4. Statement of work

4.1. Introduction -- SECC History and Approach

The mission of the Southeast Climate Consortium (SECC) is to use advances in climate sciences, including improved capabilities to forecast seasonal climate and long-term climate change, to provide scientifically sound information and decision support tools for agricultural ecosystems, forests and other terrestrial ecosystems, and coastal ecosystems of the SE USA. As a multidisciplinary, multi-institutional team, the SECC conducts research and outreach to a broad community of users and forms partnerships with extension and education organizations to ensure that SECC products are relevant, reliable, and delivered to the public by these organizations through their networks and mechanisms.

Knowledge of the history of the SECC will help reviewers understand the need for an extended commitment that is the basis for building a successful RISA. Late in 1996 a multi-disciplinary team of scientists from the Florida State University (FSU), University of Florida (UF), and University of Miami (UM) established the Florida Climate Consortium (FC) to participate in the competition to host the Core Facility of the International Research Institute for Climate Prediction (FLC, 2001). A central premise of the FC proposal to NOAA was that climate forecasts alone would be of little utility to decision- and policy-makers if they were not produced in the context of a broader information system. Although the FC was unsuccessful in its bid for the core facility, NOAA awarded funds to the Consortium to conduct research on use of seasonal-to-interannual climate forecast information in agriculture.

Initially, the FC conducted end-to-end research to develop and apply seasonal climate forecasts based on El Niño Southern Oscillation (ENSO) phase to manage climate related risks to agriculture in Argentina. An end-to-end approach addresses the flow of work from development and analysis of information to its extension and application by information users, which in this case was the agricultural community of Argentina.

In 1998, the FC shifted its focus towards the SE USA initially targeting agriculture in the State of Florida, to capitalize on the earlier experience. Early FC work was supported by NOAA-Office of Global Programs as a pilot Climate Applications Project. When the Regional Integrated Sciences and Assessment (RISA) program was established, FC work was transferred to this program. Sociologists and anthropologists with the FC conducted assessments that have greatly enhanced our understanding of the role of climate information in decision making and how users perceive climate. This research has helped researchers from all fields to understand the information needs and constraints of decision makers helped to inform decision makers about available information.

Following an external review of the FC, in 2002, the University of Georgia (UGA) joined the project and the name became the SECC. As it became clear that the climate information needs in the region were far greater than what could be provided with RISA funding alone, the SECC sought additional funding. Beginning in 2002, the USDA Risk Management Agency awarded the SECC a partnership agreement with the goal of developing a web based decision support system that would help farmers and ranchers to manage climate-related risks. In 2003 the USDA CSREES provided funding to the SECC through a Federal Administrative Research Grant. These additional funds allowed the SECC to add Auburn University (AU) and the University of Alabama – Huntsville (UAH) in 2003 and to add North Carolina State University (NCSU) in 2007. The decision to include these universities in the SECC was based on similarity of agricultural systems and a common, well-characterized ENSO signal. Both USDA RMA and

USDA CSREES have continued to support SECC activities, and we have continued to diversify our support base by attracting competitive funding to address special needs.

While this proposal addresses the SECC RISA, which provides the base for SECC activities, the SECC RISA owes much of its success to leveraging of funding from other sources, especially USDA Risk Management Agency (RMA) and USDA Cooperative State Research Education and Extension Service (CSREES). During the past 3 years alone, the SECC has leveraged RISA support with more than $11 million from other sources. Administrators of SECC universities strongly support our efforts: SECC institutions do not charge overhead on subcontracts to other SECC institutions, vice presidents and deans have provided monetary support for some SECC activities, including the Climate Information for Managing Risk symposium held in 2008, and UF administrators are supporting the development of a new Climate Institute.

Not all SECC universities have received RISA funds. Following an internal competition, the SECC provided a small amount of RISA funding to UAH beginning in 2006, but has not yet provided RISA funding to AU. Moreover, no SECC RISA funds have been or will be provided to NCSU as there is already a Carolinas RISA with responsibility for South and North Carolina. Funding for NCSU in the SECC is for agricultural applications, with funding from USDA and grants obtained by investigators from NCSU.

