REGIONAL CLIMATE CHANGE ADAPTATION IN THE UNITED STATES

Emily Basham

Nicholas Fantin

Catherine Kent

Sarah Schwimmer

James Toth

AOSS 480: Climate Change: The Move to Action

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Executive Summary

Overview
Changes in our climate affect natural and human systems in diverse ways from the global to the local level. In response, both mitigation and adaptation strategies are required. As greenhouse gas emissions continue to increase past the point where climate change mitigation policies are sufficient, climate adaptation has become an increasingly salient topic. The current issue has become the question of how to determine where it is best to enforce climate policies- on a global, national, regional, state, or local level. Since no comprehensive federal policies or regulations exist in the United States, local and state governments and policy makers have taken the lead on resource allocation and establishment of policies.

This document considers approaches to climate adaptation and mitigation at a variety of scales in order to provide a context for studying regional adaptation. It investigates disadvantages in larger scale approaches at the global and national levels and the challenges presented at those scales. It looks at the best way to take a regional approach to climate adaptation and examines how they are defined. There is support for regional adaptation as it bridges the gap between local-level stakeholder involvement and larger-scale environmental problems. Finally, a case study on the Great Lakes region and Great Lakes Integrated Sciences and Assessments (GLISA) explores the practical applications of the investigation. In this case study, GLISA's goals, recent successes, and its potential improvements will be explored. In conjunction with this section of the project, a catalog of organizations and resources provided to stakeholders was generated.

Recommendations for GLISA
GLISA's current efforts are focused in the state of Michigan; a conscious broadening of focus to the Great Lakes region will improve regional adaptation. Because of its action-oriented mandate, GLISA is well-positioned to conduct gap analysis and prioritize projects that address current holes in adaptation efforts. With the catalog of resources developed, GLISA has the tools to continuously conduct gap analysis. In the immediate term, simple changes to web resources can facilitate collaboration and cross-promotion. In the medium term, outreach to other organizations in the network will work towards a regionally integrated network.

Conclusions for Regional Adaptation
The case study in the Great Lakes region informs adaptation efforts in other regions. The Great Lakes region presents a unique problem in that it very clearly transcends state and even national boundaries and thus requires a regional approach to climate adaptation. Defining the region around a problem in this way facilitates adaptation efforts that involve stakeholders. To date the RISA program's use of this approach appears to be successful. Future regional adaptation efforts will likely follow the same pattern, in that they will be identified by region-specific problems, rather than the product of country-wide policy decisions. Ultimately, climate adaptation that meaningfully involves stakeholders becomes increasingly necessary as changes in climate become more apparent, more salient, and affect the well-being of our economy, environment, and society.

Introduction

The efforts to reduce the effects of climate change within the last decade have been increasing steadily. There are a variety of ways it is being approached, with the primary categories being mitigation and adaptation efforts. Both of these efforts are equally important and complimentary to each other. When developing policies for climate change initiatives it is crucial on how they are implemented. There are many factors to be considered when adopting climate change strategies, such as varying climate, political and demographic borders. The majority of their success is highly dependent on the geographical area that they cover. The defined area must not be too large that the effectiveness is not diminished, moreover not too localized that their affects are negligible to the scope of the problem.

Over the past decades, efforts to reduce the effects of climate change have been steadily increasing. There are a variety of ways this is being approached, with the primary categories being mitigation and adaptation efforts. These efforts are complementary, and both are equally important. When developing policies for climate change initiatives, carefully considered methods of implementation are crucial. There are many factors to be considered when adopting climate change strategies, such as varying climate and political and demographic borders. The majority of climate adaptation and mitigation success is highly dependent on the geographical area that strategies cover. The defined area must not be too large, which may diminish effectiveness, but it also should not be too localized, which may cause affects to be negligible to the scope of the problem.

The Disadvantages of Global Climate Models

Coarse resolution is the primary limitation of global climate models. In order to create actionable plans regarding natural resources, preventative measures, and other relevant issues, regions require information on a more localized, higher-resolution scale than global climate models can provide. People, and, more importantly, policy makers, are interested in the local climate; the temperature, precipitation, and wind activity where they live are often not directly affected by the information presented in global climate models. The resolution of global climate models is in the hundreds of miles, typically around 200 miles. This is too coarse for areas like the Great Lakes region, where lake effect is a localized issue, and a key factor of the regional climate.

Some solutions to overcome the course resolution of global climate models that are already being used are described below (Regional Climate Models):

- Run the whole global climate model at a finer resolution. This requires more time to simulate and great computational power. Or, a shorter simulation period could be used.
- Use a statistical approach to downscale the coarse global climate model to local detail.
- Embed a regional climate model into the global climate model. This is more consistent than statistical downscaling.

The resolution of regional climate models is in the range of tens of miles, typically 15-30 miles. This detail is especially important in regions that have complex terrain or predominant water features. Regional models are more preferable to statistical downscaling because they use the whole global climate model, which accounts for all large scale effects, as input to small localized area of interest. Statistical downscaling of a global climate model makes assumptions that are unverifiable, which can lead to large uncertainties. (Wibly et al) For example, a statistically downscaled relationship that is developed for the current climate could then be used for future predictions, not accounting for potential fluctuations. Shown below, Figure 1, demonstrates the variation in detail and accuracy of both global and regional climate models versus the actual observed conditions.

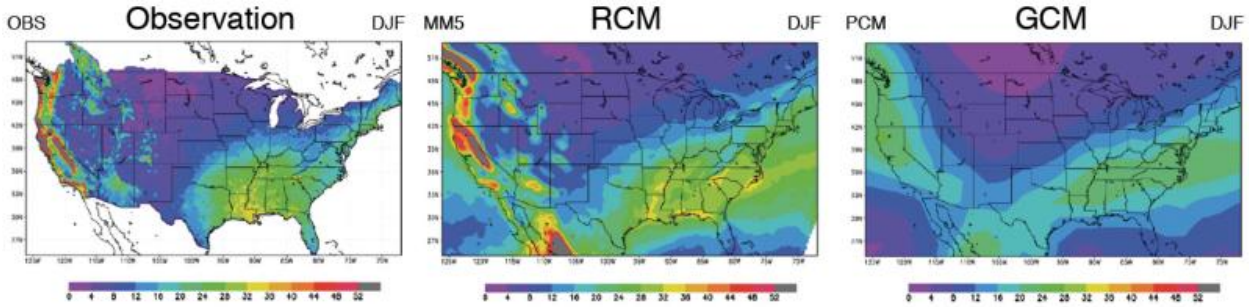


Figure 1 - Climate Model Comparisons vs. Observed Atmospheric Circulation

The regional climate model produces a more accurate depiction of the actual observed conditions. As it is shown, the global climate model does not come close to accounting for the areas of observed maxima.

