

Managing Climate Change and Variability Risks in the Great Lakes Region

Great Lakes Integrated Sciences and
Assessments, 2010-2016

Phase 1 Final Report

GLISA
A NOAA RISA TEAM



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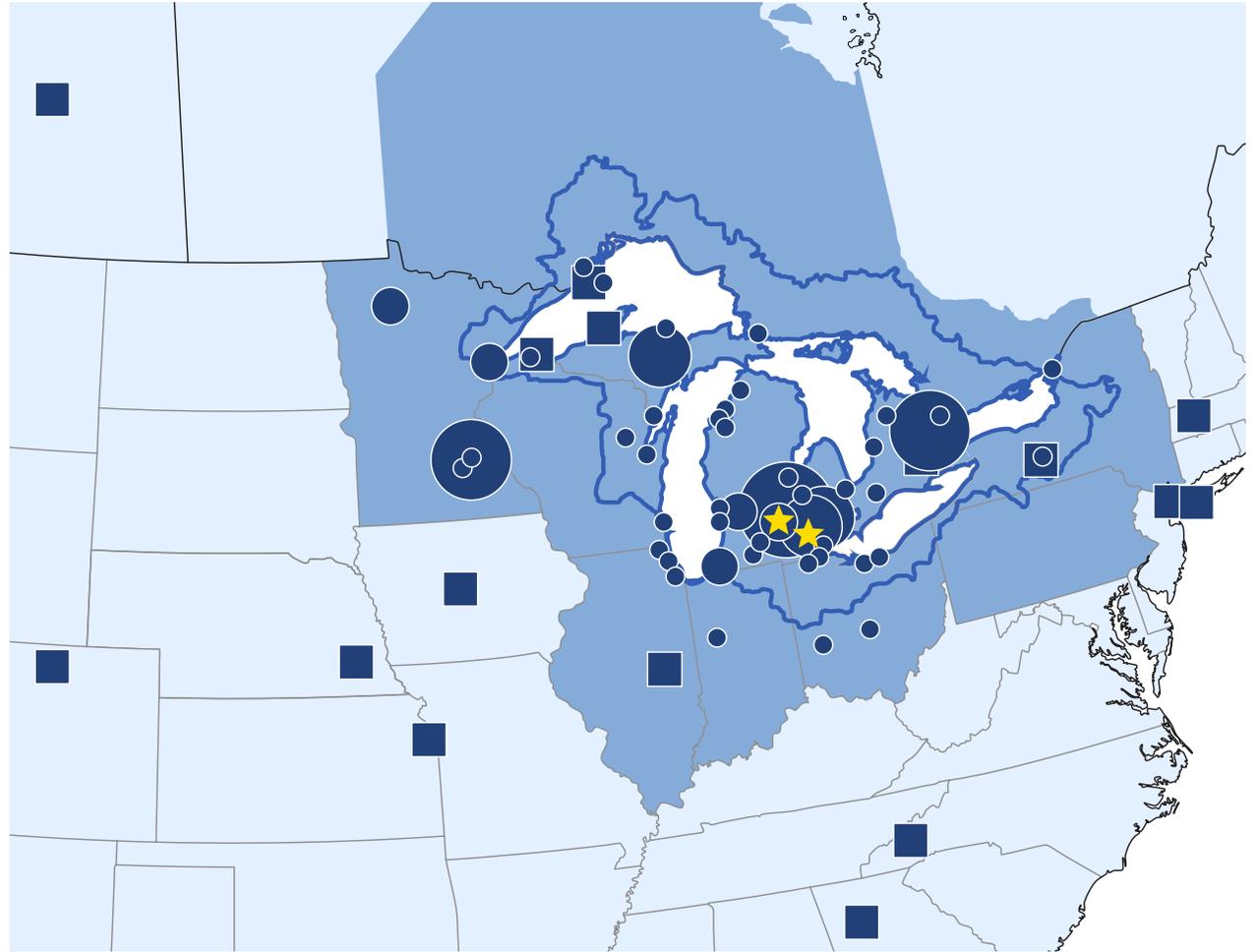
SYMBOL LEGEND

-  Research Findings
-  GLISA Tools & Resources
-  Accomplishments/Impacts
-  Publications

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Project period: September 2010 – September 2015, with one-year extension through August 2016.

GLISA Engagement



COLLABORATORS PER LOCATION



2 Countries

5 Great Lakes

95,000 Square Miles of Surface Water

8 States

10,201 Miles of Shoreline

35 Million People

Sectors Engaged



Organizations Engaged



Physical Science Research

Lake-Effect Precipitation Great Lakes Ice Cover Evapotranspiration Freezing Rain
Urban Heat Island Effect Great Lakes Lake Levels Extreme Precipitation Events

Social Science Research

The Role of Boundary Chains Great Lakes Climate Network Analysis

Regional Support

50+

Non-Governmental,
Tribal, Academic, and
Municipal Entities

1.1_M

Total Grants Awarded

2.6_M

Additional Funds
Leveraged



GLISA Team

FACULTY & CORE TEAM

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Photo Credits: B. J. Baule and Dan Brown

About the Great Lakes Integrated Sciences and Assessments Center (GLISA)

GLISA supports the region, as it charts its future, facing multiple and simultaneous changes and uncertainties.

The Great Lakes region represents a unique socio-ecological system. Bound by the Lakes that shape both its culture and natural resources, Great Lakes communities have experienced dramatic changes in the past five decades, including deep economic downturn, population shifts, and negative environmental impacts. While climate change impacts are projected to exacerbate some of these challenges, leaders in the region are increasingly committed to a sustainable future by leveraging opportunities to mitigate climate impacts and adaptively respond to them.

As a boundary organization, GLISA produces and integrates information from a wide array of scientific fields, helps develop collaborations among stakeholders and organizations with similar goals, and provides climate information to support decision makers throughout the eight Great Lakes states and the province of Ontario.

For the past five years, GLISA used two adaptive approaches to achieve its goals.

First, through a grants competition and internal research plans, it developed a flexible research program committed to annually soliciting, reviewing, and selecting proposals for both creating usable science and bridging/brokering this science to regional users. This approach generated **boundary chains**, or network linkages among boundary organizations that complement one another and make it easier to bridge climate information to decision-makers.

Second, GLISA has tailored, customized, and curated **climatologies and climate projections** from multiple sources in response to the needs of scientists, stakeholders, and Tribal partners in the region. In developing this adaptive model, we expanded the breadth and depth of our work, while building a reputation of responsiveness and trust among the region's stakeholders and organizations. The GLISA team leveraged more than \$2.5 million in external funding to support additional research and adaptation, and advanced fundamental knowledge in the physical and social sciences.

In 2010, we proposed a focus on how climate impacts water resources, agriculture, and tourism in the Lake Huron and Erie Basins. As our regional engagement evolved and the complexity of impacts became evident, we developed a more adaptive approach that is responsive to what we learn about changing needs. Our ultimate goal is to provide the critical climate information our region needs, while developing state-of-the-art integrated physical and social science to evaluate, monitor, and learn how to best deploy our human, financial, and information resources. This coupled approach allows us to provide important information to users that is attentive to what is unique to the region, and not well represented in current general climate information products. It also allows us to produce science and strategies that can inform boundary organizations development and action beyond our region.

BOUNDARY ORGANIZATION BENEFITS

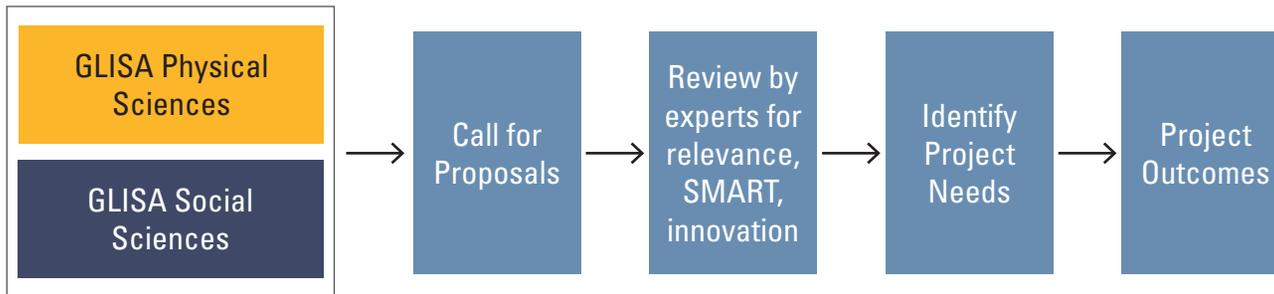
"Boundary organizations bridge the divide between information producers (scientists) and information users (policy- and decision-makers) enhancing and sustaining communication, translating technoscientific information into more usable forms, and mediating conflicts that arise in the boundary spanning process. Through this sustained bridging process, boundary organizations facilitate the development and use of science for decision-making. One prominent example of boundary organizations in the U.S. is the Regional Integrated Sciences & Assessments program (RISA), initiated and funded by NOAA in 1995. Early on, the RISAs focused on climate variability and climate extremes. Over time, the program expanded to encompass eleven U.S. regions and to include both climate variability and change at the regional to local context. RISAs use an iterative, stakeholder-driven approach to produce usable climate information such as paleoclimate data, temperature and precipitation means and extremes, interpretation of instrumental climate data, SCFs, and projections of global and regional climate change."