4.2. Problem Identification

SECC research and extension activities focused mostly on the agricultural sector until about four years ago when we started activities to develop climate information for water resource managers. Then, following the publication of the Stern Review (Stern 2006) and IPCC AR4 (IPCC, 2007) demands for climate change information has grown rapidly. These demands have come not only from the agricultural sector, but also from local governments, public health, environmental engineering firms, and others. We have also received numerous requests from scientists in other areas, particularly in coastal and other terrestrial ecosystems. A common challenge to meeting these requests is the need for reliable, probabilistic information at the local level regarding climate change. In order to meet this need, the proposed activities are designed to build on the successes of past SECC work in agriculture by broadening out into other sectors and by adding research and extension programs that respond to demands for information on climate change.

An important factor contributing to SECC success in agriculture has been a strong partnership with Cooperative Extension, which provides a boundary organization linking research to users for broad applications. The SECC also includes among its members the state climatologists for all SECC states. For the agricultural sector, we will shift much of our effort to providing information related to climate change and to developing methods to help sustain *AgroClimate*, our on-line climate information and decision support system.

For coastal and other terrestrial ecosystems we have begun to develop new partnerships with appropriate boundary organizations. For the coastal ecosystems, we will work closely with Sea Grant programs. For other terrestrial ecosystems, we will begin with scoping activities that will include the identification of suitable boundary organizations with which we will develop partnerships.

Much of the climate information that the SECC produces is based on integrated models and analyses that address the needs expressed by stakeholders. Stakeholders need climate forecasts over multiple time scales and also climate change scenarios that are specific to their local and regional enterprises. Using results of stakeholder assessments, multidisciplinary groups will develop downscaled climate forecasts and climate change scenarios to local scales for use in vulnerability assessments and adaptive management of water resources, coastal ecosystems, and agricultural systems. For example, based on information from growers and extension agents, SECC investigators were able to recommend delay of planting tomato during El Niño years to avoid probable crop injury (Messina et al., 2006). The process of engaging stakeholders in the development of decision support systems is shown in Figure 1.

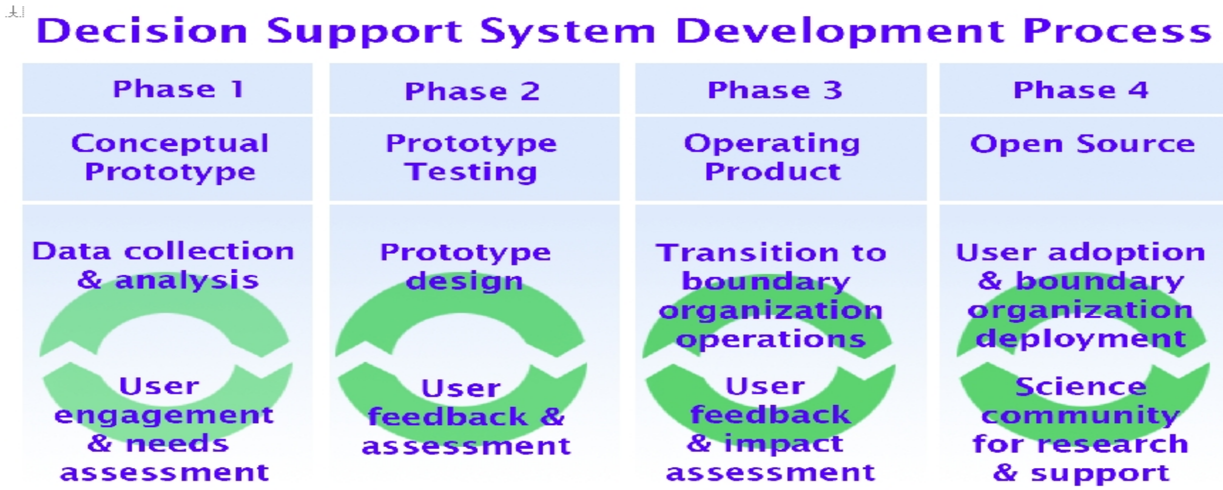

Figure 1. The SECC approach to development of a decision support system has four phases, with user or boundary organization engagement or participation throughout. While the science community may initiate and motivate the first two phases, leadership is transferred to an appropriate boundary organization in phase three. By the end of the fourth phase, the appropriate boundary organization leads the effort with support from the science community.

