will affect the tribes.

Graduate and Undergraduate Student Applied Climate Engagement – Team Lead: Richard Rood, Donald Scavia, Elizabeth Gibbons, William Baule, Daniel Brown, Laura Briley
Under Richard Rood's leadership the Atmospheric Oceanic and Space Sciences Department at the University of Michigan's College of Engineering renewed its Applied Climate Master's Program this year. In addition to bringing increased publicity to the program through Open House events and an online promotional campaign, a Memorandum of Understanding was signed between the College of Engineering and the Graham Sustainability Institute. Donald Scavia is the Director of the Graham Institute and it is the administrative home for GLISA. Through this MOU, Applied Climate Master's students work with GLISA (and other Institute) staff to apply their technical training to real-world or client-driven research questions. In addition to the Master's students, undergraduates in the Climate-Impact Engineering program also participate in

projects to develop technical skills to address real-world research questions and applications. Examples of students' work from the past year include:

- Sustained assessment of the scientific knowledge of how Great Lake levels and lake ice will change
- Climatological descriptions of important weather and climate process such as freezing rain and freeze-thaw cycles
- Integration of lake and land observations into consistent datasets to study coupled processes

Improving data access and building management partnerships with the regional NOAA Partners: Great Lakes Observing System (GLOS) and NOAA's Great Lakes Environmental Research Laboratory (GLERL) – Team Lead: Richard Rood, Jeff Andresen, Elizabeth Gibbons, William Baule, Daniel Brown, Laura Briley
Through a small grant from GLOS the GLISA team, together with researchers from GLERL and Michigan Sea Grant are assembling a Great Lakes Adaptation Data Suite to improve access to adaptation related climate variables for regional researchers and decision makers. This project initially sought to access, analyze, and standardize available data sets from a variety of data providers to improve decision makers' access to useable information. However, through the partnership with GLERL, a high level of interest in the project from the physical science community was identified and the work is now expected to serve a broader audience and accomplish the dual purpose of easing researchers' time and effort when accessing and preparing data for analysis, as well as serving the originally envisioned end-users. Once the data-set is compiled, it will be shared via the GLOS data portal and made publicly available. The data set will be used to update future GLISA climatologies and serve as a source for other regional climate information providers, institutions or organizations that want to develop similar resources for their own communities.

Boundary Organization Work
Over this performance period, GLISA continued to foster its boundary organization approach to disseminating information into stakeholder knowledge networks across the Great Lakes region and through multiple sectors. GLISA's engagement with boundary organizations comes through our competitive grants program, this year $50,000 in funding was provided to four new partners (Emerging Action Awards) and $50,000 was provided to two partners continuing to build on past efforts (Sustained Assessments Awards). Activities related to our boundary work this year include starting a systematic evaluation of the effectiveness of our approach (under Maria Carmen Lemos supervision) and the publication of a Special Issue of the Journal Climate Risk Management focusing on GLISA's boundary chain approach (edited by Christine Kirchhoff, Scott Kalafatis and Maria Carmen Lemos (for more detail on both activities see p.xxx). In 2014, the following projects received awards:

Sustained Assessment Awards
A Climate Change Risks Assessment and Adaptation Strategy for York Region, Ontario, Harris Switzman, Ontario Climate Consortium/Toronto Regional Conservation Authority

By building on previous work on municipal climate risk and vulnerability assessment by the Ontario Climate Consortium in the Region of Peel for the 2012-2013 round of GLISA funding, this project is intended to advance the following three overall objectives: (1) develop greater awareness and recognition of the importance and nature of climate change risks, vulnerabilities

and need for adaptation among municipal staff and decision makers; (2) create greater capacity to conduct risk and vulnerability assessment and adaptation planning across municipal management and service areas; and (3) produce detailed information on one of the highest priority risks within York Region as an example, or template, for adaptation planning in York Region. The project will provide identification of municipal management and service area risks in York Region (climate hazards, impacts, and systems/components), a risk database populated with basic information on the management, service area risks, and trends on these risks, a refined protocol for York Region climate change risk analysis (suitable across Great Lakes), climate trends for variables to represent key hazards in York Region, and detailed characterization of the risks in municipal stormwater management.