Inadequacies of a National Approach and State-led Progress

Impactful and appropriate responses to climate change have been difficult to determine, as signaled by the absence of government action around the world. In the United States climate change legislation is absent from federal policy. Instead, regulation has been spearheaded by the states in the form of mandates such as regional cap and trade regimes, renewable energy portfolios, and emissions standards. Although individual states have been the leader in climate change action, many of these efforts require regional collaboration to be effective. When designing strategies for adaptation to climate change, the same regional approach is most appropriate to successfully respond to climate change. This paper explains the importance for a regional approach to climate change adaptation, how particular regions come to be defined, and explores the challenges and considerations to such an approach by looking at the Great Lakes region as a case study and other current regional efforts.

The United States system of federalism creates institutional barriers that handicap national action for environmental policy, as signaled by the inability to commit to international agreements like the ratification of the Kyoto Protocol and the absence of national climate change policy. The concept of "compensatory federalism" explains that other levels of government, namely states, work to compensate for defects or weaknesses inherent to the system of federalism (Derthick 2010). There are characteristics of federalism that account for these shortcomings. One barrier is attributed to the arrogance of power associated with a large centralized government. Although state governments have functioned as policy laboratories, national legislators do not inquire into the lessons that can be taken from state-level experiences and instead "proceed with limited regard for the consequences of their actions for state governments" (Derthick 2010). Subsequently, environmental protection has proven to be an example of state power checking federal power.

Environmental legislation at the federal level is characterized by the inclination to issue unrealistic statutory commands and uniform standards, seen in the Clean Air Act and the Resource Conservation and Recovery Act. These provisions disregard the costs and constraints of implementation and are problematic for a diverse society, economy, and ecology (Derthick 2010). In general, federal policymaking is susceptible to paralysis due partly to institutional design, but also because of the crowded agenda, high stakes, high visibility, and need for a supermajority (Derthick 2010). These barriers to policymaking at the federal level are extremely evident in environmental legislation. Despite high political feasibility, the 111th Congress spanning 2009-2011 once again failed to pass federal climate legislation.

Unrestrained by these barriers, states have emerged as the leaders in environmental policy. With a narrower focus, states are more cohesive and homogenous and, thus, can reach consensus on policy action more timely (Posner 2010). States have been significant actors in political execution, developing programs like smart growth plans and recycling initiatives. Climate policy championed at the state level has instigated progress regionally, at the national level, and globally. In 1991, Iowa developed the first statewide Renewable Portfolio Standard (RPS), which reserves a portion of the energy market for renewable resources. As of 2009, mandatory RPS policies have been implemented in 29 states, accounting for over half of the nation's retail electricity sales (Rowlands 2010). In 2002, California became the world's first government to

instate carbon emission restrictions on new automobiles, a policy that later became the model for the national program for mandatory fuel economy. In 1993, Wisconsin also became a world leader by mandating full disclosure of carbon emissions from a wide set of sources (Rabe 2010).

Perhaps the most far-reaching climate policy innovation initiated at the state level used regional coordination to facilitate implementation and achieve emissions reductions. It was initiated in 2001 by the passing of carbon cap-and-trade legislation in the state of New Hampshire, expanded to become a ten-state regional network in 2008, and 4 Canadian provinces. The ten-state regional network, the Regional Greenhouse Gas Initiative (RGGI), is a largely successful program that uses an auction-based system to trade emissions credits, auctioning nearly all of its carbon allowances in the first year of implementation (Rabe 2010). RGGI and other programs such as the Western Climate Initiative are successful programs where states organized by region to advance environmental policy in ways the federal system has yet been able to accomplish.

The presently insurmountable obstacles at the federal level for environmental policy exemplify the inadequacy of federal environmental management. Although management needs to have a national lens because environmental problems have far-reaching effects, state-led progress is indicative of the pertinence of a more localized focus. States may be more progressive in passing policies and regulations for climate change, but the effects of climate change are not dictated by state boundaries or political systems. Policies for environmental management in the United States is operational at the federal level and momentous at the state level, but is exclusive to management approaches for mitigation rather than adaptation to the effects of climate change. Failure to develop and invest in approaches for adaptation will leave the nation "poorly prepared to cope with adverse changes and increases the probability of severe consequences [of future climate change]" (Scheraga 1998). Thus, it is important that national dialogue includes adaptation to climate change, but this approach will not be appropriately addressed through the political system.

Although efforts to mitigate climate change are at the forefront of the global environmental movement, an increase in the earth's temperature and subsequent effects of this increase are inevitable. However, the impacts of climate change will occur at different spatial and time levels (IPCC 2007). "The human and ecological systems that are sensitive to climate change, and the degree to which they are vulnerable, will vary geographically" (Scheraga 1998). Not only do the changes in climate vary across regions, but also the associated effects, and therefore warrant adaptation strategies that are dictated by regional consideration. Despite an increase in global average temperature, parts of the United States such as North Dakota and Oregon have experienced an increase in average temperatures of up to 3C while other areas in the southwest United States have experienced paralleled decreases. Such variation has implications for the categorization of future ecosystems, the knowledgebase of these systems, and the organization of adaptation strategies (Scheraga 1998).

The varying impacts of climate change present both risks and opportunities that need to be considered concurrently. An evaluation from the EPA points out that the systemic nature of climate impacts complicates the development of adaptation strategies because an adaptation strategy that may protect one particular system may, inadvertently, increase risks to other systems (Scheraga 8).

Approaching climate change adaptation at the national level can pose a number of challenges due to the sheer scale of the undertaking. These challenges include disconnects between information providers and information users, a lack of organizational resources and support, and fragmentation and redundancies. A national level approach can make it difficult for information-providers to create information that fits the specific needs of decision-makers. Furthermore, a national approach does not typically enable the critical link between stakeholders and climate scientists through which they can actively work together to create decision-relevant research and information (Miles et al 2006).

Challenges to a Regional Adaptation Approach

Although this report recommends the strengths of regional approaches, there are legitimate challenges to a regional climate adaptation approach that must be recognized. While one of the strengths of the regional approach is its small scale, this is also one of its weaknesses. Climate problems do not follow geo-political boundaries; many climate issues transcend state lines and international borders. Examples of this include sea level rise, Missouri River basin flooding, heat waves, and El Nino Southern Oscillation Events (ENSO).