4.3. SECC Organizational Structure

In order to meet the growing and changing demands for local climate change information, including information needs for sectors other than agriculture, to understand what information stakeholders need and their decision environments, and to develop accessible decision support tools, the SECC is reorganizing using a three-dimensional structure that is designed to promote collaboration among scientists and our partners (Figure 2). The three dimensions are: 1) ecosystem-based adaptation sectors; 2) natural resources sciences; and 3) application sciences. The SECC RISA activities will not support all components of the structure, but we present the structure to show how SECC RISA activities are part of our overall SECC program, much of which is leveraged with other funds.

4.3.1. Adaptation Sectors: Agricultural, Coastal, Other Terrestrial Ecosystems

The ecosystem-based adaptation sectors each tend to have different boundary organizations. In agriculture we have worked closely with Cooperative Extension and have begun working with other boundary organizations that provide targeted outreach to socially disadvantaged farmers, such as the Federation of Southern Cooperatives, which works primarily with black farmers, and the North South Institute, which works with Spanish-speaking, Asian, and black farmers. For coastal ecosystems, we will work closely with Sea Grant Extension, the Association of County Governments, Florida Oceans Coastal Council, Gulf of Mexico Alliance, and others depending on the findings of our assessments. For other terrestrial ecosystems, we will work in partnership with diverse boundary organizations, including Fish and Wildlife Service, Natural Resource Conservation Service, US Geological Service, and others to be identified in our scoping activities.

We do not plan to give all adaptation sectors equal emphasis in the SECC RISA. While agriculture will remain our largest program, we will also address the needs of other ecosystems. For coastal ecosystems, we plan to conduct stakeholder assessments and to strengthen CoastalClimate.org, our on-line prototype information system for coastal ecosystems. Work in the other terrestrial ecosystems will begin with scoping activities. Over the 5 years of the SECC RISA project, we anticipate increasing efforts for both coastal and other terrestrial ecosystems, and much of this increase will be through competitive funding.

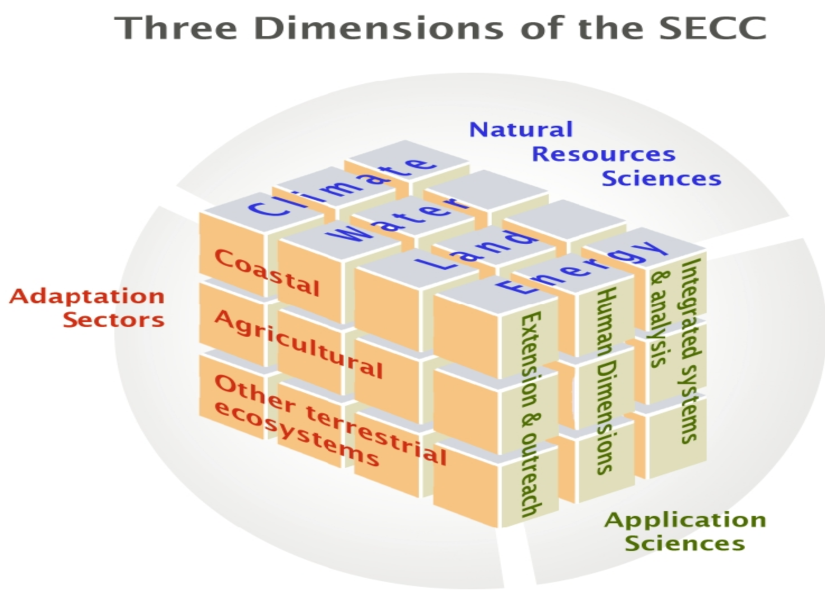

Figure 2. This diagram shows the three dimensions of the new SECC structure and their components. Though shown separated to emphasize that each cell includes all three dimensions, in operation, the cells are linked and projects may address multiple cells as will be clear from the examples in the Methodology section.