Ready & Resilient: Climate Preparedness in Saint Paul, Minnesota, Roopali Phadke, and Macalester College
This project extends and deepens engagement with Saint Paul residents by focusing on two previously identified areas of need: more education and reinvigorated social networks. In addition to revising and updating the Ready & Resilient guide produced for the 2014 – 2015 Climate Assessment Award, a model "modern" climate disaster kit that participants can assemble at a community-wide training will be put together. Additionally, pilot projects will be created to select, support, and record the efficacy of ideas to address barriers faced by lower-income neighborhoods and communities of color.

Emerging Action Awards
On-Farm Water Recycling as an Adaptation Strategy for Drained Agricultural Land in the Western Lake Erie Basin, Dr. Jane Frankenberger, Purdue University
This project will evaluate the potential benefits of drainage water storage and recycling systems under future climate conditions by revisiting data from three wetland-reservoir-subirrigation systems constructed in the 1990s and monitored for 12 years. Benefits of the systems included yield increases due to subirrigation as well as reduced nutrient and sediment loads to receiving water. Both of these are expected to increase in future climate conditions. The project will also use future climate predictions to identify design and operational strategies that would be most beneficial in future systems. Opportunities and barriers to implementation will be investigated through engagement with drainage designers and installers and other key stakeholders in the region.

Implementing Forest and Water Climate Adaptation Solutions to Build the Resilience of Two Northwoods Communities, Deb Kleinman, Model Forest Policy Program
Can rural and tribal communities increase the adaptive capacity of their forests, waters, and livelihoods by communicating climate science and engaging a broader, regional network of stakeholders to implement a climate adaptation plan? This project will explore this question through building the resilience of two Northwood communities to climate change, helping them to transition from science-based planning to implementation. The Menominee Conservation District and the Red Lake Nation Band of the Chippewa Indians are the two groups involved, both of who depend directly on the benefits of the ecologically and economically valuable Northwood forests. The Model Forest Policy Program will support these communities in addressing their governance challenges, as well as adopting a regional, multi-sectoral approach to achieve more effective climate adaptation implementation.

Sensitive Sites and Infrastructure Protocol, Dave Ulrich, Great Lakes Saint Lawrence Cities Initiative
In response to the more frequent and intense weather around the Great Lakes region, the primary goal of this project is to help municipalities prepare for the next storm by understanding where their community's vulnerable infrastructure is and having a plan for emergency responders to identify and secure it. The secondary goal is to broadly disseminate the protocol and lessons learned from the pilot city so that more cities around and beyond the region can adopt the protocol and become better prepared. The Sensitive Sites and Infrastructure Protocol will outline how to identify and secure sensitive sites such as water and wastewater treatment plants and electricity transformers that are susceptible in extreme weather; this project will also provide guidance on what steps can be taken to secure this vulnerable infrastructure. The protocol will be tested in a Gary, Indiana city so that it can be refined and fine-tuned prior to broad dissemination.

Using Future Scenarios to Identify Potential Policies for Climate Change Adaptation along Lake Ontario, Katherine Bunting-Howarth, New York Sea Grant
This project will extend the results of a Lake Ontario scenario exercise completed in 2012 to assist the New York State Department of Conservation (NYSDEC) and its partners to update the Lake Ontario 2008 Lakewide Action and Management Plan (LaMP) while also providing similar information to inform local watershed plans. During a two-day workshop, diverse stakeholders utilizing the scenarios, accompanied with alternate extreme climate precipitation projections and potential impacts on water resources and habitats, will brainstorm how they might react to four sets of future changes. In the process, these stakeholders will discuss and determine what actions may be needed, the pros and cons of those actions and identify other needed data in order to assist the Lake Ontario basin to become more resilient to a changing climate. These results will be packaged for LaMP stakeholders and watershed planners to consider when writing and updating their documents.