ENSO events provide a strong example of the challenges that a large-scale global phenomenon can pose for a smaller-scale adaptation approach. Over the past two decades, scientists have made major advances in the ability to predict ENSO events up to a year in advance (Dillings and Lemos 2011). These advances in forecasting suggested that decision-makers in affected nations use forecasts to prepare for impacts of ENSO events (Dillings and Lemos 2011). Some nations have used these forecasts. The United States predicted the 1997-1998 ENSO events six months in advance and, as a result, an estimated 850 lives and billions of dollars were saved (Miles et al 2006). Because of the national forecasts, California was able to prepare for an increased risk of flooding, and other regions were able to reduce heating costs to consumers in anticipation of an unusual severe winter (Miles et al 2006). Despite this success story, research shows that climate predictions are not typically used well, if at all: every empirical study conducted before 2006 shows that forecasts are underused (Miles et al 2006). Studies attribute this fact to institutional barriers and a lack of understanding among decision-makers (Miles et al 2006).

Many of these barriers are caused by the very same problems that weaken a national approach. Both global and national observational and adaptive capacity is highly fragmented, with "different systems having been established at different times by different organizations for different reasons, all without cross-calibration" (Miles et al 2006). No structure currently exists to coordinate these disparate parts into a cohesive whole, a fact which researchers believe is a major barrier to forecast use. Due to this, global, national, and regional observations and forecasts are not easily integrated into an actionable format for all parties for whom this information is relevant.

Another obstacle to forecast usage with large-scale events is the disconnect between information providers and information users (Miles et al 2006). If a research team is working in one nation, it may be difficult for the information-users and decision-makers in another nation to utilize their forecasts. Not because the forecast information is poor, but because consistent dialogue between research teams, political agencies, and stakeholders has been shown to increase forecast usage by facilitating region-specific information (Miles et al 2006). In order to form the effective relationships necessary to cope with large-scale climate events, greater international, national, and regional connectivity is needed.

Ultimately, these barriers are institutional and there is great potential for them to be improved in the future. In order to avoid suffering unnecessarily from large-scale events, regions need highly-developed climate adaptation organizations with the ability to create region-specific forecasts and work directly with decision makers.

Challenges of Regional Climate Mitigation

There are two primary policy related responses to climate change: mitigation and adaptation. Climate change mitigation policies seek to reduce greenhouse gas emissions or to improve the rate at which these gases are removed from the atmosphere, whereas adaptation climate change policies seek to reduce the vulnerability of human and natural systems to the effects of climate change.

There has been somewhat more of a focus on mitigation efforts than on adaption, due to the desire to significantly reduce greenhouse gas emissions in order to effectively combat climate change. Therefore, within the last decade there have been enormous efforts towards the reduction of greenhouse gas emissions through alternative and renewable energy sources, energy efficiency and conservation, and even geoengineering.

While these efforts are a necessary component to combat climate change, the current political atmosphere suggests that they may not happen quickly enough to prevent significant climate problems in the United States. Many of these advancements take years to develop and implement at a large scale level. During this delay in policy development and implementation, greenhouse gas emissions continue to increase. Many sources point to the fact that even if emissions where stabilized in the near future, the effects on the climate at their current level would last for many years.

Adaptation prevents a vital and necessary alternative in efforts to address the issues created by climate change. There has been some debate over whether or not climate adaptation policies are a good approach to climate change, however, neither mitigation nor adaptation should be considered the single answer to the problem. Rather, mitigation and adaptation should be viewed as complementary strategies to each other in the response to climate change.

There have been a fair amount of regional climate mitigation initiatives created within the last decade. The figure below maps out some major mitigation initiatives in the United States.

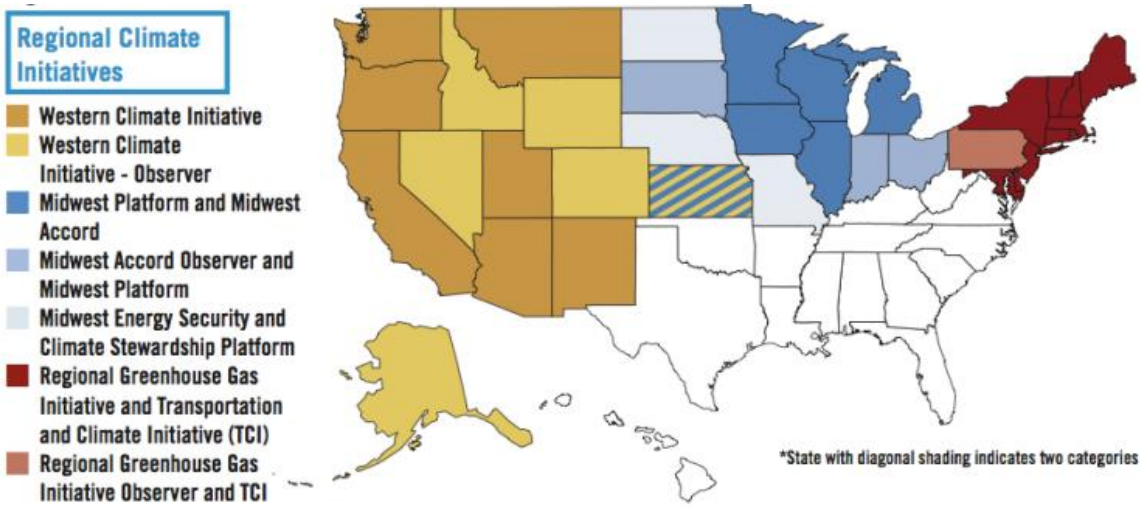


Figure 2 - Regional Climate Mitigation Initiatives

The majority of these initiatives operate as cap and trade programs, selling emission allowances and then investing the proceeds into mitigation efforts. The Regional Greenhouse Gas Initiative (RGGI), in red, was the first market based cap and trade regulatory program in the United States to reduce greenhouse gas emissions. The states in the RGGIs have made the goal to cap emissions from the power sector by 10 percent by 2018. (Multi-State) While the efforts of these initiatives are important, their planned reductions are modest compared to the scale of climate change. Also, some of the initiatives have become stagnant after making their recommendations, such as the Midwest Greenhouse Gas Reduction Accord.