Agricultural Ecosystems

Agriculture is one of the most important sectors in the SE USA and contributes significantly to the economy of the region both in annual value of production and the number of jobs generated. In contrast to other regions of the USA, agriculture in the SE is extremely diverse, including tropical fruits, sugarcane and traditional row crops such as cotton, peanut, and corn, while livestock and poultry production are as important as crop production. This wide array of agricultural systems is partially due to the diversity of ecosystems in the region, ranging from the Florida Keys to the Blue Ridge Mountains. Previous SECC studies have shown the vulnerability of the agricultural sector to climate variability (Hansen et al. 1998a, b). During the past five years the SECC has disseminated this research information to local growers and producers through its web-based portal *AgroClimate* (Fraisse et al., 2008). A key aspect of the SECC approach has been to provide information at a county level by studying how farmers use local climate information, including seasonal to annual climate forecasts. Through recent interactions with stakeholders it has become clear that they are now very concerned about potential impacts that climate change may have on their livelihoods. Recent studies of both the US Climate Change Program and the IPCC address climate change at a national level (Backland et al., 2008; IPCC, 2007), but not at a regional and local level where most agricultural decisions are made. Drought and access to water are key issues for agriculture in the SE USA. Recent droughts significantly reduced crop production, leading many farmers to invest in irrigation. However, access to water for irrigation has become a major issue. The 'water war' among the states of AL, FL, and GA continues and is likely to limit agricultural access to irrigation more in the future, especially in GA. In early spring, the GA State Climatologist, also an SECC RISA investigator, recommends to the Governor whether the status of water resources warrants issuing a declaration of drought. If drought is declared, the Flint River Drought Mitigation Act is implemented and farmers are paid by the state 'not' to irrigate, which has occurred twice since 2000. There is a strong need to provide state-level projections of irrigation water needs for the next season and for the next 10 to 20 years for policy makers, taking onto account climate variability and change. Traditional agriculture produces food for human consumption, feed for animals, and fiber for clothing. However, recent developments in the energy sector have added a new market through biofuel production, including corn for ethanol, peanut or soybean for biodiesel, or other feedstocks for cellulosic ethanol production. In 2007 there was a sharp increase in corn production in the SE USA, mainly due to its use for producing bio-ethanol. Many of these changes are market driven, but at the same time they provide opportunities for local farmers. Biofuels not only provide an alternate to fossil fuels, but also have the potential to reduce greenhouse gas emissions.

Goals. The four principal goals of the agricultural program in the SECC are: 1) to quantify the potential impact of climate change and seasonal climate variability on agriculture and to develop adaptation options; 2) to understand the interactions among climate, drought, and water supply on agricultural production systems; 3) to evaluate options for agricultural use of land to provide environmental services; and 4) to develop tools and delivery systems for decision support that link climate forecasts and climate change information to agricultural stakeholders for use in decision making and planning. We will conduct research aimed at producing information and tools that the stakeholders can use for seasonal to decadal adaptive management and for helping them to prepare for longer term changes in climate and climate variability.

Research questions. Specific SECC research activities will address the following questions: 1) What is the value of using downscaled seasonal to decadal climate forecasts for predicting crop yield at a county scale? 2) How do climate variability and climate change affect crop production and can this information be used to develop adaptation options for crop management to reduce risks? 3) What approaches can be used to integrate models of crop production, water resources, climate, and land use to increase understanding of the complex interrelationships among these components? 4) What are the risks of agricultural drought associated with climate change scenarios and what adaptation options should be considered for reducing those risks? 5) How do climate variability and climate change affect bio-fuel production and what management options are required in order to maintain a sustainable supply of bio-fuel? 6) What is the impact of bio-fuel production on water requirements for irrigation, water quality and greenhouse gas emissions? 6) What is the carbon footprint and environmental impact of locally produced crops and how can these be reduced?

Agricultural research will have strong collaborations with water, human dimensions, and extension components to ensure that we understand stakeholder needs and uses of climate information and that we make sure that our information and tools are useful to those who need them. Our stakeholders in the agriculture program include the State Cooperative Extension Services through both extension specialists and extension agents who have direct interactions producers. Other partners include crop consultants who, in many cases, manage or provide advice to farmers with respect to crop management. We have also begun cooperation with state commodity groups, such as the Georgia Peanut Commission, Georgia Organics, and Florida Strawberry Growers Association. A close cooperation has also been established with minority groups, including the Federation of Southern Cooperatives.