KEY GLISA RESEARCH FINDINGS

Network analysis finding

Understanding network composition
National affiliation and local interactions seem to influence how network members interpret changes in lake levels, a key economic and ecological driver in the region. In this case, those network members who are Canadian tend to be more concerned about falling lake levels than network members in the United States. We also were able to examine connections between the network of scientists and policy makers who co-authored documents regarding climate change in the Great Lakes with the network of those who translate scientific work for the public. In particular, roughly 20 authors of the scientific and policy documents also appeared at events for those who translate science into policy. Furthermore, one translator then appeared in person to person networks of those who make on the ground decisions concerning ravine management, a critical ecological issue in part of the region (and who work with the Alliance for the Great Lakes). Thus we were able to link networks at three different levels: scientists/policy makers; translators; stakeholders/end users.

Uncertainty Lost

As discussions about projected lake levels move from primary source documents and articles to referenced peer reviewed articles and grey literature, some information on uncertainty about lake level projections had been lost. In at least three examples, papers or articles reference primary source documents which clearly state the uncertainty about lake levels, but do not carry the statement of uncertainty forward into the new document. For example, the document: From Impacts to Adaptation: Canada in a Changing Climate 2007 states "the increase in evaporation caused by high temperatures is expected to lead to an overall decrease in Great Lakes water levels" (page 9). It then cites Mortsch et al., 2000; Cohen & Mill, 2001; Lofgren et al., 2002; Kling et al., 2003). Most of these cited studies were out of the same lab, which emphasized uncertainty, however that uncertainty was not communicated in the Impacts to Adaptation paper. For example. Lofgren 2002 indicates that one set of models predict increases in lake levels while another set predict decreases.

The role of networks in adaptation

A question emerging from our network analysis work (Frank et al. 2012) is how networks actually influence information use. To shed light on this question, we updated our database of co-produced climate change science/policy documents in the region and mapped a Great Lakes region network of co-authors and event participants. We also reviewed the career history of each of the network participants and determined what scale their work focused on (i.e. local, state, Great Lakes region, other multi-state region, national, or international). This revealed that the regional network was composed of regional-scale participants surrounded by more dispersed specialized and local work towards the outer edges of the network. Twenty interviews with those working for key organizations around a particularly important issue in the Great Lakes region - water quality - provided insight on the significance of this structure. The interviews implied that overlaps between these scales generated more usable knowledge as potential users formed their own specialized networks that operated as communities of practice tailoring regional discussions about climate change to match particular application needs. We published this work in Global Environmental Change (Kalafatis et al. 2015), arguing that such feedbacks across scales offer opportunities to "scale-up" the development of usable climate information. For more information on these findings, refer to the paper below:

- Kalafatis, S. E., M. C. Lemos, Y.-J. Lo and K. A. Frank (2015). "Increasing information usability for climate adaptation: The role of knowledge networks and communities of practice." Global Environmental Change 32: 30-39.

Application of historical data

Through employing the boundary chain model to partner with organization throughout the region and integrating climate information into their work we continue to engage successfully with stakeholders seeking to integrate climate information in their decision-making. Integrating information requires a combined application of locally relevant historic climate information, along with regionally relevant future climate projections. We explain this process as asking, "what has happened"; "what will happen;" and "what is the impact." Introducing the idea of climate change by looking at historic information (we typically compare two past climate-normal periods of 1950 – 1980 versus 1980 – 2010) we can make the argument that climate change is already occurring and allow partners to apply this quantitative data to their own qualitative

experiences. By building an understanding and acceptance of the lack of stationarity in the system our partners are more willing to look at projected future change as a likely path.