— Kirchhoff, C.J., Lemos, M.C., Engle, N. L., (2013)
Elsevier, Environmental Science and Policy

Role in the Region

FACILITATING PARTNERSHIPS – BOUNDARY CHAIN MODEL

GLISA's social science program tests different approaches to engage stakeholders, taking advantage of our own research, research conducted in collaboration with others, research results published by other RISAs, and the knowledge and experience from the tight network of RISA scientists and stakeholders. Our boundary chain model relies on existing knowledge networks to pass pertinent climate information to stakeholders and end users. Through the boundary chain model, GLISA is able to multiply its reach across numerous sectors and communities, while decreasing costs (e.g., personnel, financial, and resource development). Our model also ensures that knowledge from partner boundary organizations flows back to GLISA and informs the social and physical science needs of the region.



“Boundary chains” are links between organizations that may have different but critical roles in co-producing knowledge and decision-making.

Understanding how knowledge moves across networks is critical to GLISA's work and essential when employing the boundary chain model. GLISA social scientists have studied how knowledge moves across the region via climate-related documents, events, communities of practice, and individuals, in order to better understand where we can harness these networks to inform broader audiences. Recent findings point to GLISA providing a crucial role in scaling information across levels of government and ensuring that federal agencies and local actors are able to learn from one another, as well as share experiences and knowledge to continue building climate ready sectors and communities across our region.



GLISA integrates across the following three fronts by monitoring all of our engagements to build a cumulative understanding of practices and solutions, and to evaluate our progress. We also continuously examine the regional network around climate adaptation to better understand how information flows, allowing us to leverage intervention points for future activities - links that will substantially enhance information flow and build capacity for adaptation across the region.

1. We competitively selected boundary organizations to serve as boundary chains or facilitators of information exchange between stakeholders and our tailored climate information. These boundary chains reduce overall costs by saving time and leveraging human and social resources normally required to build the trust and legitimacy essential to effective co-production of knowledge and decision-making. To date, we have experimented with two main configurations: the *key chain*, in which boundary organizations link with one other organization, and the *linked chain*, where several linked organizations continuously broker between producers and users of knowledge.

2. We use an adaptive approach to set priorities for our own research. Each year, our researchers submit short proposals and we allocate resources competitively to ensure we are both creating usable science and bridging/brokering this science to regional users. This approach recognizes that research needs and emphases evolve throughout a RISA's lifetime, particularly as we receive greater input from stakeholder networks.

3. We work closely with GLISA climatologists who tailor, customize, and curate climate information and projections from multiple sources. We promote the use of this information by scientists and stakeholders, in general, as well as in the boundary chains. We tested and evaluated these efforts through continuous interaction with users (Lemos et al. 2014; Special Issue, Climate Risk Management 2015).

CLIMATE SERVICE PROVIDER – MAKING SCIENCE USABLE

Through employing the boundary chain model, the GLISA team has successfully engaged with partners and 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?* (see climatologies section, below), *What will happen?* (see projections, below), and *What are the impacts?* This framework allows partners to see how their local climate has already changed, and then apply this quantitative data to their own qualitative experiences. By building an understanding and acceptance of continual changes in our Great Lakes climate system, our partners are then more willing to consider how climate may change in the future.

Climatologies – “What has happened?” This focus area brings attention to historical climate trends. This approach builds from the fact that managers, planners, and elected officials are more aware of local station data than of projections, and are therefore more familiar and comfortable with these data. We analyze trends in station data within the

context of locally-relevant scales, along with observations within climate divisions, gridded datasets, and model projections. This process anchors confidence and uncertainty descriptions with observations at a tangible scale for decision-makers.



- Station Climatologies: <http://glisa.umich.edu/resources/great-lakes-climate-stations>
- Division Climatologies: <http://glisa.umich.edu/climate-divisions>
- Maps Depicting Past Changes: <http://glisa.umich.edu/climate-divisions#maps>

Projections – “What will happen?” Because decision makers perceive regional weather as the primary driver of vulnerability, GLISA engagements draw attention to how well climate models predict this weather. Much of the uncertainty surrounding projections in our region is driven by lack of a credible representation of the Great Lakes and their impact on regional weather and climate. In our evaluation of CMIP3/5, only a few models had water in the region of the lakes, with land being the more typical representation. Not only do most models fail to simulate the lakes and lake effects, but they also do not capture how the lakes have changed and will continue to change (i.e., increased surface temperatures, decreased

ice cover), let alone their impacts (i.e., impacts on lake-effect snowfall). We are dealing with an integrated system of land, lake, and atmospheric interactions embedded in globally changing temperature and circulation conditions, which requires interpretation and tailoring of information for actionable knowledge, even in the face of uncertainty.

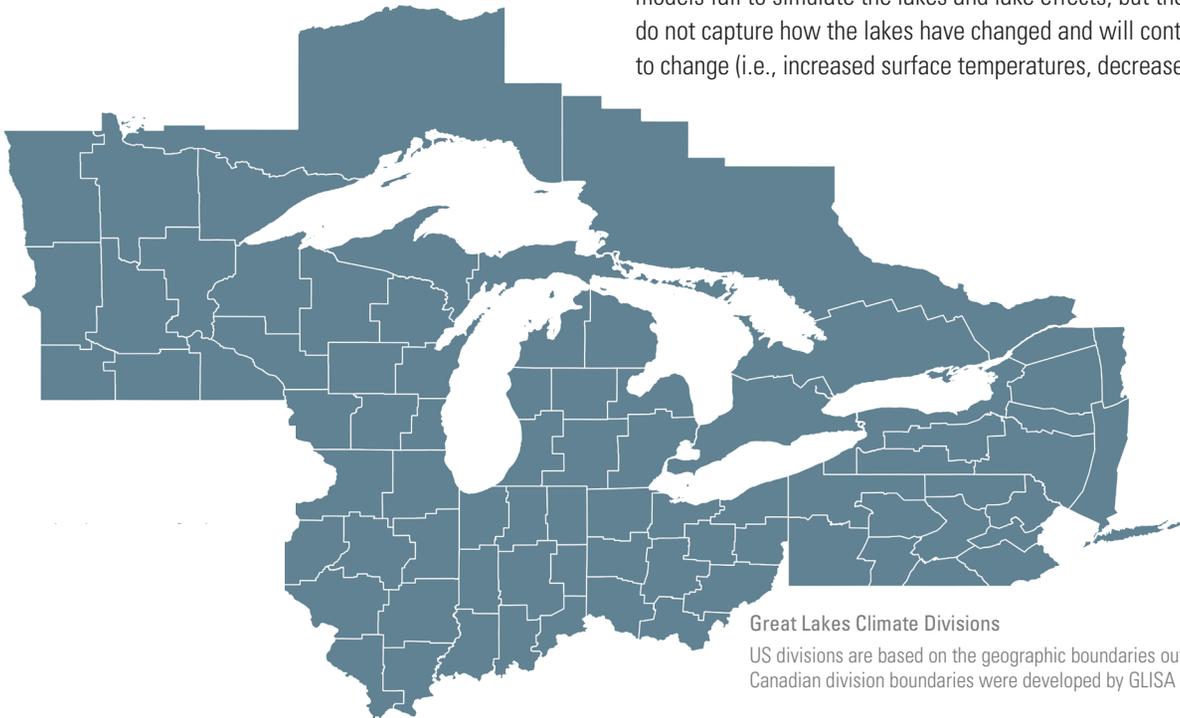


- Future Climate Maps: <http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps>
- Climate Information Guide – Do I need downscaled climate data for my problem? <http://www.glisacclimate.org/climate-information-guide>
- GLISA is currently (2016) working on evaluating climate models for their representation of the Great Lakes and developing resources for the region as part of our Great Lakes Ensemble project. <http://glisa.umich.edu/projects/great-lakes-ensemble>

Partnerships – “What are the impacts?” In our engagements, GLISA fills the role of climate data and information expert, but the information we provide is most useful when partnerships include experts in the fields/systems that are being investigated (i.e., ecosystem impacts, water resources management, public health, etc.). GLISA’s climate information, leveraged with information about how existing systems operate (natural and human systems), allows linkages to be made between disciplines to emphasize the interacting effects.



- Climate Changes and Impacts in the Great Lakes Region: <http://glisa.umich.edu/climate>
- Synthesis of the Third National Climate Assessment for the Great Lakes Region: http://glisa.umich.edu/media/files/Great_Lakes_NCA_Synthesis.pdf



Great Lakes Climate Divisions

US divisions are based on the geographic boundaries outlined in the NOAA U.S. Climate Divisional Dataset (available at <ftp://ftp.ncdc.noaa.gov/pub/data/>). Canadian division boundaries were developed by GLISA and are an aggregate of municipal boundaries in similar climate regions.