Because the efforts of many of these initiatives are relatively negligible, the rate at which greenhouse gases are emitted will continue to increase; and even if emissions were stabilized right now by all of the regional initiatives, climate change and its effects would be felt for many years to come. For this reason, there must be another component to help cope with the situation. Therefore, adaptation at a regional level is a necessary and complimentary strategy to effectively handle climate change.

Support for Regional Climate Change Adaptation

Because the local level is where most climate adaptation services are actually delivered, it is important to understand the social reasons for a regional approach to climate adaptation. There is a solid body of research supporting the psychological and sociological strengths of regional approaches to climate adaptation.

In recent years, Americans have increasingly begun to draw on personal weather experiences as the basis for their belief in climate change. According to a recent study published by the Brookings Institution, more Americans than ever before are pointing to personal experiences with weather events as the main reason they believe in global warming (Borick and Rabe 2012). The reasoning behind individuals' beliefs appear to be largely influenced by the region they are from: 42% of individuals from the South cite severe drought as the main reason for their belief in global warming, while only 25% of those in the rainy Northeast cite drought as having an influence in their beliefs on global climate change (Borick and Rabe 2012). About half of Americans now cite personal observations of temperature change and weather events as the main reasons they believe global warming is occurring (Borick and Rabe 2012). This evidence that individuals are highly influenced by region-specific weather events supports a region-specific approach to climate adaptation, since it enables researchers to produce information that is highly relevant to the concerns of residents within their region.

Experience has also shown that connections between climate scientists and stakeholders are most effective at the regional, state, and local scales at which stakeholders operate (Miles et al 2006). Because scientists and information users do not make the same assumptions about what information is useful and what they know is usable (Lemos and Rood 2010), collaboration between the two is especially important in order to create actionable information. In northeast Brazil, scientists from the state meteorological agency produced seasonal climate forecasts (SCFs), believing that this information would be useful for farmers, and found that agricultural policy makers perceived SCFs as most useful when the forecasts could be used to issue a strict planting calendar (Lemos and Rood 2010). The farmers themselves had different views and needs than the agricultural policy makers, demonstrating how perceptions of information usefulness are influenced by different contexts and factors (Lemos and Rood 2010). These interactions between scientists and users are essential in facilitating the customization of information to make it relevant and actionable.

These interactions are also important in building a high level of trust between information users and scientists (Dillings and Lemos 2011). Relationships between users and producers build social capital among the involved parties, which can help prevent issues of distrust, misunderstanding, and perceived irrelevance (Dillings and Lemos 2011). Credibility, legitimacy, and salience have been found to be strong determinants of information use (Dillings and Lemos 2011). Long-term commitments, such as those taken by the RISAs, have been found to increase trust through established relationships, thereby increasing the use of SCFs and other climate information (Dillings and Lemos 2011).

An Example of Successful Regional Adaptation: RISA

In order to better understand the potential of regional adaptation, this section will examine NOAA's Regional Integrated Sciences and Assessments (RISA) Program, which is a highly regarded example of regional adaptation.

According to information provided on their website, the RISA Program was started by NOAA in an effort to facilitate better connections between climate sciences and society. Established in the mid-1990s, the RISAs have helped create a new paradigm of stakeholder-driven climate sciences, intended to directly address societal needs and concerns, as their webpage states. The regional assessment teams conduct research and provide information on an array of climate-sensitive sectors, including water resources, fisheries, wildfire control, agriculture, human health, and coastlines.

There are many aspects that make the RISA programs so effective. The principle upon which the RISA program was founded, the intention to build stronger connections between stakeholders and researchers, is one of its greatest strengths. The level of interaction between information providers and information users that the program has achieved has been found to be a critical measure behind increased information usability in the RISA regions (Dilling and Lemos 2011). The explicit goal to build long-lasting partnerships between regional research assessment teams and groups of stakeholders has been shown to lead to increased utility of decision tools and climate forecasts (Miles et al 2006).

These close partnerships make it easier for region-specific climate-based forecasts and information to be made relevant to the concerns of decision- and policy-makers. Many of the RISAs actively involve stakeholders in the determination of research directions through workshops, direct communication with researchers, and stakeholder consultation (Dilling and Lemos 2011). Most of the RISA teams are university-based, but the programs also draw on researchers from nonprofits, government research facilities, and private-sector entities (Miles et al 2006). In this way, they involve and utilize multiple resources specific to their region, which further increases the degree of collaboration between researchers and stakeholders.

Regional Classifications

Within the discussion on regional adaptation, it is important to consider how to define region. Presently, there are no set rules regarding how this should be done, so various methods are used. At the same time, some common methods are used across organizations. The simplest method utilizes political boundaries. This is due to the legal boundaries that correspond to each political region. In the US, this explains why groups operating inside the US will most likely only operate within the US and. This occurs because it prevents conflict with the laws of other countries.

A potential method of defining region is by its climate. An example for this would be the Köppen climate model which looks at trends of various annual conditions. This would involve studying an area to see if it has an annual average temperature above 22C and, if so, it would be assigned a classification letter along with looking at minor traits. Together these characteristics generate a 3 letter code for example; Michigan would get Dfa due to its moderate climate (World Maps of Köppen-Geiger climate classification). Taking the Köppen idea one step further by including something such as plant life, it is also possible to define a region by its ecosystem (Explore Five of the World's Main Biomes); however, both of these methods would prove too detailed in the classifications for a regional adaptation group to properly utilize. However, an alternative method would be to use only the first letter or first two letters for climate classification or for ecosystems use dominate tree types (e.g. deciduous forest).

Most regions are defined geographically which means that the area is divided up by basic zones. In the US, the 5-6 states in the northwest area of the map are usually called simply the northwest region. However, another interesting method used in classification is by impact or problem. In this case, if there is a large area that would suffer the same results from climate change, it is then classified as a region with the idea that the solutions to the problems in this region would be similar.

In examining the various groups and how they defined their regions, two types of group classifications emerged. The first one was “Information based” groups that focus more on making sure resources such as temperature records and history of climate behavior are easily available to groups, decision makers, and the general public. Secondly, “action based” regions are more focused on the actual data collections as well as direct interaction with key decision makers for climate policy. This includes working with stakeholders such as farmers and assisting them in preventing damages from climate changes and helping them to learn how to adapt to climate variability and change. The described classifications are not exclusive; because, resource groups maintain updated archives and the action groups provide findings to those who need the information.