Understanding and enhancing the boundary chain approach

We proposed an analytical framework to identify drives and constraints for boundary chains success and shortcomings based both on the level of complementarity between the boundary chains links and on their level of embeddedness. Our main hypothesis was that chains with higher levels of embeddedness and complementarity were more likely to create synergies between the links and potential increase the usability of climate information among chain participants. The framework served as basis for a series on in-depth case study analysis of past funded chains reported in the Climate Risk Management (CRM) Special Issue. Among our findings are:

- In an evaluation of GLISA's partnership with the Huron River Watershed Council we found that the boundary chain partnership between the two organizations: 1) sped up the co-production process by increasing climate information usability for a variety of users over a short period of time, 2) improved climate information dissemination by users within user networks and improving climate literacy (of users) and resilience (in the watershed) without requiring additional organizational effort from either boundary organization, and 3) created climate brokers within the chain who took the lead in identifying new audiences and introducing them to customized, relevant climate science.
- In a case study of GLISA's work with the Great Lakes Adaptation Assessment for Cities (GLAA-C) in the City of Toledo, we found that those in the City were able to leverage relationships with GLISA and GLAA-C to build a regional network in their greater metropolitan area. Importantly, this network was robust enough to withstand the loss of key players in the city and political turnovers.
- The Alaska Center for Climate Assessment and Policy (ACCAP) used boundary chains as a means to enhance their remote outreach to geographically dispersed and often difficult-to-reach communities (Kettle and Trainor 2015). Through partnering with other boundary organizations to host webinars that were actually embedded in particular communities, ACCAP found that they could enhance the impact of their remote engagement.
- The California Ocean Science Trust developed a set of linked, key, and networked chains that served different goals in their effort to manage the West Coast Ocean Acidification and Hypoxia Science Panel (Meyer et al. 2015). In this case, boundary chains could be used for purposes other than improving efficiency. While the development of chains enhanced information usability through the cultivation of complementary relationships, they also led to more interactions. The authors concluded that the chains were effective but needed to be pursued judiciously.

Climate Model Structure and Spatial Distribution of Precipitation.

A persistent deficiency of climate models is their ability to organize precipitation in spatial and temporal patterns that have the same characteristics as observed. For example in the continental United States east of the Rockies, summertime precipitation is organized in spatial scales greater than 200 km X 200 km that persist for several hours. The complexes of convective storms

propagate as coherent structures. Climate models generally do not represent summertime precipitation as such coherent structures. Rather the storms are more random, popping up and disappearing. Similar spatial-temporal biases are observed in behavior of precipitation in areas of topographical relief and near shorelines. Though the climate models might provide a sufficient representation of average conditions, this inability to represent the weather-scale behavior of precipitation limits the direct application of model projections in local or regional planning.

As part of his doctoral research, funded in part by GLISA, Soner Yorgun investigated the relationship of patterns of precipitation to the structure of climate models. Specifically, Dr. Yorgun investigated the sensitivity of precipitation to the numerical method chosen to represent the physics of atmospheric flow and transport. In idealized numerical experiments Yorgun identified strong sensitivity to the numerical method. If precipitation is qualitatively classified as large-scale (1000 km), middle-scale (100s km), and small-scale (10s of km, grid size), then both the amount and variability in the classifications are sensitive to the numerical method. Numerical methods that are mathematically accurate because they use non-local information (spectral methods) are less able to organize the precipitation in realistic patterns than schemes limited to local information (finite-volume methods). This is a novel study showing a cause and effect relationship between decisions on how to represent fluid flow and the model representation of local physical processes. Current work includes determining whether or not these relationships manifest in climate simulations used for climate-change planning.
See the two peer review papers by Yorgun and Rood, included in the publications section for more details:

- "An Object-Based Approach for Quantification of GCM Biases of the Simulation of Orographic Precipitation. Part II: Quantitative Analysis," Yorgun, M. S., and Rood, R. B., J. Climate, 28, 4863-4876, 2015.
- "An Object-Based Approach for Quantification of GCM Biases of the Simulation of Orographic Precipitation. Part I: Idealized Simulations," Yorgun, M. S., and Rood, R. B., J. Climate, 27, 9139-9154, http://dx.doi.org/10.1175/JCLI-D-14-00051.1, 2014.