Regional Expertise

CONTRIBUTION TO THE U.S. NATIONAL CLIMATE ASSESSMENT

The GLISA core team has played a central role in the development, promotion, distribution, and synthesis of the Third National Climate Assessment (NCA). Led by Julie Winkler, GLISA provided the **technical input reports** for the Midwest chapter of the NCA. Don Scavia was the chapter's lead co-author. GLISA hosted the assessment's Midwest draft review and rollout. In addition to helping formal efforts related to the NCA, GLISA also helped to ensure that the NCA is useful and usable for stakeholders across the Great Lakes region. To this end, GLISA wrote a **Great Lakes Synthesis** report, summarizing key impacts from the Northeast and Midwest Chapters about the eight Great Lakes states. Additionally, GLISA staff acquired the Kunkel data set, which was used to make many of the maps in the NCA, and with his permission created all of the NCA maps for the Great Lakes region and will develop an online interface where users can scroll through the regional maps based on their interests.

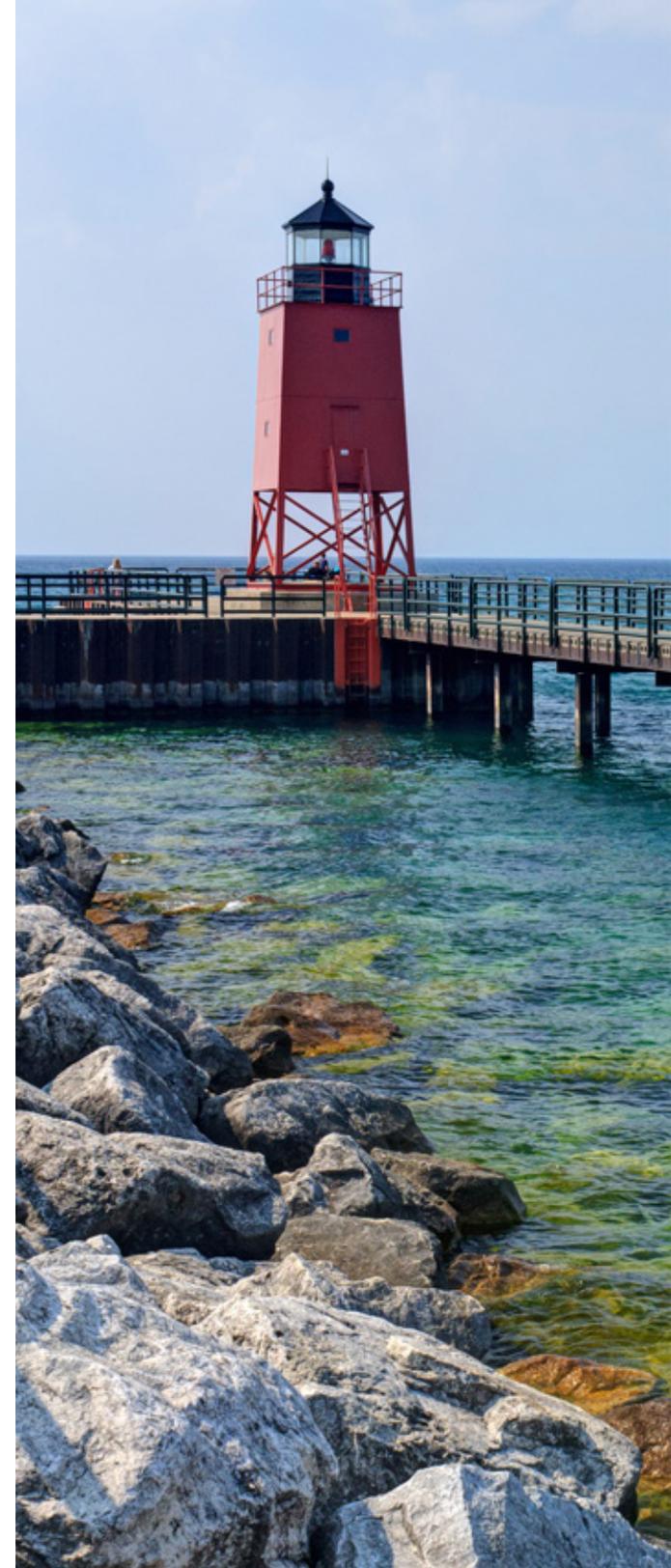
CLIMATE ADAPTATION FIELD ADVOCATE AND FORCE

Over the past five years, GLISA transitioned from a new organization in the region to a program that adaptation professionals trust and with whom they desire to partner. Our funded project partners include agricultural extension professionals, land managers, municipalities (with populations ranging from 20,000 to 2.5 million), watershed councils, ravine managers, tribes, and researchers focused on lake evaporation, public health planning, and ecosystem health and stability.



Online Collaboration – GLISA developed an **online space**, the Climate Workspace (<http://glisacclimate.org>) for project teams spanning multiple disciplines to facilitate collaborating on climate change problem-solving. The site supports projects by providing space to:

1. Describe and promote your work
2. List project members
3. Upload, list, share, and customize relevant project resources
4. Define terms which despite common use may not be commonly known by all project members.
5. Develop project pages to share information, expertise, and/or solutions



Understanding Our Network

GREAT LAKES CLIMATE NETWORK ANALYSIS – 2015

GLISA is mapping climate policy networks in the region. By surveying stakeholders and the people and organizations with whom they communicate and collaborate on climate-related issues, we are better able to understand the structure of relationships around these issues and develop more effective engagement strategies for subsequent assessment activities. This network analysis will also provide critical information about stakeholder views, concerns, behaviors and preferences. This information is vital in developing effective engagement strategies and in allowing us to respond to changes in stakeholder views and the structure of the network over time.



Understanding network composition – Through our study of how people perceive lake levels, and connections between the network of scientists and policy makers who co-authored Great Lakes climate change documents, we were able to link networks at three different levels: scientists and policy makers; translators; and stakeholders and end users. In addition, we worked closely with partners who translate scientific work for the public.

Uncertainty Lost – As discussions about future lake levels move between different levels of literature (i.e., documents, articles, peer-reviewed literature), some information on the uncertainty of future lake levels was lost. In at least three examples, papers or articles reference primary source documents which clearly state the uncertainty about lake levels, but fail to carry the statement of uncertainty forward into the new document.

The role of networks in adaptation – A question emerging from our network analysis work 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 each network participant's career history and determined on what scale their work was focused (i.e., local, state, Great Lakes region, other multi-state region, national, or international).



This effort 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. We found that overlaps between these scales generated more usable knowledge as potential users formed their own specialized networks. Operating as communities of practice, these specialized networks tailor regional discussions about climate change to match particular application needs. Such feedbacks across scales offer opportunities to “scale-up” the development of usable climate information.

Additional Impact – Established a 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.



- 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. DOI: <http://dx.doi.org/10.1016/j.gloenvcha.2015.02.007>
- Frank, K., I. Chen, Y. Lee, S. Kalafatis, T. Chen, Y. Lo, and M. Lemos. 2012. *Network location and policy-oriented behavior: An analysis of two-mode networks of co-authored documents concerning climate change in the Great Lakes region*. *Policy Studies Journal*. 40:492-515. DOI: <http://dx.doi.org/10.1111/j.1541-0072.2012.00462.x>

PUBLIC PERCEPTIONS, CODE-SWITCHING, AND KNOWLEDGE NETWORKS – 2014 to 2015

As part of our Network Analysis, the GLISA team studied how different societal groups perceive science in an effort to better know how to communicate climate change information. We used our network to study the language mediators use to communicate with lay audiences or stakeholders in the Great Lakes region.



The public draws distinctions between different forms of science, in particular science directed towards supporting economic production and science directed towards assessing environmental impacts. Different groups within society accord different levels of trust to these different areas of science. If communication about climate risks and adaptation is to be effective, we may need to be attentive to these differences.



We found mediators working throughout the Great Lakes region did not use the language of “climate change” in communicating with lay audiences or stakeholders. Instead, they used the language of temperature, precipitation, etc. This is similar to “code switching,” in which members of a racial minority use language to conform to a majority context. As a result, mediators deliberately choose language when communicating with stakeholders and end users. We also note that there are some members of the network who do not code switch, although typically they were less engaged in stakeholder networks than those who did code switch. An unintended consequence of code switching is that stakeholders and end users may not be aware of the scientific sources of the knowledge presented to them. As a result, they may be exposed to a single finding through multiple mediators, appearing to reinforce certainty, when in fact the original finding is uncertain. For example, Brent Lofgren's work on lake levels presents a high level of uncertainty, but end users who hear about this paper anonymously through several mediators may not be aware of the level of uncertainty.



Auer, 2013 available at <http://www.udc.es/dep/lx/cac/c-s/>

Understanding Our Network (Continued)

IMPROVING OUR APPROACH:

UNDERSTANDING AND ENHANCING THE BOUNDARY CHAIN APPROACH – 2014 to 2015

The GLISA team proposed an analytical framework to identify drivers and constraints for boundary chains (partners) successes and shortcomings, based on the level of complementarity between the boundary chains links and 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 potentially increase the usability of climate information among chain participants. The framework formed the basis for a series of in-depth case study analyses of chains in the journal of Climate Risk Management (CRM) Special Issue.



Social scientists evaluated GLISA's partnership with the Huron River Watershed Council and found that the boundary chain partnership between the two organizations: 1) improved the efficiency of the co-production process by increasing climate information usability for a variety of users over a shorter period of time; 2) improved climate information dissemination by users within user networks, increasing climate literacy of users and resilience in the watershed, without requiring additional resources from either boundary organization; and 3) created climate brokers within the chain who led efforts to identify new audiences and introduced them to customized, relevant climate science.