Information groups as described above follow similar trends when it comes to dividing the regions in the US. This entails dividing the contiguous US once horizontally and twice vertically, while counting Alaska and Hawaii as their own regions. An example of this is the United States Geological Survey (USGS), as seen by the map below. The USGS states their focus is on the management of a region's resources and how to manage the resources for possible climate impacts in order to preserve them (U.S. Department of the Interior Overview). Next, the National Weather Service (NWS), which keeps detailed weather records, both past and present, defines

regions as the US divided into 4 parts (NWS Climate Services Division). In addition, NOAA Regional Climate Centers (NOAA RCC) which provide up-to date climate archive information to decision makers at every level (local to national) about climate change follows a similar regional division to the USGS. (Regional Climate Centers)

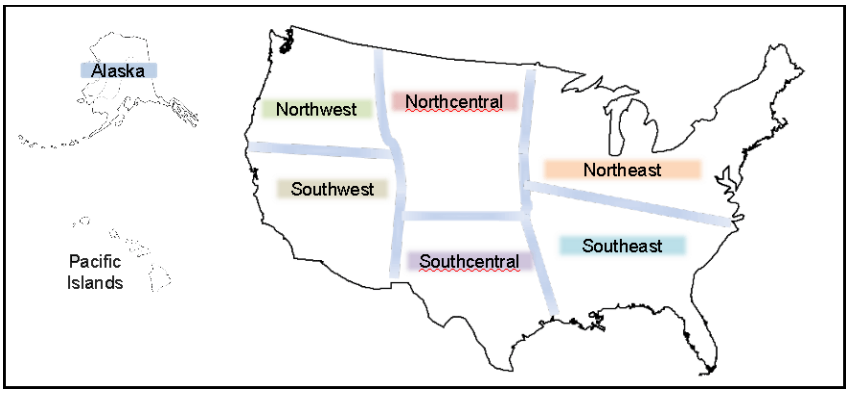


Figure 3 - Regional map used by the USGS

For the action based regions, regional identification is bit more complicated. These groups tend to focus on projects such as data collection of various types depending on the interest of the group, such as local climate changes to potential harm from climate change, direct interaction with decision makers, about events involving climate change and how to prevent negative effects and/or adapt to changes. However, most of these groups are highly specialized with one or two primary focuses which is reflected in their region selections. In other words, the region only consists of the areas that are relevant to the group. A prime example of this is the RISA program because it is composed of multiple small groups of a few states, each operating with its own goals. RISA, as a whole, promotes research of climate issues that is specifically relevant to decision makers. (Climate Program Office) Outside of RISA, there are groups such as the Midwestern Regional Climate Center (MRCC), which is similar to GLISA in location and size but is focused on the research on how climate changes would affect things such as lake effect and, in turn, how that would affect the environment, health, water resources, etc. (MRCC Overview)

Examining the two types of groups informs recommendations for regional groups. The first is to promote collaboration between the various groups and share information, because redundancies occur in data collection. From this lack of proper collaboration various gaps are present as well due to too many groups covering the same things and would only reduce the efficiency potential for groups. Also, groups such as GLISA need to have a region defined to the scope of the problem. Most groups already do this, and should be noted as a best practice for possible future groups. Ultimately, higher resolution models would be ideal for each of these groups because their effectiveness is limited to the quality/accuracy of the information they provide to the necessary people.

Regional Adaptation Case Study: Great Lakes RISA

This project examines the Great Lakes Integrated Sciences and Assessments center (GLISA) as a case study in regional adaptation. This organization, one of the NOAA RISAs, defines itself as a boundary organization between science and decision-making (2011 Grant Recipients), typical of many of the RISA programs (Buzier 2010). In particular, GLISA seeks to:

- Develop a database and network of stakeholders in the region.
- Conduct research that addresses knowledge gaps.
- Compile climate information and develop approaches to improve usability.
- Develop best practices for use of climate information (GLISA Program Summary).

The study of this organization and its current projects allows for better understanding of regional climate adaptation. This project provides recommendations to improve its function as a Great Lakes adaptation center.

Summary of GLISA Activities

GLISA, founded in 2010, focuses on the watersheds of Lake Huron and Lake Erie in Michigan, Ohio, and Ontario, but encompasses the broader Great Lakes basin. Focus areas include agriculture, watershed management, urban management, and natural resources-based tourism. During its first year, GLISA researchers studied stakeholder documents, science-policy networks, and downscaled climate data and its use (About GLISA). The organization funded researchers focusing on climate impacts (2011 Grant Recipients), and partnered with local NGOs to provide climate information (Kent and Bidwell). GLISA developed an E-Newsletter and a social media presence (About GLISA), and is currently developing its web resources to facilitate collaborative problem solving (Briley).

Evaluation of GLISA Activities

Current Successes

GLISA is focusing many of its efforts on methods supported by the RISA literature. The GLISA projects provide information directly, solicit feedback on useful information, and encourage relevant science.

Direct Provision of Information

Research on stakeholder interactions suggests that co-production of knowledge and information brokering are important to success (Dilling and Lemos 2011), and that few top-down interactions lead to actual use of application of climate information to stakeholder decisions (Towler 2011). GLISA's staff act on this knowledge by working directly with stakeholders to provide relevant information. For example, GLISA acted as an information broker and facilitated co-production of knowledge in a project with the Huron River Watershed.

Researching Useful Information

Many information users have noted the breadth of climate information available, and some have identified it as an obstacle to use of information (Towler 2011). GLISA's projects research what makes information relevant to stakeholders; this was a central focus of the GLISA annual

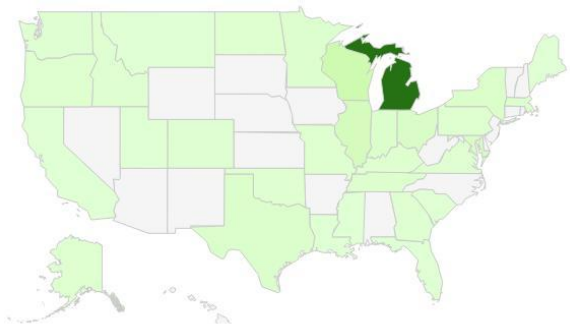
meeting in 2011 and a theme of GLISA-funded projects (GLISA). The 2011 GLISA-funded project on decision maker response to extreme heat events includes a participatory workshop that asked stakeholders to identify what information is most useful to them (Kent and Bidwell). Current social science evaluates the interactions of GLISA scientists with the HRWC (Frank and Lemos 2012) to facilitate successful information brokering in the future.