OUTREACH ACTIVITIES FROM THE PAST YEAR

Shifting Seasons Conference

In October 2015 GLISA staff participated as opening speakers at the Shifting Seasons Summit. As described above, the Summit was designed to bring together tribal decision makers, federal agencies, indigenous practitioners, and climate change scientists to benefit both tribal and non-tribal decision making in the face of climate change for the Northeast Region. The presentations from GLISA provided a Great Lakes relevant discussion of climate change and risks and opportunities and approaches to adaptation at the local to regional scales. This targeted presentation complemented a presentation by staff from the Northeast Climate Science Center which provided a broad overview of climate change across the country. This event provided an opportunity for tribal members and representatives to understand how GLISA could offer a local interpretation of national trends and has led to two new relationships with tribes in the region. The event drew 153 participants from 13 tribes and tribal nations, in addition to United States federal agencies, and states government representatives.

Interagency Engagement

National Park Service
Through joint funding from the National Park Service and NOAA, GLISA faculty and staff assisted with the organization, resource development, and information delivery for a scenario planning workshop with staff from the Apostle Islands National Park. Prior to the workshop GLISA staff coordinated with NPS and Apostle Island staff to develop multiple scenarios for discussion and planning use during the meeting. The two-day workshop drew 33 participants and featured presentations from GLISA Faculty member Richard Rood and GLISA staff member William Baule. Additionally, GLISA Co-Director Maria Carmen Lemos and graduate researcher Scott Kalafatis participated in the workshop.

Resilient Michigan – Department of Defense Pilot Project
The Michigan Army National Guard has been selected by the Department of Defense to participate in a pilot program to develop adaptation planning programs which will provide an example for the rest of the military installations throughout the country. GLISA has been a key member in this pilot project from the initial briefing between Pentagon officials and Michigan National Guard leadership, participating in a series of three meetings to date which have sought to bring together representatives from the three army National Guard installations in Michigan and their surrounding communities to discuss climate change impacts and adaptation.

Social Media and Online Engagements
GLISA team members are increasingly using social media and other online engagements to reach a broad national audience. Through GLISA's social media campaigns the program now has over 250 followers on Twitter and over 350 'likes' via Facebook. Additionally, the regular GLISA newsletter sees a consistent 'open-rate' of over 40%, far exceeding the industry standard of approximately 25%.

Two members of the GLISA team have also found tremendous success in providing pieces to the online blog, "The Conversation". The Conversation is completely open access and provides a forum for academics to provide expert analysis and opinion on pressing issues in range of topics. To-date Richard Rood has had two pieces published in The Conversation and his pieces have had 758,637 readers. Donald Scavia has also contributed a piece to The Conversation and saw a total readership of 5837 for his piece.

In support of the successful launch of the NOAA administered, U.S. Climate Resilience Toolkit, GLISA provided content for three cases studies addressing water resources in the Great Lakes region and has shared meta-data and descriptions for our two online decision support tools, the Cities Impacts and Adaptation Tool and Great Lakes Atlas.

National Climate Assessment Midwest Roll-Out
In June 2014, GLISA co-hosted the National Climate Assessment Midwest Roll-Out event. Through collaboration with USGCRP the event featured presentations from Kathy Jacobs and Emily Cloyd, as well as University of Michigan NCA chapter authors, GLISA Co-Director Donald Scavia, Rosina Bierbaum, and Marie O'Neill. Hosting this event was another opportunity to play a role in the development and release of the Third National Climate Assessment. The

event drew approximately 200 participants and was the kick-off event to the 2014 Great Lakes Climate Adaptation Conference.