1. In a case study of GLISA's work with the Great Lakes Adaptation Assessment for Cities (GLAA-C), the GLISA team found that City of Toledo leaders leveraged relationships with GLISA to build a regional network in the Toledo greater metropolitan area. Importantly, this network was robust enough to withstand the loss of key city leaders.
2. 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, embedded in particular communities, the ACCAP enhanced the impact of their remote engagement.
3. 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 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 peer-reviewed and open access journal Climate Risk Management focusing on an analysis of GLISA and its boundary chain partnerships for five of the articles cited in sidebar (right). Remaining articles were contributed by other RISA programs and NGOs.



- Briley, L.; Brown, D.; Kalafatis, S.E. (2015) "Overcoming barriers during the co-production of climate information for decision-making." Climate Risk Management, DOI: <http://dx.doi.org/10.1016/j.crm.2015.04.004>
 - Kalafatis, S.E.; Grace, A.; Gibbons, E. (2015) "Making Climate Science Accessible in Toledo: The Linked Boundary Chain Approach." Climate Risk Management, DOI: <http://dx.doi.org/10.1016/j.crm.2015.04.003>
 - Kettle, N.; Trainor, S. (2015) "The role of climate webinars in supporting boundary chain networks across Alaska." Climate Risk Management, DOI: <http://dx.doi.org/10.1016/j.crm.2015.06.006>
 - Kirchoff, C.J.; Esselman, R.; Brown, D. (2015) "Boundary organizations to boundary chains: Prospects for Advancing Climate Science Application." Climate Risk Management, DOI: <http://dx.doi.org/10.1016/j.crm.2015.04.001>
 - Kirchoff, C.J.; Lemos, M.C.; Kalafatis, S.E. (2015) "Creating synergy with boundary chains: Can they improve usability of climate information?" Climate Risk Management, DOI: <http://dx.doi.org/10.1016/j.crm.2015.05.002>
 - Kirchoff, 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, DOI: <http://dx.doi.org/10.1016/j.crm.2015.06.002>
 - Meyer, R.; McAfee, S.; Whiteman, E. (2015) "How California is mobilizing boundary chains to integrate science, policy and management for changing ocean chemistry" DOI: <http://dx.doi.org/10.1016/j.crm.2015.04.002>
 - Phadke, R.; Manning, C.; Burlager, S. (2015) "Making it Personal: Diversity and Deliberation in Climate Adaptation Planning." Climate Risk Management, DOI: <http://dx.doi.org/10.1016/j.crm.2015.06.005>
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- Bidwell, D., Dietz, T. and Scavia, D. 2013. *Fostering knowledge networks for climate adaptation*. Nature Climate Change 3:610-611. DOI: <http://dx.doi.org/10.1038/nclimate1931>
 - Lemos, M. C., Kirchoff, C. J., Kalafatis, S. E., Scavia, D. and Rood, R.B. 2014. *Moving climate information off the shelf: Boundary Chains and the role of RISAs as adaptive organizations*. Weather, Climate, and Society. DOI: <http://dx.doi.org/10.1175/WCAS-D-13-00044.1>



Project List By Theme, pages 11-24

GLISA has a technical role in several climate change adaptation projects across the Great Lakes region. Climate experts collaborate with other experts involved in projects to understand climate-related problems or challenges. Annually, **GLISA awards between three and six one-year grants** of up to \$50,000 each to boundary organizations. These organizations partner with GLISA to address the risks of climate change and variability in the Great Lakes region. Project descriptions are found on following pages.

OUR CHANGING LAKES

- Great Lakes Evaporation
- Great Lakes Whitefish in a Changing Climate
- Helping Marina and Harbor Operators Respond to Climate Change

WATERSHED PLANNING

- Creating Climate Resilient Communities
- Ravine Restoration
- Using Future Scenarios to Identify Potential Policies for Climate Change Adaptation along Lake Ontario
- Stormwater, Flooding and Decision-Making in the Great Lakes Region

URBAN ADAPTATION

- Great Lakes Adaptations Assessment for Cities
- Sensitive Sites and Infrastructure Protocol
- Detroit Climate Action Collaborative
- Adapting to Climate Change and Variability in Two Michigan Communities
- Winter Climate Information for the Chicago Climate Action Plan
- Diversity and Deliberation on Climate Adaptation
- A Climate Change Risks Assessment and Adaptation Strategy for York Region
- Ready & Resilient: Climate Preparedness in Saint Paul, Minnesota
- Climate and Extreme Weather Resilience for the Region of Peel, Ontario

PUBLIC HEALTH

- Michigan Climate Health Profile
- Heat and Human Health: Present and Future
- Participatory Modeling of Extreme Heat Impacts

AGRICULTURE

- Michigan Agribusiness Association
- On-Farm Water Recycling as an Adaptation Strategy for Drained Agricultural Land in the Western Lake Erie Basin
- Predicting the impacts of climate change on agricultural yields and water resources in the Maumee River Watershed
- Climate Variability Risks Impacting the Michigan Tart Cherry Industry
- Agricultural best management practices and models assessing vulnerability

NATIONAL PARKS SCENARIO PLANNING

- Isle Royale National Park
- Apostle Islands National Lakeshore

TRIBAL COMMUNITIES

- Strategic Foresight Scenario Development
- Implementing Forest and Water Climate Adaptation Solutions to Build the Resilience of Two Northwoods Communities

TOURISM

- Climate Change and Michigan's Downhill Ski Industry

TRANSPORTATION

- Michigan Department of Transportation

DEFENSE

- Resilient Michigan – Department of Defense Pilot Project

TRAINING AND OUTREACH

- University of Michigan Applied Climate Program
- Outreach and Planning Professionals
- Peer Network Engagements
- Shifting Seasons Summit

CLIMATE DATA FOR ADAPTATION

- Great Lakes Adaptation and Data Suite (GLADS)
- Great Lakes Ensemble

Our Changing Lakes



GREAT LAKES EVAPORATION – 2011

Institutes/Organizations – LimnoTech, University of Colorado Boulder, the Great Lakes Environmental Research Laboratory, Great Lakes Evaporation Network

In 2011, GLISA provided funding to a consortium of scientists (see partners list) to study evaporation off of Lake Superior. Lake level change and lake level variability are a major concern for industry, property owners, and natural systems managers throughout the Great Lakes region. Lake level change and variability in the face of climate change remains relatively unstudied. This research initiative sought to understand how lake evaporation off of Lake Superior could be impacted by climate change, and what that potential impact could mean for lake levels.



The particularly warm summer of 2010 accelerated the onset of the evaporation season in Lake Superior. Four years of cumulative evaporation data collected at Stannard Rock lighthouse showed that evaporation totals during 2010-11 were “roughly 10 inches greater than the high ice year of 2008/09. While 10 inches of water may not sound like a lot, this is only an example of what one or two unusually warm years can do.”



The research generated out of this study has gained national attention and the research that GLISA supported has led to further work in lake temperature forecasting for Lake Superior. Both of these variables (evaporation and temperature) have immense impact on the health, safety, and economic viability of the lakes for individuals, municipalities and industries. This work brought a new understanding of lake evaporation and since has led to innovative research on lake temperature forecasting for Lake Superior. It is also shaping the way GLISA frames future discussions about lake levels in the Great Lakes region.



- J.D. Lenters, J. B. Anderton, P. Blanken, C. Spence, and A. E. Suyker. 2013. *Assessing the Impacts of Climate Variability and Change on Great Lakes Evaporation*. In: 2011 Project Reports. D. Brown, D. Bidwell, and L. Briley, eds. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center: http://glisacclimate.org/media/GLISA_Lake_Evaporation.pdf
- C. Spence, P.D. Blanken, J.D. Lenters, and N. Hedstrom. 2013. *Spring and autumn atmospheric conditions are major factors that define the evaporation regime of Lake Superior*. *Journal of Hydrometeorology*. DOI: <http://dx.doi.org/10.1175/JHM-D-12-0170.1>

GREAT LAKES WHITEFISH IN A CHANGING CLIMATE – 2011

Institute/Organization – Michigan State University

Whitefish are an ecologically and economically important species in the Great Lakes. Researchers are working with stakeholders to assess decision support tools for Great Lakes whitefish management in the context of climate change.



The positive relationship between spring temperatures and recruitment with climate change suggests the potential for increased lake whitefish production in the Great Lakes, if foraging habitat is not limited and food resources are available at (i.e., “match”) larval hatch. However, the negative relationship between fall temperatures and recruitment may inhibit egg survival and lake whitefish production.



- A.J. Lynch, and W.W. Taylor. 2013. *Designing a Decision Support System for Harvest Management of Great Lakes Lake Whitefish in a Changing Climate*. In: GLISA Project Reports. D. Brown, D. Bidwell, and L. Briley, eds. Available at: http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Lake_Whitefish.pdf
- A.J. Lynch, E. Varela-Acevedo, and W.W. Taylor. 2015. *The need for decision-support tools for a changing climate: application to inland fisheries management*. *Fisheries Management and Ecology* 22: 14-24
DOI: <http://dx.doi.org/10.1111/fme.12013>

HELPING MARINA AND HARBOR OPERATORS RESPOND TO CLIMATE CHANGE – 2014

Institute/Organization – Michigan Sea Grant (University of Michigan, Michigan State University)

Decision making bodies have questioned how changing water levels could impact the coastal communities of the Great Lakes. This project sought to assist marina and harbor operators in sector-specific problem identification, decision making, and planning related to climate change adaptation by developing an online training module that would be introduced and tested at workshops targeting marina and harbor operators.