Coastal Ecosystems

The coastal areas of the SE USA are particularly vulnerable to climate change and extreme weather events. In Florida alone, there are more than 1,200 miles of coastline, almost 4,500 square miles of estuaries and bays, more than 6,700 square miles of other coastal waters and low-lying topography. Over 75% of its 18 million population lives within 60 miles of the Atlantic or Gulf of Mexico. These diverse, productive coastal and marine ecosystems provide food and other products, valuable and irreplaceable ecological functions and provide aesthetic and recreational opportunities.

Coastal ecosystems face challenges of population growth, salt water intrusion, sea level rise and storm surge. Sea level rise and storm surge are related, in that higher sea level increases risk of storm surge damage. While there is a growing understanding of storm surge (Dukhovosky and Morey, 2008; Irish et al., 2008; Morey et al, 2006), people living in coastal communities of the SE USA tend to be more concerned about sea level rise (Broad et al., 2008). Such dichotomies underscore the need for science-based information for coastal user groups (FOCC 2009; GOMA 2004). To be effective, delivery of extension and education programs should be inclusive and have the active engagement of state and local elected officials, resource managers, planners, public works officials, coastal zone managers, community development specialists, fishermen, mariners, seafood processors, coastal transport businesses, tourists, coastal businesses residents and property owners.

Through Sea Grant, we will link with the Gulf of Mexico Coastal Ocean Observing System Regional Association, which is an element of the national integrated, sustained ocean observing system for the United States (http://gcoos.tamu.edu/). GCOOS provides timely ocean information and real-time observations of the Gulf of Mexico and its estuaries for use by decision-makers, including researchers, government managers, industry, the military, educators, emergency responders, and the general public.

The Land Grant and Sea Grant Universities associated with SECC RISA play a critical role in planning, implementing, and evaluating climate change outreach programs that include new adaptive strategies for climate change. These boundary organizations operate at the local level throughout the region through established formal and informal networks that bring in peers from other programs to solve distinct local problems (National Assembly, 2007).

The SECC will focus on four overall research questions in this new program area: 1) How are coastal county governments considering climate change and sea level rise in their policies, what information are they using, and what do they need for more effective policies? 2) To what extent are coastal property owners aware of potential threats of sea level rise, increased storm surge, and climate change issues, and how are they responding to this information? 3) To what extent does existing coastal erosion legislation address stakeholder needs regarding climate change and sea level rise, and are these policies being used by developers and other stakeholders? 4) What information is needed by coastal stakeholders for information on climate

variability, climate forecasts, and climate change, would they make use of an information and decision support system, and if so, what information and tools are needed?
As a new adaptation ecosystem for SECC research, we will begin with stakeholder engagement and needs assessment. Results of this research will guide future research for coastal ecosystems as well as providing user feedback needed to evaluate and improve our prototype information delivery web site, CoastalClimate.org.

Other Terrestrial Ecosystems
Climate change and its cascading environmental effects may affect the terrestrial ecosystems of the SE USA more profoundly than any other factor in the coming century. Climate change is likely to alter patterns of human settlement and land use, productivity of natural and anthropogenic systems, including forests, production of environmental services, distribution of pest species and disease organisms (Dukes et al. 2009; Pascual and Bouma 2009), extinction rates for species (Pimm 2008; Isaac 2009) and a myriad of other factors. However, the most appropriate societal responses to climate change for mitigating and adapting to impacts on natural systems and capitalizing on opportunities are poorly understood. Advancing our understanding of the region-specific implications of climate change on terrestrial ecosystems and development of adaptive approaches for addressing climate change at meaningful scales are critical if the region is to maintain productive natural environments in the coming decades.
As the SECC begins its programs on these ecosystems, we will focus on four overall research questions:

- What key resources are likely to have the greatest influences on health and functioning of Florida's terrestrial ecosystems under a changing climate regime?
- How do the public, land management agencies and organizations, and economic interests interface with these resources, and how are climate-induced changes likely to impact those relationships?
- What potential strategies can be adopted to mitigate negative consequences of climate-induced changes in terrestrial ecosystems on societal interests?
- What are the predicted efficacy, costs, benefits, and environmental consequences of alternative adaptive strategies?