KEY GLISA TEAM PUBLICATIONS FROM THE PAST YEAR

Peer Reviewed Publications

- M. Soner Yorgun and Richard B. Rood, 2014: An Object-Based Approach for Quantification of GCM Biases of the Simulation of Orographic Precipitation. Part I: Idealized Simulations. *J. Climate*, **27**, 9139–9154.
- doi: http://dx.doi.org/10.1175/JCLI-D-14-00051.1

- M. Soner Yorgun and Richard B. Rood, 2015: An Object-Based Approach for Quantification of GCM Biases of the Simulation of Orographic Precipitation. Part II: Quantitative Analysis. *J. Climate*, **28**, 4863–4876.
- doi: http://dx.doi.org/10.1175/JCLI-D-14-00730.1

- Lemos, M. C. (2015). Usable climate knowledge for adaptive and co-managed water governance. Current Opinion in Environmental Sustainability, 12: 48-52.

- Kalafatis, S. E., M. C. Lemos, Y.-J. Lo and K. A. Frank (2015). "Increasing information usability for climate adaptation: The role of knowledge networks and communities of practice." Global Environmental Change 32: 30-39.

- Dilling, L; Lackstrom, K; Haywood, B; Dow, K; Lemos, MC; Berggren, J.; Kalafatis, SE. (2015) "What Stakeholder Needs Tell Us about Enabling Adaptive Capacity: The Intersection of Context and Information Provision across Regions in the United States" Weather, Climate and Society 7(1) p.5-17

- Marquart-Pyatt, Sandra T, Aaron M McCright, Thomas Dietz, and Riley E Dunlap. 2014. "Politics Eclipses Climate Extremes for Climate Change Perceptions." Global Environmental Change 29:246-257.

- Bartolai, A.M., et al., Climate change as a driver of change in the Great Lakes St. Lawrence River Basin, J Great Lakes Res (2015), http://dx.doi.org/10.1016/j.jglr.2014.11.012

Climate Risk Management Special Issue
Maria Carmen Lemos, Christine Kirchoff (former PhD student with Lemos) and Scott Kalafatis led the development of a special issue for the journal Climate Risk Management (peer-reviewed and open-access) that includes GLISA and its boundary chain partnerships at the core of five papers. The special issue puts GLISA's work in conversation with papers discussing similar outreach efforts made by the California Ocean Science Trust and the Alaska Center for Climate Assessment and Policy.

Special Issue Papers:

- Briley, L.; Brown, D.; Kalafatis, S.E. (2015) "Overcoming barriers during the co-production of climate information for decision-making." Climate Risk Management (in press) http://www.sciencedirect.com/science/article/pii/S2212096315000157
- Kalafatis, S.E.; Grace, A.; Gibbons, E. (2015) "Making Climate Science Accessible in Toledo: The Linked Boundary Chain Approach." Climate Risk Management (in press) http://www.sciencedirect.com/science/article/pii/S2212096315000145
- Kettle, N.; Trainor, S. (2015) "The role of climate webinars in supporting boundary chain networks across Alaska." Climate Risk Management (in press)
- Kirchhoff, C.J.; Esselman, R.; Brown, D. (2015) "Boundary organizations to boundary chains: Prospects for Advancing Climate Science Application." Climate Risk Management (in press) http://www.sciencedirect.com/science/article/pii/S2212096315000121
- Kirchhoff, C.J.; Lemos, M.C.; Kalafatis, S.E. (2015) "Creating synergy with boundary chains: Can they improve usability of climate information?" Climate Risk Management (in press)
- Kirchhoff, C.J.; Lemos, M.C.; Kalafatis, S.E. (2015) "Narrowing the gap between climate science and adaptation action: the role of Boundary Chains." Climate Risk Management (in press)
- Meyer, R.; McAfee, S.; Whiteman, E. (2015) "How California is mobilizing boundary chains to integrate science, policy and management for changing ocean chemistry." http://www. Climate Risk Management (in press) sciencedirect.com/science/article/pii/S2212096315000133
- Phadke, R.; Manning, C.; Burlager, S. (2015) "Making it Personal: Diversity and Deliberation in Climate Adaptation Planning." Climate Risk Management (in press)