- J. Diana, C. Riseng, and A. Samples. 2014. *Helping Harbor and Marina Operators Respond to Climate Change*. In: Project Reports. D. Brown, B. Baule, L. Briley, and E. Gibbons, eds. Available from the Great Lakes Integrated Sciences and Assessments Center. <http://glisa.umich.edu/media/files/projectreports/14-728%20Increase%20Resilience%20at%20Marinas%20and%20Harbors.pdf>

Watershed Planning



CREATING CLIMATE RESILIENT COMMUNITIES – 2013
Institute/Organization – Huron River Watershed Council, Ann Arbor, MI

The Huron River Watershed Council (HRWC) facilitated Peer Learning Groups to build the capacity of professionals and community decision-makers to address the water-related impacts of climate change at the local level.

The Peer Learning Groups were based upon three sectors with members collaborating and developing resources:

1. Natural Infrastructure – for wildlife biologists, aquatic ecologists, natural lands managers
2. Water Infrastructure – for stakeholders involved with drinking water, waste water, storm water infrastructure
3. In Stream Flow – for dam operators, fisheries biologists, and hydrologists



This partnership with the HRWC resulted in a number of impactful outcomes. Based on the early financial and technical support GLISA provided, HRWC assembled key stakeholder groups to provide a better understanding of climate impacts. Through a series of GLISA-supported workshops, the working group published a guide to adapting forests for the watershed area. This toolkit also provides management strategies that can be adopted to enhance resiliency. HRWC is distributing the planning kit distributed across other watersheds and natural systems management groups to strengthen their capacity to adapt land and forest management, based on climate information. In addition, the Washtenaw County Water Resources Commissioners Office revised their stormwater rules to require additional onsite infiltration of stormwater after vulnerabilities were identified during input from community experts and GLISA's analysis of heavy precipitation trends for the watershed.



- R. Esselman, and D. Brown. 2015. *Huron River Watershed Council: Creating Climate Resilient Communities*. In: Project Reports. D. Brown and E. Gibbons. eds. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center. Available at: <http://glisa.umich.edu/projects/huron-river-watershed-council-making-climate-resilient-communities>
- C.J. Kirchhoff, R. Esselman, and D. Brown. 2015. *Boundary organizations to boundary chains: Prospects for Advancing Climate Science Application*. Climate Risk Management. DOI: <http://dx.doi.org/10.1016/j.crm.2015.04.001>

RAVINE RESTORATION – 2014
Institutes/Organizations – Alliance for the Great Lakes, Field Museum

A series of ravines along the shoreline of Lake Michigan have become a major focus of conservationists in Northeast Illinois and Southeast Wisconsin. Restored ravines protect property values, drinking water quality, and recreational opportunities. They also decrease storm water flowing onto the beaches and into the lake, slowing erosion and decreasing water pollution. There is considerable uncertainty as to the scope of climate impacts on ravines, and therefore appropriate management actions. This project provides an avenue for decision makers to implement strategies of adaptive risk management by allowing them to co-develop with technical experts as part of a local “knowledge network.” Two pilot projects will allow local ravine managers to implement those strategies and integrate metrics into their existing restoration projects.



Larsen, A., Derby Lewis, A, Lyandres, O. Chen, T., and K. Frank. 2014. *Developing a Community of Climate-Informed Conservation Practitioners to Protect a Priority Coastal Landscape in Illinois and Wisconsin*. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_ILWI_Ravines.pdf

USING FUTURE SCENARIOS TO IDENTIFY POTENTIAL POLICIES FOR CLIMATE CHANGE ADAPTATION ALONG LAKE ONTARIO – 2015

Institute/Organization – New York Sea Grant

Draft recommendations were developed iteratively for the binational Lake Ontario Lake-wide Action and Management Plan (LAMP), and for watershed planners to consider when adapting existing, and new plans to incorporate climate change. This project consisted of a series of workshops that brought together stakeholders and researchers from multiple disciplines to: 1) develop a set of future watershed scenarios; 2) identify planning and management actions that could be taken to address negative implications of the scenarios; and 3) vet and validate the scenarios and recommendations.



Bunting-Howarth, K., MacNeill, D., Spaccio, J., Schneider, R, Weidel, B., DeGaetano, A., and L. Briley. 2016. *Developing a Using Future Scenarios to Identify Potential LAMP and Watershed Planning Measures for Climate Change Adaptation along Lake Ontario*. In: Project Reports. D. Brown, W. Baule, L. Briley, E. Gibbons, and I. Robinson, eds. Available at http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_NY_SeaGrant.pdf

Watershed Planning

STORMWATER, FLOODING, AND DECISION-MAKING IN THE GREAT LAKES REGION – 2015

Institute/Organization – University of Michigan Climate Center

The project team: 1) tested the effectiveness of GHCN-Daily (Global Historical Climate Network) data in quantifying regional sensitivity to the frequency of flash flooding following heavy precipitation, and 2) tested the effectiveness of GHCN-Daily data in quantifying potential increases in the capacity of separate sewer systems.



Understanding of how GHCN-Daily data can be used to identify past and future vulnerabilities will help decision makers plan for changing weather patterns in the region.



Krajewski, M., D. Brown, E. Gibbons, 2015. *Flash Flooding, Stormwater, and Decision Making for Cities in the Great Lakes*. Available at http://glisa.umich.edu/media/files/studentprojects/stormwater-decision-making/Krajewski_stormwater.pdf

Urban Adaptation

GREAT LAKES ADAPTATION ASSESSMENT FOR CITIES (GLAA-C) – 2011 to 2014
 Institute/Organization – Graham Sustainability Institute
 Integrated Assessment

From 2011-2014, the Great Lakes Adaptation Assessment for Cities (GLAA-C), an Integrated Assessment project supported by the Kresge Foundation, worked with cities throughout the Great Lakes region to better understand the challenges municipalities face when dealing with climate change. The project also helped develop and implement a variety of adaptation strategies throughout the region.



Project efforts included working with six cities, including Ann Arbor and Flint (Michigan), Dayton and Toledo (Ohio), and Kingston and Thunder Bay (Ontario). Ann Arbor and Flint stood out as two cities that share geographic proximity but dramatically different socio-economic conditions. Work in Ann Arbor led to the creation and deployment of videos addressing climate change impacts on the city, actions that the city is taking to regarding these impacts, and actions individuals could engage in. In Flint, a community beset by economic decline and decreasing population, GLISA and GLAA-C collaborated with the City Planning Office. This collaboration led to the City incorporating accurate climate information in the Master Planning Process, including climate-resilient policies in the forthcoming zoning and building code review.

In addition to the work in Ann Arbor and Flint, GLISA provided climate data and analysis central to the development of a new resource, the Cities Impact and Adaptation Tool (CIAT). CIAT is designed to help municipal decision makers identify and engage communities currently facing projected climate impacts for their city. The tool includes historical and projected climate information along with a database of more than 500 climate adaptation strategies.



- CIAT: <http://graham-maps.miserver.it.umich.edu/CIAT/home.xhtml>
- Climate Videos: <http://graham.umich.edu/climate/adaptation/urban/ann-arbor/project>

SENSITIVE SITES AND INFRASTRUCTURE PROTOCOL – 2015
 Institute/Organization – 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 was 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 was to broadly disseminate the protocol and lessons learned from the pilot city, so that more cities in and beyond the region can adopt the protocol to become better prepared. The Sensitive Sites and Infrastructure Protocol outlined how to identify and secure sensitive sites such as water and wastewater treatment plants, as well as 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 was tested in Gary, Indiana.



Crawhall, N., M. Donahue, L. Frank, B. Scott-Henry, D. Brown, S. Belisle, and M. Soline. *The Climate-Ready Infrastructure and Strategic Sites Protocol (CRISSP)*. In: Project Reports. D. Brown, M. Krajewski and I. Robinson, eds. Available at http://glisa.umich.edu/media/files/projectreports/GLISA_ProjReport_GLSLCL_CRISSP.pdf

DETROIT CLIMATE ACTION COLLABORATIVE – 2012
 Institute/Organization – Detroiters Working for Environmental Justice

The Detroit Climate Action Collaborative (DCAC) was established to help the city of Detroit identify short and long term actions to reduce greenhouse gas (GHG) emissions, provide expert advice on the most credible, aggressive and economically viable targets, develop a replicable and complete Climate Action Plan, and ready Detroiters for coping with the impacts of climate change. GLISA provided DCAC with a summary of climate changes impacts Detroit is likely to face.