Encouraging Relevant Science

GLISA encourages relevant science through the GLISA grants competition, which makes funding contingent on the meaningful involvement of stakeholders in the process. During the 2011-2012 year, one grant recipient in particular was adamant that the grant and its conditions changed the project in a real way, adding an entire additional stakeholder component to the project (Hyndman 2012).

Primary Investigation

Preliminary observations identified a potential weakness in GLISA's operation as a regional climate adaptation center because efforts are heavily focused in Michigan. All of the five projects funded in 2011 had a person on the research team focused in Michigan, and four of them had Primary Investigators from Michigan State University. Demographic analysis from Google Analytics of the GLISA website as shown below displays the large number of visitors from Michigan and the poor reach into other states (Wisconsin in particular will be discussed later).



Google Analytics from the www.glisa.umich.edu site show a disproportionately large number of visitors from the state

1.	Michigan	263
2.	Wisconsin	28
3.	Illinois	18
4.	Ohio	11
5.	Maryland	10
6.	New York	8
7.	Indiana	7
8.	Texas	7

These observations are consistent with the original Program Description provided by NOAA, and are structurally integrated into program's design because seven of the eight Co-Investigators are based in Michigan (About GLISA). However, GLISA's stated goals encompass the whole region. To better achieve objectives of a regionally integrated network and compilation of information, the project researched organizations working on climate adaptation projects in the region, and the resources those groups provide.

Methodology

The project developed a matrix of organizations working on climate change adaptation for the Great Lakes region and the resources provided on the websites of those groups. Organizations were identified through snowball sampling with an initial sample of organizations with resources on the GLISA website. There are so many organizations that it would be difficult to draw meaningful conclusions from the collection of all of them, and because GLISA seeks to provide relevant information to stakeholders (GLISA Program Description), the research narrowed its focus to organizations that provide informational resources specifically designed for stakeholders. Organizations were selected that published "stakeholder-friendly" documents, such as fact sheets, webinars, or presentations.

Wisconsin Initiative on Climate Change Impacts (WICCI)'

WICCI stands out as a regional climate adaptation organization. Its trajectory was examined through web research and interviews with its Program Manager to glean best-practice information.

Creation and Organization: The driving force for its creation in 2007 was atmospheric scientists who desired to downscale datasets who realized they needed to know what the data would be used for before they could create the datasets. The Science Council consists of scientists from UW-Madison and the WI DNR and provides downscaled climate projections to approximately 15 working groups, the focus of which are climate impacts (such as water resources) as well as geographic areas (such as Green Bay). The use of specific Working Groups is a driver for its success, according to the Program Manager. A flexible process of working group creation and activity has helped sustain momentum.
Work Groups: Work Groups are all staffed by volunteers, recruited primarily through word-of-mouth and networks within groups of experts. Recruitment happens most often at meetings and conferences, as well as by phone calls. Oftentimes people encounter the organization on their own and request to join work groups.
Work Groups are all self-governing, which recently poses a problem finding leaders of the groups. A proposed solution for this is to split large groups into smaller, more specific topics to lessen responsibility. For example, the agriculture work group will likely split into specific crops.
Funding: The organization is staffed by volunteers, with the exception of the Program Manager, which is a half-time position funded by the University of Wisconsin-Madison Nelson Institute (Betz 2012).

In addition to cataloging the organizations mentioned, the project also created a catalog of the specific resources provided by each organization. The resources provided serve as a proxy measure for how well the organization is providing climate information.

Results of Investigation
Please see attached Excel file.

Network Extent and Organization
Many organizations have overlapping mandates, both in terms of their geographic extent and the impacts covered. For example, there are more than 10 organizations with a Great Lakes mandate.

The network is disorganized, with no central authority. There is little integration at the regional level, evidenced by the lack of links to related groups on many of the organization's websites. However, there was evidence of state-level networks, particularly in Wisconsin, Ohio, and Michigan.

Lack of regional coordination can cause redundancy in efforts, as organizations take on similar projects and repeat similar research. To illustrate, two organizations have created a webinar with the identical title of Great Lakes Climate Change Impacts on Public Health. Lack of coordination also causes collective action problems, where projects that would otherwise happen do not because each organization assumes another one will handle the problem. This is of particular concern in Great Lakes climate adaptation (Brown 2012). The specific issues that may be a result of collective action problems are identified in the Network Capacity analysis that follows.

Network Capacity by Geographic Extent
The states with evidence of state-level networks for climate adaptation (Wisconsin and Ohio in particular) provide the most climate information to stakeholders. Michigan has a fledgling organization –

the Michigan Climate Coalition - that is attempting this apart from the activities of GLISA. On the other hand, Indiana and Pennsylvania in particular have very few available resources for climate adaptation. They may be disconnected from Great Lakes efforts due to the shortness of their coastlines. This suggests that GLISA focus efforts there, as they are particularly needed.

Another hole identified in the network is international collaboration. Besides the International Joint Commission (IJC), there was little mention of collaboration with Canada, and the IJC does not provide climate adaptation information for stakeholders. The 2012 International Upper Great Lakes Study noted, "No bi-national organization currently is responsible for coordinating data and information on an ongoing basis for adaptive management efforts in the Great Lakes basin" (IUGLS 2012). According to the GLISA goals, this is the type of activity the organization seeks to accomplish.

Network Capacity by Sector

Analysis of the existent organizations shows which sectors, or groups of impacts, are best covered by existing efforts.

Agriculture. In most states, agricultural extension services provide information to agricultural stakeholders. Most of these organizations have a small part of their program addressing climate change. Thus there is good infrastructure and satisfactory resources for agricultural adaptation across the region.

Water Resources. In most states, the NOAA Sea Grant provides extension services related to water issues. The Sea Grant Great Lakes Network provides some regional coordination. Each of these organizations has a component of the group that considers climate change issues. At the regional level, a variety of groups that focus on Great Lakes water issues. Thus there is saturated infrastructure and sufficient resources for water issues adaptation.

Tourism and recreation. No formal organizations were identified and few resources available for the impacts on recreation and tourism, though this is a focus area of GLISA. A notable exception is information provided by the National Park Service to manage parks.

Other sectors. There do not appear to be dedicated organizations for many other impacts. The Midwest Climate Assessment 2012 heightened the importance of public health impacts, but regional impacts from public health have been projects of state agencies in Michigan (funded by GLISA), and broad-spectrum topics of presentations by some of the organizations identified. GLISA could fill holes in the network by continuing to support adaptation projects considering public health concerns.