EMERGING TOOLS, RESOURCES, POLICIES AND PRODUCTS RESULTING FROM GLISA WORK

Huron River Watershed Council (HRWC) Stormwater Management Policy Impact
The Water Resources Commissioners Office in Washtenaw County, Michigan revised their stormwater rules to require additional onsite infiltration of stormwater. Two other counties are considering similar revisions. HRWC has been a climate assessment grant recipient and partner with GLISA since 2011. As a part of their GLISA-supported efforts, HRWC convened workgroups on stormwater, hazard mitigation, and in-stream flows. Vulnerabilities in stormwater management were identified based on input from community experts and GLISA's analysis of heavy precipitation trends for the watershed. The stormwater rules were updated to address these vulnerabilities and help prepare for future changes in precipitation.

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Decision Support Tools and Problem Solving Platforms Launched and Updated

Decision Support Tools
GLISA provided climate data and analysis central to the Cities Impact and Adaptation Tool (CIAT). The CIAT was developed to help municipal decision makers identify and engage communities that are already facing the climate impacts projected for their own city. The CIAT includes historical and projected climate information along with a database of over 500 climate adaptation strategies. Another decision support tool that GLISA staff and faculty advised, the Great Lakes Atlas has received an update and now includes information on infrastructure spending and conditions updated through 2012. The Great Lakes Atlas combines climate data with economic, social, and infrastructure information to frame how climate change impacts effect these three areas of concern. The Climate Resilient Toolkit includes the meta-data for both the Cities Impacts and Adaptation Tool and Great Lakes Atlas.

Problem Solving Environments
The Climate Workspace has been utilized, tested, and further developed this past year. The Apostle Island climate adaptation work was able to leverage the resources and expertise of the previous Isle Royale project in the Workspace and therefore more quickly advance their own adaptation efforts. Usability aspects of the Workspace were evaluated by a team of specialists with recommendations for future improvements which are now underway. In addition, the Workspace is being prepped for its first official release with the intent of adoption by other climate adaptation communities and further development by web experts.

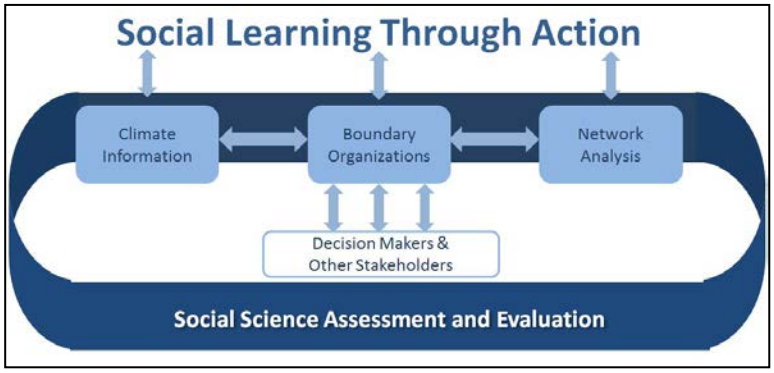
Expanded Clean Marina Program (Climate Change Module)
In 2013, GLISA awarded a Climate Assessment Grant to Michigan Sea Grant in support of the Clean Marina Program. At the end of the project period, outcomes included a suite a resources for harbor and marina operators addressing climate impacts and adaptation strategies in the region. Since the project concluded Sea Grant has continued to expand and enhance the Climate Module of the Clean Marina's Program. The Clean Marina Program is a well-respected training program that harbor and marina operators can participate in to earn the 'Clean Marina' Status. The program is a collaboration between Sea Grant programs in Ohio, Michigan, and Minnesota. Inclusion of a climate resilience module in the Clean Marina program will insure information on impacts and adaptation strategies is reaching a broad audience across the region. Additionally, project staff will be presenting the module at the National Working Waterfronts and Waterways Symposium in November.