The Potential Impacts of Climate Change on Detroit, Michigan available at http://glisa.umich.edu/media/files/projects/DCAC/DCAC_Climate_Impacts_Executive_Summary.pdf

Urban Adaptation

ADAPTING TO CLIMATE CHANGE AND VARIABILITY IN TWO MICHIGAN COMMUNITIES – 2013

Institutes/Organizations – Michigan State University Extension, City of Marquette, Southwest Michigan Planning Commission

Project leaders collaborated with two Michigan communities, Benton Harbor and Marquette, to determine vulnerabilities, strengths, and knowledge related to climate change. The project goal was to make these communities more resilient in the future by incorporating adaptation strategies into local land use master plans.



Marquette incorporated climate adaptation strategies into their master plan, which was in the process of being updated. The Twin Cities

Area Transportation Study incorporated the findings of their collaboration with MSUE and GLISA into their transportation planning.



- http://glisa.umich.edu/media/files/projects/MSUEcommunities/Southwest_Final_Report%208_14_13.pdf
- http://glisa.umich.edu/media/files/projects/MSUEcommunities/Marquette_Final_Draft_Sept%202013.pdf

WINTER CLIMATE INFORMATION FOR THE CHICAGO CLIMATE ACTION PLAN – 2013

Institutes/Organizations – Illinois-Indiana Sea Grant, Midwestern Regional Climate Center

This project formulated a suite of climate change indicators for Chicago, IL officials and their partners to assist them in making more effective winter climate change adaptation decisions. These indicators could also be used as thresholds to trigger the implementation of municipal adaptation strategies, as well as provide metrics for local officials and the public to assess how well their municipal climate change adaptation measures are working (complementing the Chicago Climate Action Plan's on-line "dashboard" being developed to assess the City's climate change mitigation performance).



- Jaffe, M., M.E. Woloszyn. 2013. *Development of an Indicator Suite and Winter Adaptation Measures for the Chicago Climate Action Plan*. In: 2011 Project Reports. D. Brown, D. Bidwell, and L. Briley, eds. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Chicago_Winter_Adaptation.pdf

DIVERSITY AND DELIBERATION ON CLIMATE ADAPTATION – 2014

Institute/Organization – Macalester College

Climate vulnerabilities are distributed unevenly across races, ethnicities, classes, ages, incomes and genders. The objective of this project was to make climate adaptation personal for those who tend to remain outside of climate change planning discourses. However, engaging these neighborhoods and individuals in climate communication is challenging. Identifying appropriate messengers and language that resonates with these communities is difficult. To address this gap, GLISA provided funding to Macalester College in Saint Paul, Minnesota to launch a pilot program in three low-income, racially and ethnically diverse neighborhoods.



The project team identified whether individuals, the neighborhood, or the city should be responsible for climate preparedness activities.



Through this pilot, project leaders facilitated a collaborative effort with community members to create two climate impact scenarios in each neighborhood, one acute impact (e.g., flooding) and one chronic impact (e.g., heat). By employing videos and other tools, project leaders simulated an event and asked participants to articulate how they would react, identify resources available to respond, and determine gaps in resources.



- Phadke, R., C. Manning and S. Burlager. 2015. *Making it Personal: Diversity and Deliberation in Climate Adaptation Planning*. In: *Project Reports*. D. Brown, E. Gibbons, and I. Robinson, eds. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center. <http://glisa.umich.edu/projects/making-it-personal-diversity-and-deliberation-climate-adaptation>
- Phadke, R., C. Manning, and S. Burlager. 2015. *Making it Personal: Diversity and Deliberation in Climate Adaptation Planning*. *Climate Risk Management* DOI: <http://dx.doi.org/10.1016/j.crm.2015.06.005>

A CLIMATE CHANGE RISKS ASSESSMENT AND ADAPTATION STRATEGY FOR YORK REGION – 2015

Institutes/Organizations – Toronto and Regional Conservation Authority, Ontario Climate Consortium, Regional Municipality of York, Clean Air Partnership

The main objective of this project was to advance climate change adaptation action planning in York Region and thus enhance the resilience of local communities, natural systems, and municipal assets. The core objective of this work has been reached by establishing the processes, tailoring the tools and templates, compiling the necessary information, and enhancing staff capacity to conduct risk and vulnerability assessments and resiliency-based adaptation planning.



Fausto E., Nikolic V., Milner, G., Cline T., Behan K., and L. Briley. 2016. *Assessing and Mitigating Municipal Climate Risks and Vulnerabilities in York Region, Ontario*. Ontario Climate Consortium, Clean Air Partnership and Great Lakes Integrated Sciences + Assessments: Toronto, ON. In: Project Reports. D. Brown, W. Baule, L. Briley, E. Gibbons, and I. Robinson, eds. Available at: http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_OCC_York.pdf

READY & RESILIENT: CLIMATE PREPAREDNESS IN SAINT PAUL, MINNESOTA – 2015

Institutes/Organization – Macalester College

This project extended and deepened engagement with Saint Paul residents by focusing on two previously identified areas of need: 1) more education and 2) reinvigorated social networks. In addition to revising and updating the Ready and Resilient guide produced for the 2014 – 2015 Climate Assessment Award, the team developed a model “modern” climate disaster kit for participants to assemble at a community-wide training. Additionally, pilot projects were created to select, support, and record the efficacy of ideas to address barriers faced by lower-income neighborhoods and communities of color.



Phadke, R., Manning, C., and I. Bardaglio. 2016. *Ready & Resilient: Climate Preparedness in Saint Paul, Minnesota*. In: Project Reports. D. Brown, W. Baule, L. Briley, E. Gibbons, and I. Robinson, eds. Available at: https://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Macalester_2015.pdf

CLIMATE AND EXTREME WEATHER RESILIENCE FOR THE REGION OF PEEL, ONTARIO – 2014

Institute/Organization – Toronto and Regional Conservation Authority

The intent of this project was to provide case studies of vulnerability and risk analysis methods being used to inform actionable strategies for increasing climate resilience. These included priority impacts of climate change and extreme weather with respect to two different community assets within the Region of Peel: (1) Caledon’s agricultural sector, and (2) critical services and infrastructure in Port Credit. These projects focused on building local capacity for understanding and managing climate and extreme weather risks, experience that could be used for similar work in the future.



- Video documentaries (Caledon, Port Credit and project overview), http://climateontario.org/wp/?page_id=699&preview=true
- Switzman, H.R., Dutfield, S.J. and C. Sharma. 2014. *Toward Extreme Weather and Climate Resilience in the Region of Peel: Analysis of Multiple Hydroclimatic Risks and Vulnerabilities in Two Case Studies (Agriculture and Municipal Services)*. In: GLISA Project Reports. D. Brown, D. Bidwell, and L. Briley, eds. Available at: http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_TRCA.pdf

Public Health

MICHIGAN CLIMATE HEALTH PROFILE – 2014 to 2016
Institute/Organization – Michigan Department of Health and Human Services

GLISA worked with the Michigan Department of Health and Human Services (MDHHS) to develop a Climate Profile Report for the State of Michigan. The Climate Profile Report is a synthesis of historical and future climate information for the state, with emphasis on specific geographic areas of concern. With support from GLISA and the Center for Disease Control (CDC), MDHHS previously identified several health risks and associated climate stressors. GLISA is tailoring climate information to address their specific concerns with respect to projected climate change.



GLISA co-authored the Michigan Climate and Health Profile Report 2015 with MDHHS to complete Phase I of the CDC's BRACE pilot program in Michigan. This report identifies five areas of increased health concerns due to climate change impacts.



Cameron, L., A. Ferguson, R. Walker, D. Brown, and L. Briley. 2015. Michigan climate and health profile report 2015: Building resilience against climate effects on Michigan's health. Accessed at: www.michigan.gov/climateandhealth

HEAT AND HUMAN HEALTH: PRESENT AND FUTURE – 2013
Institute/Organization – University of Michigan

Extreme heat events are linked to mortality rates, making them an important research subject in both the climate and public health fields. This research evaluated trends in extreme heat events using observational station data and evaluated long-term heat event trends across the continental United States.



Extreme heat events have generally declined or remained stable in central regions of the country and have increased in southern and coastal regions. Overall, increases seen between 1970 and 2010 were mostly offset by decreases between 1930 and 1970. A large number of daily maximum extreme heat events around the 1930s resulted in a decreasing trend from 1930 to 2010 in daily maximum heat events, while a number of high minimum temperatures in the 2000s led to an increase in the daily minimum extreme heat events. Trends depended on the daily temperature extreme used as a threshold.



Evan M. Oswald and Richard B. Rood. 2014. *A Trend Analysis of the 1930–2010 Extreme Heat Events in the Continental United States*. *Journal of Applied Meteorology and Climatology*. 53:3, 565-582. DOI: <http://dx.doi.org/10.1175/JAMC-D-13-071.1>

PARTICIPATORY MODELING OF EXTREME HEAT IMPACTS – 2013
Institute/Organization: Michigan State University

Local decision-makers lack tools that would help them evaluate policy and management options to reduce heat risk for vulnerable populations, and to prevent deaths and illness once a heat event arrives. This project developed a system dynamics modeling tool, called the Mid-Michigan Heat Model (MMHM), to depict the dynamics of hospitalizations and deaths over the course of a heat event in Detroit. Modelers incorporated input from decision-makers at each stage of the model-building process, and the project culminated with a workshop in which potential model-users offered feedback on MMHM. The process of building a model in a participatory manner was useful for facilitating conversations and data-exchange around an important topic, and for developing a tool with the greatest potential utility.