Partners and target stakeholders in this work include: State Fish and Wildlife Conservation Commissions, State Departments of Environmental Protection, State Divisions of Recreation and Parks, county governments, water management agencies, US Forest Service, US Fish and Wildlife Service, US Geological Survey, The Nature Conservancy, the Florida Wildlife Federation, and the Audubon Society.

4.3.2. Natural Resources Sciences: Climate, Water, Land, Energy

Climate
The understanding of climate and climate variability and communicating the associated risks and benefits to end users interconnects all SECC activities. The overarching goals of the SECC climate program are: 1) to improve our understanding of the climate system and use this improved understanding to characterize historical climate as well as to forecast future climate of the SE USA; 2) in collaboration with other scientists, develop tools and analyses that decision makers can use to adapt to and mitigate climate changes and climate variability; and 3) to support educational and outreach programs to help decision makers use information. To meet

these goals we will address the problems associated with: 1) use of historical data analysis and downscaling to understand regional climate change; 2) application of multi-model approaches to predicting decadal climate variation over the SE USA, and 3) detectability of prediction skill for extreme events or tropical cyclones. In addition, education and outreach is an essential role for state climatologists in the SECC.

Historical data analysis and downscaling for understanding climate change. Long-term changes in climate response variables are important to quantify as climate forcing parameters change. Because some changes in forcing parameters are induced by human activity, it is necessary to know precisely the magnitudes of responses to attribute the sources of the causes. For surface temperature in a region a few hundred kilometers across, the long-term changes we seek to measure are about 0.1°C $decade^{-1}$), which is of the same magnitude as the errors of the raw measurements (e.g., Christy 2002). Errors arise due to changes in location, instrument, or observational procedures, to name a few possible sources. Common adjustments include the removal of the artificial effects that arise from urbanization or other forms of land use changes (Kukla et al. 1986; Karl et al. 1988; Peterson et al. 1998a).

While data quality poses a challenge to historical data analysis, especially when the length of record is short or monitoring stations scarce (Christy et al., 2009), such analyses are essential for understanding how our climate has changed, which, in turn allows us to project more accurately how climate is likely to change in the future. An important research question that we will address is: Using analogues based on historic records, can we generate scenarios for the future that show trends in a warming climate, stable climate, and cooling climate? Because they are based on historical observations, these scenarios will give probabilistic results and retain realistic characteristics of daily, inter-annual, inter decadal fluctuations and spatial variability.

Outputs from IPCC AR4 (IPCC, 2007) do not give sufficient detail for local and regional users. The SE USA, for example, is covered by only 16 to 20 grid cells. The results suggest that there will be little or no change in temperature in the region and a modest increase in precipitation. Though coarse in resolution, IPCC AR4 simulations have established the state-of-the-art in use of Global Circulation Models (GCMs) for climate projections. A second important research question we will address is: Can we use IPCC AR4 results (and AR5 results when available) to recreate historical observations and to project the local impacts of future climate agriculture and other adaptation sectors that can be applied to stakeholder needs?

Decadal climate predictability. In order to meet the needs of stakeholders, we need to expand our forecast efforts into decadal and longer term climate prediction, including climate change. Although research in decadal prediction is still at a nascent stage (Meehl et al. 2009), an initiative of the climate science community as part of the Coupled Model Intercomparison Project 5 (CMIP5; Taylor et al. 2008) aims to explore the predictability of climate from one to three decades in advance. This community-wide effort is predicated by three relatively successful studies of decadal prediction (Smith et al. 2007; Keenlyside et al. 2008; Pohlmann et al. 2009), which showed that initializing the ocean enhances the prediction skill of multi-year averages of surface temperatures especially over North America and Europe. All three studies indicate that this enhanced skill is much greater than that obtained from the specification of external radiative forcing alone, or that attained from damped persistence or a trend forecast. In fact both Smith et al. (2007) and Keenlyside et al. (2008) indicate that natural internal variability was found to temporarily offset anthropogenic global warming for the decades ahead extending to 2030.

The research question here is whether we can effectively use experimental outputs from CMIP5 decadal prediction efforts of Taylor et al. (2008) to provide decadal climate information of value to our stakeholders.