State of Michigan Building Resilience Against Climate Effects (BRACE) Pilot Program Report Completed
The **Michigan** Department of Health and Human Services completed the report, Climate and Health Profile Report 2015. This report marks the completion of Phase I of the Center for Disease Control's BRACE pilot program in Michigan. This report, which included input from the GLISA team, identifies five areas of increased health concerns due to climate change impacts. The report was co-released by Michigan Department of Health and Human Services and GLISA. The impacts identified in the report are included below:

1. Respiratory Diseases: Overall, projected conditions favor increased air pollution and worsening respiratory disease. Climate projections also favor earlier and longer growth period for plants indicating increased pollen levels, which could increase allergies and exacerbate symptoms including asthma.
2. Heat Illness: Air mass stagnation events may increase in frequency if high humidity occurs with high temperature and low winds, leading to increased heat stress-related morbidity and mortality. Projected increasing numbers of high heat days by mid-century suggest there will likely be large direct impacts on human health, especially if occurring simultaneously with other variables such as urban heat island effect.
3. Water-borne Diseases: In general, climate conditions leading to flooding will be the same or more intense in the future. This leaves areas vulnerable to sewage/septic failures and runoff at an increased risk for waterborne diseases and in certain areas, development of harmful algal blooms.
4. Vector-borne Diseases: Projections point to warmer winters, earlier springs, and warmer summers, conditions suitable for West Nile Virus and its mosquito vector. Similarly, current and future conditions are suitable for Lyme disease and its tick vector although there is greater difficulty in projecting the burden based on the complex sequence of climate conditions and the tick's life cycle needs.
5. Injury and CO Poisoning: Extreme weather events conducive to power outages are projected to increase, especially in winter, leading to increased use of generators and thus increased risk of CO poisoning. Clean up after an event utilizing power washers may also increase risk of CO poisoning. Freezing rain and flooding increases will raise traumatic injury risk.

MEASURING GLISA'S IMPACT ON DECISION MAKING IN THE GREAT LAKES REGION

Understanding how GLISA resources inform decision making and build climate literacy across the Great Lakes region is a top priority for the GLISA team. Our approach to building an integrated model of physical science, social science and end-user engagement via our boundary chain model is premised on this goal. Over the past year the team has adopted several more specific actions to ensure that we understand the strengths and opportunities that our model provides and we have also taken strides to modify our program where necessary to ensure that the flow of information between our team members and to and from the external community remains strong.



External Evaluation and implementation of recommendations
In 2014 we completed an external evaluation of the GLISA program. For this evaluation an impartial evaluator with substantial RISA experience was engaged. She conducted surveys and interviews with over 50 members of the climate community, GLISA network, and Great Lakes communities. The evaluator identified a number of key achievements including: The development of the boundary chain model; Contributions to the National Climate Assessment; and a hallmark

approach to partner and stakeholder engagement. Additionally, the evaluation pointed out several areas where the GLISA program could improve. Over the past year we implemented a number of recommendations including: altering the leadership of GLISA by bringing Maria Carmen Lemos and Jeff Andresen into co-director roles and having Donald Scavia and Thomas Dietz reduce their roles to administrative PIs; we have taken steps to build the visibility of our physical science portfolio and begun building stronger partnerships with the physical science community through coordination with NOAA's Great Lakes Environmental Research Lab; organized two virtual meetings and one in-person meeting with federal agency climate partners in the region in order to build collaboration between our regional climate efforts.

Internal evaluation of past projects through white papers and interviews
In addition to the steps described above, two GLISA supported graduated students, under the supervision of Maria Carmen Lemos are undertaking an internal evaluation of the GLISA grants initiative. This evaluation includes reviewing and coding all the white papers (reports) crafted by past grant recipients and identifying outcomes, outputs, and drivers of success and constraints of boundary chains as well as best practices within the framework. The white paper evaluation will be followed-up by interviews with project members and their stakeholders to validate, complement and add more detail to the documentary analysis. The goal of the evaluation to gain a better understanding of the effectiveness of the boundary chain model in our work and to use its findings to guide how we approach our funded project model in the future. Ultimately the evaluation aims to assess the impact of our model of engagement and dissemination of climate information on decision-making in the region.