Participatory modeling is a valuable tool for applying climate data to decision making in the region. This process engaged key public health stakeholders in defining key parameters in an extreme heat impacts model and evaluating the usefulness of the model.



Olabisi, L.S., R. Levine, L. Cameron, M. Beaulac, R. Wahl, and S. Blythe. 2012. *A Modeling Framework for Informing Decision Maker Response to Extreme Heat Events in Michigan Under Climate Change*. In: 2011 Project Reports. D. Brown, D. Bidwell, and L. Briley, eds. Available at: http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Mid-Michigan_Heat_Model.pdf

Agriculture

MICHIGAN AGRIBUSINESS ASSOCIATION PARTNERSHIP Institute/Organization – Michigan Agribusiness Association (MABA)

Our ongoing collaboration with MABA 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. MABA represents a diverse group of agricultural businesses and associations and is engaged with farmers. Our partnership with MABA is focused on providing information on the impact of climate variability and change on Michigan agriculture. GLISA developed new resources, including updated localized climatologies, tailored for agricultural needs, and a potential evapotranspiration (PET) climatology. We anticipate that this collaboration will result in targeted resources aimed at helping farmers improve production efficiency and reduce environmental impacts. By strengthening our partnership with MABA, this collaborative effort will facilitate connections between farmers and researchers, stakeholders and others.



Through this partnership, GLISA developed new data on regional potential evapotranspiration (PET). PET identifies potential water demand by a vegetated surface, under specific atmospheric conditions (e.g., irrigated agricultural crop). PET has the potential to be a critical tool in agricultural water management. Also, we anticipate that PET will help identify key agronomic trends in the region (e.g., increasing use of field tile drainage and irrigation) that require detailed water use information. PET resources will be delivered to the agricultural community via the Michigan Agribusiness Association. The GLISA and MABA team will continue to increase public access to a number of useable climate resources tailored to the agricultural community.

ON-FARM WATER RECYCLING AS AN ADAPTATION STRATEGY FOR DRAINED AGRICULTURAL LAND – 2015 Institutions/Organizations – Purdue University, USDA- Agricultural Research Service, The Ohio State University

The goal of this project was to begin a process of analyzing the potential for increasing on-farm water storage as a climate change adaptation strategy. To gain understanding of the opportunities and barriers to on-farm water recycling in the Great Lakes region, we talked with drainage contractors, agency staff, extension specialists, irrigation dealers, and farmers who have and have not installed on-farm water recycling. We used historic yield data and climate projections to estimate potential yield benefits that could be achieved by the Ohio Wetland Reservoir Subirrigation System water recycling systems under expected future climate conditions.



Frankenberger, J., Allred, B., Brown, L., Gamble, D., Gunn, S., Baule, W., and J. Andresen. 2016. *On-Farm Water Recycling as an Adaptation Strategy for Drained Agricultural Lands in the Western Lake Erie Basin*. In: Project Reports. D. Brown, W. Baule, L. Briley, E. Gibbons, and I. Robinson, eds. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Purdue.pdf

PREDICTING THE IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL YIELDS AND WATER RESOURCES IN THE MAUMEE RIVER WATERSHED (2011) Institution/Organization – Michigan State University

The Maumee River watershed encompasses areas of Southeast Michigan, Northeast Indiana, and Northwest Ohio. After meeting with stakeholders from this area, the researchers developed a coupled crop-growth and hydrologic model to simulate scenarios of climate change impacts on crop yields and water resources across the watershed.



Based on the model results, the research team predicts that simulated corn yields will significantly decline by the end of the century, under a high carbon emission scenario. Also, a medium emission scenario showed moderate crop yield reductions, while a low emission scenario showed small yield reductions. New groups of plants and agricultural economic management strategies are necessary for climate change adaptation and mitigation.

Agriculture

CLIMATE VARIABILITY RISKS IMPACTING THE MICHIGAN TART CHERRY INDUSTRY – 2013

Institutions/Organizations – Michigan State University Extension, Cherry Marketing Institute

The Michigan tart cherry industry experienced two devastating weather events (2002,2012) in the last decade that impacted production, markets, and farm sustainability. This project gathered appropriate weather and climate information for the Michigan tart cherry industry to make decisions about future investments. The research results continue to inform industry leaders on best practices for mitigating risks and appropriating resources to adapt to climate variability and extreme weather events.



Growers indicated a desire to have more information on evidence based risk management methods, especially on frost protection methods. Specifically, support is needed for 1) how to use wind fans, 2) installation of weather monitoring stations 3) analyzing and using data from weather stations, and 4) tying those data to frost protection measures.



Rothwell, N., M Woods, and P. Korson. 2013. *Assessing and Communicating Risks from Climate Variability for the Michigan Tart Cherry Industry*. In: *Project Reports*. D. Brown, D. Bidwell, and L. Briley, eds. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_TartCherry.pdf

AGRICULTURAL BEST MANAGEMENT PRACTICES AND MODELS ASSESSING VULNERABILITY (2013)

Institution/Organization – The Nature Conservancy

Conservation practices in the watersheds of the Great Lakes region focus on connecting agricultural and ecological systems together through best management practices (BMPs) to reduce environmental stress and affect policy changes. The project team studied and assessed the vulnerabilities of BMPs related to climate change to improve the efficiency, effectiveness, and transparency of agriculturally focused conservation practices in the Great Lakes basin.

National Park Service

ISLE ROYALE SCENARIO PLANNING – 2012 to 2014
Institution/Organization – National Park Service Climate Change Response Program

Beginning in 2012, GLISA partnered with the National Park Service (NPS) to integrate climate information into NPS's scenario-planning approach in an effort to evaluate potential impacts on the delicate wolf and moose ecosystem on Isle Royale. Through the development of four scenarios (least change, summer drought, warmer than Duluth, and isle savanna), the team created an easy-to-read table that outlines how each species would fare under each condition relative to its current state. The key findings, released in the workshop report, are summarized as: 1) 'Restoration to past not possible', 2) 'Perpetuation of present unlikely', and 3) 'Make best possible future'. GLISA and NPS partnered again to replicate this process on the Apostle Islands to see if the lessons learned from the Isle Royale engagement are transferable.



A key lesson learned is that there is a need to plan actively for the best possible future, as opposed to trying to restore a past state or maintain the status quo. Planning for restoration or maintaining the status quo without realistically reflecting the changes taking place in our climate and subsequently in ecosystems will not lead to effective and candid vulnerability or needs assessment processes.



GLISA's localization of climate data and information for Isle Royale proved valuable in the scenario planning template NPS uses, and led to a sustained engagement with Apostle Islands National Lakeshore.



N. Fisichelli, C. Hawkins Hoffman, L. Welling, L. Briley, and R. Rood. 2013. *Using Climate Change Scenarios to Explore Management as Isle Royale National Park*. Natural Resource Report NPS/NRSS/CCRPNRR – 2013/714, National Park Service, Fort Collins, CO, 2013. <http://irmafiles.nps.gov/reference/holding/483446>

APOSTLE ISLANDS SCENARIO PLANNING – 2015 to 2016
Institution/Organization – National Park Service Climate Change Response Program

This project focused on re-using the NPS scenario planning processes originally conducted at Isle Royale National Park for Apostle Islands National Lakeshore. GLISA investigated whether the localization of information conducted for Isle Royale could be reused at Apostle Islands to accelerate the incorporation of climate-change knowledge into adaptation planning. Our prototype problem-solving environment, GLISAClimate.org, was the platform for the information reuse.



Although the localization of climate data and information for Apostle Islands was not a straightforward reuse of the information collected for Isle Royale, many of the Lake Superior climate change impact summaries (i.e., lake level, and lake ice trends) could be reused, and the overall process of data collection and synthesis moved more quickly. Our experience with reusing relevant climate data and information for a new, nearby location was encouraging from a human capital and adaptation standpoint—less time is required to deliver the same level of resource, and practitioners can more quickly use that information to make decisions.



GLISA completed their second round of scenario planning using the NPS template, and sustained engagement with the Apostle Islands after the workshop. We are currently researching topics that came out of the workshop in order to develop additional usable information for Apostle Islands.



Jonathan Star, Nicholas Fisichelli, Gregor Schuurman, Leigh Welling, Richard Rood, and Laura Briley. 2015. *Climate Change Scenario Planning Workshop Summary*. Apostle Islands National Lakeshore. <https://www.nps.gov/apis/learn/nature/upload/APIS-Scenario-Workshop-Report-20160104-FINAL.pdf>

Tribal Communities

STRATEGIC FORESIGHT SCENARIO DEVELOPMENT – 2014

Institutions/Organizations – USDA Forest Service, College of Menominee Nation's Center for First Americas Forestland

Traditional knowledge is seen as an important contributor to climate adaptation planning for both American Indian communities and neighboring communities in the region. This project addressed the challenge of how specific Tribes can adapt to climate change in ways that ensure the protection of tribal cultures and harness cultural resources, as well as integrate the best scientific resources about environmental change, address emerging social problems, and negotiate jurisdictional challenges unique to federally-recognized Tribes. The project team explored two questions: 1) Can foresight processes be used to create viable climate adaptation scenarios that can help Tribes build capacities in advance?; and 2) Can foresight processes garner sufficient community involvement for building scenarios that reflect Tribes' cultures, social situations, knowledge needs and resources, and jurisdictional and legal complexities?