The following table summarizes results of the investigation.

Well-covered	**Not well covered**
Wisconsin	Indiana; Pennsylvania; New York
	Ontario
Water Resources	Tourism/Recreation
Agriculture	Biodiversity
	Public Health
	Transportation

Recommendations for GLISA
Suggestions for improved regional adaptation are based on theoretical investigation as well as the catalog described above.

Pursue a More Regionally Integrated Strategy
GLISA would better act as a regional adaptation center if it better expands its activities outside of the state of Michigan. This is particularly relevant for the geographic areas identified immediately above for which few adaptation resources are available to stakeholders.

A more regionally integrated approach would consist of GLISA at the center of a network of organizations providing climate adaptation information. On the climate outreach side, state-level services like extension offices and Sea Grant offices - or more formalized programs like WICCI or the Michigan Climate Coalition - facilitate adaptation at the state level. As the organization researching stakeholder information use, GLISA shares methods and resources with these organizations to expedite their development and facilitate implementation of best practices.

A region-wide strategy advances the goals of each individual organization by opportunities for cross-promotion. People understand information better in context, so their introduction to GLISA through an organization with which they are already familiar would expedite understanding. This is also useful for promotion of organizations through social media. Communication across the network facilitates easier maintenance of the organizations and resources catalog, which not only supports the GLISA goal of compiling climate information, but also facilitates gap analysis to identify areas of need.

Immediate term actions
The following are "low-hanging fruit" actions GLISA can take in the near term. Recommendations are biased toward the web portion of GLISA activities because of the Internet-based nature of our investigation.

Web Promotion
To facilitate cross-promotion efforts, GLISA can create a section or page of its website that details related organizations as identified by this report. Links could be posted under a Resources tab that also listed current projects in the region and also linked to the GLISAClimate site. Next, it is recommended that GLISA reach out to these organizations and request that GLISA resources and projects be featured on their sites as well. This would be particularly important for other sites that post collections of resources, namely GLIN, Michigan Climate Coalition, and OSU Changing Climate. This would streamline resources in the region, which is necessary because there is little concordance between posted resources across sites.

Streamline Intraorganizational Resources
It is recommended that GLISA streamline postings between the GLISA site, GLISA Climate, and the resources collected. This is especially timely considering the collection of resources identified, many of which could be posted to GLISAClimate.

At present, the GLISAClimate site includes a fair amount of academic articles on a variety of topics, but many materials created specifically for stakeholders - webinars, fact sheets, videos - are largely absent. Although the catalog of resources created for this project might be useful to

some, it will quickly become out-of-date, and the multiple tags features of the GLISAClimate site are ideal for organizing the multimedia and interdisciplinary resources which are available.

Medium term Actions

In the medium term, movement toward a regionally integrated approach includes development of relationships between GLISA and the state-level organizations described. There is evidence that the new GLISA grant process is already doing this to a small extent (Betz 2012, Bidwell 2012), though the award of 2 to 4 grants as planned cannot have a large impact by itself and will not address needs in areas of focus identified above. The websites of the organizations identified in the catalog often include stakeholder outreach representatives, whose professional development would benefit from being involved in the program. GLISA could develop an introductory message to send to these groups, and utilize a student employee to respond to any inquiries and facilitate transfer of knowledge.

Long term Actions

If the above actions are completed and GLISA successfully establishes a regional climate-change network, it would provide fodder for its own social science research program. In addition, the results of the efforts would be best used to inform regional adaptation programs in other regions of the country.

Conclusions

Considering institutional barriers in the current political climate in the United States, regional climate adaptation presents a viable strategy for adjusting to the adverse affects of climate change. Regional adaptation is strongly supported by various scientific, political, sociological, and logistical factors. This approach is further supported by the detail, accuracy, and relevance made possible by regional-scale climate models. Regional adaptation facilitates collaboration between information users and providers, which directly increases the usability of climate information. It combines the advantages of local-level provision of information with the scale of environmental and climate adaptation problems that transcend state boundaries.

Adaptation efforts in the Great Lakes region present a good start for a regional adaptation approach. GLISA, the Great Lakes RISA, is presented with an opportunity to take a leadership role in coordinating adaptation efforts in the Great Lakes region. Continuous assessment of the goals of the organization, its successes, and opportunities for improvement presents the best option for improved climate adaptation in the Great Lakes. Within this region, better coordination among existing networks and projects will improve regional-scale adaptation; this will likely apply to other regional climate adaptation programs as well.

For regions across the United States, the timing and the nature of climate change impacts will vary by geographic region. Approaching these problems on a regional scale with flexible strategies enables adaptation approaches to focus on region-specific impacts, utilize more accurate information, and provide climate resources to those that need them.

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Appendix A: Additional Figures

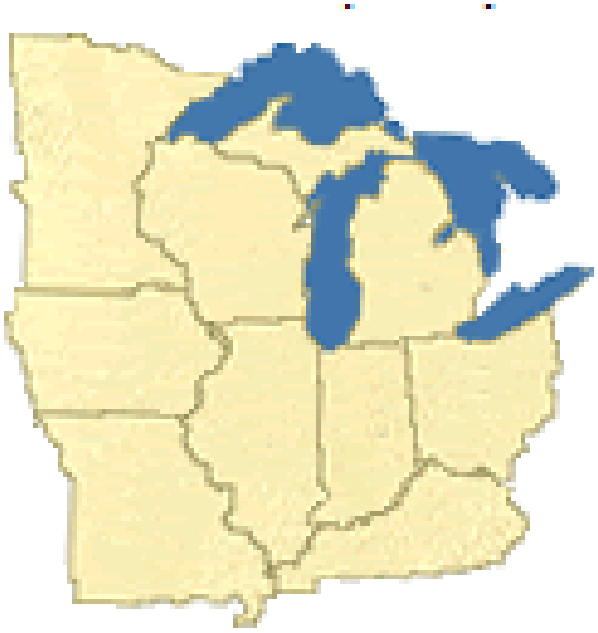

Figure 4 - Regional Map For the Midwest Regional Climate Center (MRCC)