1) Different institutions/communities within each Tribe, some of which rarely communicate with each other, were able to share knowledge and insights through storytelling (since scenarios are narratives); and 2) Scenario planning is more than a tool; it is a process. Communications among different Tribal departments, community members and elected officials prior to the scenario planning workshop were just as important as the workshop itself.



Whyte, K.P., M. Dockry, W. Baule, and D. Fellman. 2014. *Supporting Tribal Climate Change Adaptation Planning Through Community Participatory Strategic Foresight Scenario Development*. In: Project Reports. D. Brown, W. Baule, L. Briley, and E. Gibbons, eds. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Strategic-Foresight.pdf

IMPLEMENTING FOREST AND WATER CLIMATE ADAPTATION SOLUTIONS TO BUILD THE RESILIENCE OF TWO NORTHWOODS COMMUNITIES – 2015 to 2016

Institution/Organization – Model Forest Policy Program

This project explored whether rural and tribal communities could increase the adaptive capacity of their forests, waters, and livelihoods by communicating climate science and engaging a broader, regional network of tribal partners to implement a climate adaptation plan. The Menominee Conservation District and the Red Lake Nation Band of the Chippewa Indians were the two Northwood communities involved, both of which depend directly on the benefits of the ecologically and economically valuable Northwood forests. The Model Forest Policy Program supported these communities in addressing their governance challenges, as well as adopting a regional, multi-sectoral approach to achieve more effective climate adaptation implementation.



The project team determined that: 1) the synthesis and translation of climate science for key tribal partners leads to more diverse stakeholder engagement in support of climate adaptation planning and implementation, but this has to go hand in hand with local direct observations, and 2) Tribal-wide and region-wide tribal engagement leads to more successful local and regional-scale implementation of forest and water management strategies for tribal and rural communities in the Northwoods. However, this takes time and effort, and has to be directly relevant to a community or region's more immediate needs and interests. A disciplined focus on a limited number of short-term strategies and objectives that are both concrete and achievable is critically important.



Kleinman, D., M. Hall, D. Buechler, D., and J. Jourdain. 2015. *Implementing Forest and Water Climate Adaptation Solutions to Build the Resilience of Two Northwoods Communities*. In: Project Reports. D. Brown, W. Baule, L. Briley, E. Gibbons, and I. Robinson, eds. Available at http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_MFPP.pdf

Tourism

Transportation

Defense

Tourism**CLIMATE CHANGE AND MICHIGAN'S DOWNHILL SKI INDUSTRY – 2011**

Institution/Organization – Michigan State University

This project assesses the potential impacts of climate variability and change on the winter sports and state parks in Michigan. Researchers interact directly with the winter sports industry and state park managers to identify vulnerabilities and options for adaptation.



- Nicholls, S., and B. Amelung. 2013. *Attitudes Towards Climate Change: Attitudes Towards and Observations Regarding Climate Variability and Change: Evidence from Michigan's Downhill Ski Sector*. In: GLISA Project Reports. D. Brown, D. Bidwell, and L. Briley, eds. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Attitudes_Ski.pdf
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Defense**RESILIENT MICHIGAN: DEPARTMENT OF DEFENSE PILOT PROJECT – 2015**

Institution/Organization – Michigan Army National Guard

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. We have participated in three meetings to date, convening representatives from the three Army National Guard installations in Michigan and their surrounding communities to discuss climate change impacts and adaptation.

Transportation**MICHIGAN DEPARTMENT OF TRANSPORTATION PARTNERSHIP – 2014**

Institution/Organization – MDOT

GLISA participated on the technical advisory committee for the Michigan Department of Transportation's climate change vulnerability risk assessment. This study provides MDOT an opportunity to use a risk management approach to evaluate the likelihood and impacts of extreme weather events on the transportation system. Funding for this effort comes through the Federal Highway Administration (FHWA) and MDOT.



- Posey, J. 2012. *Climate Change Impacts on Transportation in the Midwest*. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators. Available from GLISA http://glisa.msu.edu/docs/NCA/MTIT_Transportation.pdf

Training & Outreach

UNIVERSITY OF MICHIGAN APPLIED CLIMATE PROGRAM

GLISA staff are dedicated to mentoring students in the University of Michigan's Applied Climate graduate program. As part of the degree program, the students must complete an applied practicum, which is under the leadership and management of GLISA staff. The practicums are directly related to the work that GLISA is doing in the region, which allows the students to gain real-world experience in the field of applied climate. Students have developed information for our urban adaptation stakeholders, provided analysis of freezing rain data and extreme precipitation events for the Region, and investigated climate model projections.

OUTREACH AND PLANNING PROFESSIONALS

In October 2015 GLISA staff participated as opening speakers at the Shifting Seasons Summit. 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 workshop was entitled "Gearing up for Change: Climate Training for Outreach Professionals" and was attended by 26 participants from the Great Lakes region. Later that month, GLISA collaborated with Larissa Larsen (U-M Urban & Regional Planning) and Evan Mallen (Research Associate, GLAA-C) to provide a 75-minute training presentation for participants at the Michigan Association of Planning annual conference. The workshop was entitled "Climate Adaptation Planning: Increasing Community Resilience and Sustainability" and was attended by 36 planning professionals from the state of Michigan.

PEER NETWORKS ENGAGEMENTS

GLISA serves in a membership and advisory capacity on a number of membership organizations or peer to peer networks.



Through these engagements, GLISA shares best science practices for the Great Lakes region and provides insight to the scientific and academic communities on stakeholder needs and engagement approaches. *Networks include:*

- Michigan Climate Coalition
- Michigan State University Extension Coalition
- NOAA Great Lakes Regional Coordination Collaboration Team
- American Society of Adaptation Professionals
- Detroit Climate Action Collaborative and Technical Advisory Team
- Ann Arbor Technical Advisory Group

SHIFTING SEASONS SUMMIT

GLISA collaborated with Michigan Sea Grant to obtain NOAA funding and hired an outreach specialist. This specialist provided two key training events for outreach professionals in the region. In October, 2012, a half-day train-the-trainer workshop was delivered for participants of both the Great Lakes Sea Grant Network Meeting and the National NEMO (Nonpoint Education for Municipal Officials) Conference in Duluth, MN.



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. The 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.

Climate Data for Adaptation

GREAT LAKES ADAPTATION AND DATA SUITE (GLADS) 2015 to 2016

Institutions/Organizations – GLISA, Great Lakes Observing System (GLOS), Great Lakes Environmental Research Laboratory (GLERL), LimnoTech, Great Lakes Aquatic Habitat Framework (GLAHF)

Through a Data Management Mini-Grant from the Great Lakes Observing System (GLOS), GLISA has created a data suite—the Great Lakes Adaptation Data Suite (GLADS)—that is a compilation of over-land and over-lake observational information within the Great Lakes Basin. GLADS integrates point-based and gridded observational datasets available through the National Centers for Environmental Information (NCEI, formerly NCDC), the Great Lakes Observing System (GLOS), the Great Lakes Environmental Research Laboratory (GLERL), the Great Lakes Aquatic Habitat Framework (GLAHF), and the Great Lakes Evaporation Network (GLEN) into a single Great Lakes Adaptation Data Suite (GLADS). Each of these suites/frameworks of data has proven valuable to their own user networks. GLISA has standardized these regional data sets to the same time step, variables examined, data structure, and quality control processes to make the data more easily accessible and to increase capacity of researchers to study lake, nearshore, and coastal interactions for climate adaptation efforts.

GREAT LAKES ENSEMBLE – 2015 to PRESENT Institution/Organization – GLISA

In 2015, GLISA formally started the development of an Ensemble of future climate projections for the Great Lakes region. This project is motivated by the need for high-quality climate projections for use in climate change adaptation work. Previous evaluation of a subset of models for the region revealed strong inconsistencies between observed and simulated physical processes of lake-land-atmosphere interactions—the U.S. Great Lakes are known for their impact on local and regional weather and climate, however, the processes responsible for producing lake-effects and lake-induced modifications of weather are often poorly represented or missing from climate models.

To address the need for high-quality climate projections for the Great Lakes region, the Ensemble work will:

1. Develop an evaluation framework, specifically tailored to the Great Lakes region, to provide a regional perspective on the quality of information coming from the models.
2. Apply the evaluation framework to several climate model data sets—including regional modeling efforts—to provide expert guidance regarding the limitations, shortcomings, and appropriate uses of the data.
3. Integrate projections from the models that “pass” our evaluation framework into GLISA’s existing products (i.e., regional climatologies) to provide narratives and visual representations of future climate change information to stakeholders.

Additional Publications

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- Dilling, L., Lackstrom, K., Haywood, B., Dow, K., Lemos, M.C., Berggren, J., Kalafatis, and S.E. (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
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The Great Lakes Integrated Sciences and Assessments Program (GLISA) is a partnership between the University of Michigan (U-M) and Michigan State University, housed in the U-M Graham Sustainability Institute's Climate Center.

As one of ten regional centers in the nation supported by NOAA, GLISA builds capacity to manage risks from climate change and variability in the Great Lakes region. See: <http://www.glisa.umich.edu>