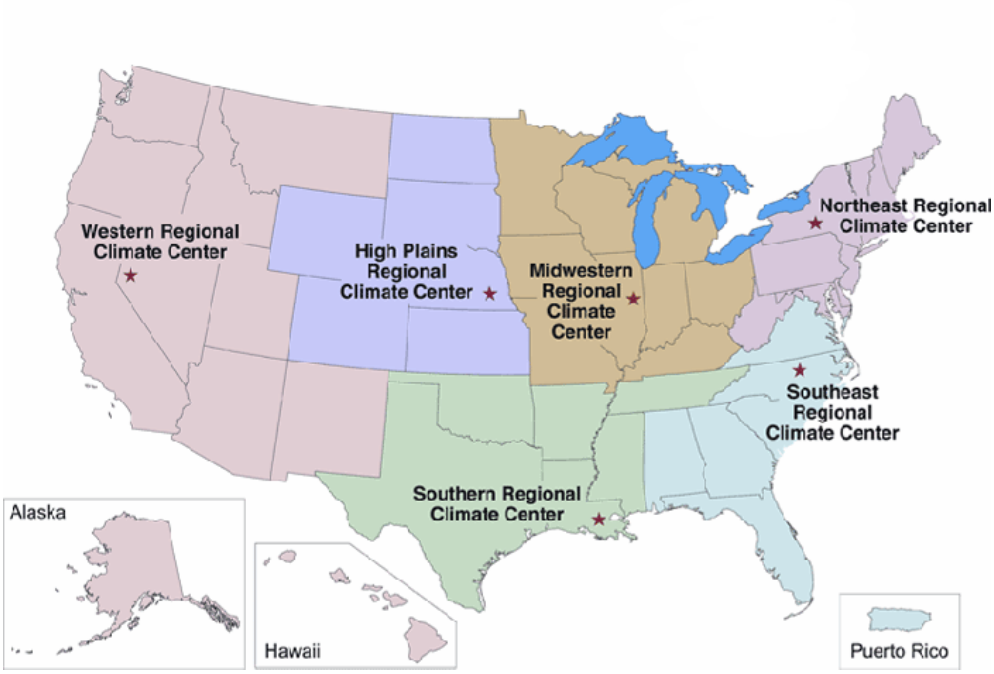

Figure 5 - Regional Map For the NOAA Regional Climate Center (NOAA RCC)

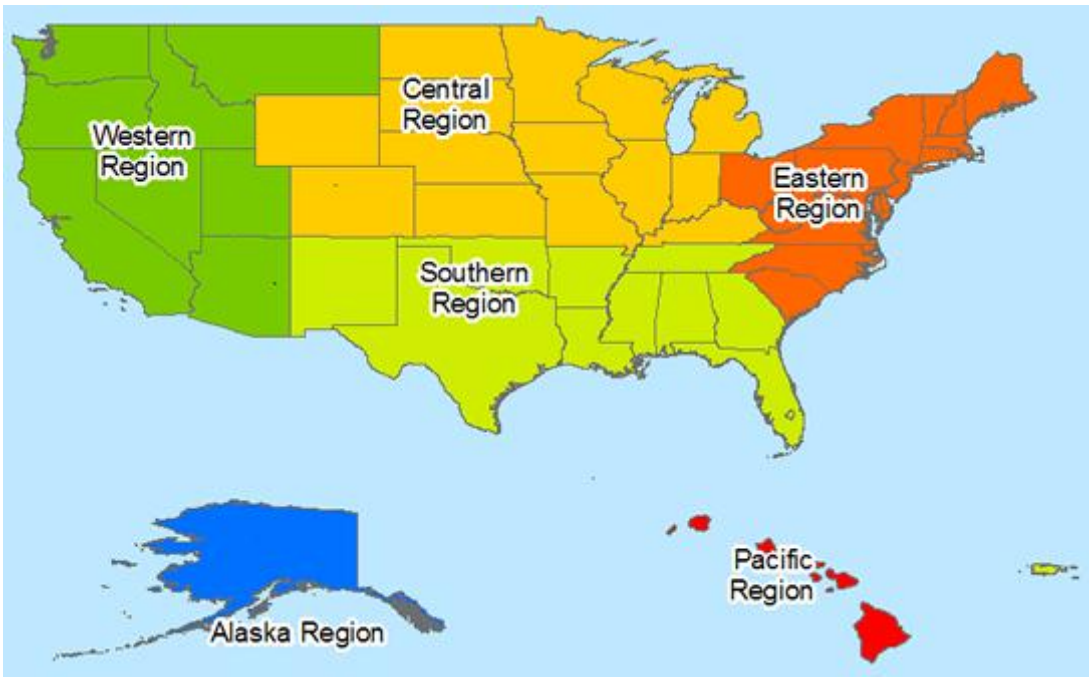

Figure 6 - Regional Map for the National Weather Service (NWS).

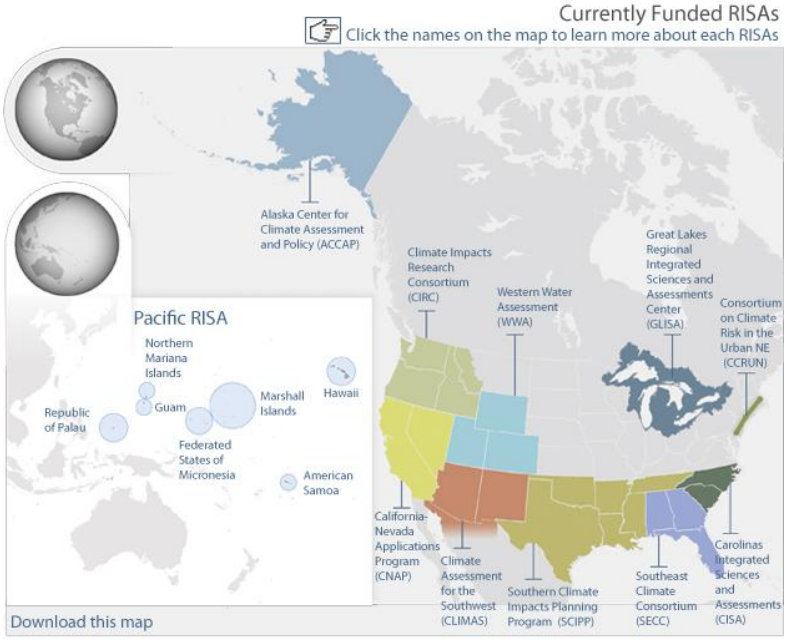

Figure 7 - The map of the Regional Integrated Sciences and Assessments (RISA)

Figure 8 - Regional Map for the United States Geological Survey.