Impacts of changing land use and land cover on climate. How does climate anomaly over the SE USA from land-use land cover change compare with natural variability and radiative forcing from increasing greenhouse gases? Traditionally, regional climate change information is gleaned from two important sources: climate change commitment (Wigley, 2005) and from increasing greenhouse gases (Lee et al. 2006). The former implies that even if greenhouse gas concentrations were stabilized today, the climate system would continue to warm at a rate of about 0.1C per decade owing to the large thermal inertia of the oceans (Meehl et al. 2007). However, over the SE USA it is speculated that land cover and land use change would have larger impact on the surface temperature and precipitation (Marshall et al. 2004; Pielke et al. 1999). Unfortunately, clean experiments, as proposed in the Land-Use and Climate, IDentification of robust impacts (LUCID; Ducoudre and Pitman 2007) are missing in the CMIP5 baseline simulations (Taylor et al. 2008). Land use and land cover datasets are available for several periods, historical or pre-industrial (Klien 2001), present (ISLSCP, 2009), and projected (UCAR, 2009). These datasets for land cover and land use will be forced at the lateral boundaries with the CMIP5 multi-decadal 20^{th} and 21^{st} century integrations for a selected set of models to provide policy makers with quantitative estimates of separate impacts greenhouse gases and changes in land cover and land use change on climate.

Forecasting of extreme climate events, particularly tropical cyclones. Extreme climate events, particularly tropical cyclones, may cause billions of dollars in damage and threaten health of humans and ecosystems. An improved ability to forecast seasonal and decadal tropical cyclone activity can lead to better preparedness through adaptive planning, response, and mitigation efforts. Tropical storm activity is closely tied to characteristics of the large-scale circulation, sea surface temperatures (SSTs), horizontal and vertical shear, and low-level vorticity (e.g., Gray 1979). Most changes in the large-scale features can have pronounced impacts on the variability of Atlantic tropical storm activity. For example, during an El Niño, the number of tropical storms in the Atlantic tends to be reduced (Gray 1984; Shapiro 1987). GSMs are able to reproduce these large scale features reasonably well, thereby allowing GCMs and coupled ocean–atmosphere models (e.g., Vitart et al. 2007) to hindcast and forecast tropical cyclone activity. Our research challenge here is whether we can build on this work to improve the inter-annual predictability of seasonal Atlantic tropical cyclone activity and extend that research to exploring the predictability of tropical cyclone activity at decadal and longer time scales.

Education and outreach. Outreach and education are critical component of our climate program activities. A key to the effective use of the information in *AgroClimate* is proper education and outreach to the users, which we will expand to include climate change information (Fraisse et al. 2009). The State Climatologists will produce routine climate information for dissemination through our decision support systems in the form of climate and agricultural summaries and seasonal outlooks. The Cooperative Extension Services in Florida, Georgia, and Alabama are key partners in this outreach and function as a trusted broker of the information. State climatologists with the SECC will participate in extension-sponsored workshops to provide training and to promote *AgroClimate* and our other DSSs.

Water

Water is essential to maintain human health, agriculture, industry, ecosystem integrity, and the economic vitality of communities in the SE USA and the Nation. While the United States has been benefited from good water-related science, technology, planning and management over the last 50 years, the 21^{st} century brings a new set of water resource challenges. Climate variability and change, coupled with population growth and land use change, have the potential to dramatically affect the amount and quality of fresh water available at any given time (IPCC, 2007; Bates et al., 2008; CCSP, 2008; Zorn and Waylen (1997), Lueng et al. (1999), Hamlet and Lettenmaier (1999); Hamlet et al. (2002), Miralles-Wilhelm et al. (2005). Predicted impacts of global climate change include changing weather patterns; higher surface air temperatures; longer, more frequent droughts; shorter, higher intensity rainy seasons; and sea-level rise which will cause salt water intrusion into freshwater aquifers and habitat destruction (e.g. Meehl et al. 2007; Bates et al. 2008; Karl et al. 2009).

These pressures will increase competition among water users requiring that critical decisions be made to allocate sufficient water for agricultural use and consumption by cities, to maintain water reservoirs and ensuring in-stream flows for aquatic ecosystems, to maintain water quality standards, and for industrial and energy production and recreational uses. Managing these increasingly complex water resource problems requires an understanding of the primary drivers of water supply and demand over different time and space scales and of the policies and decisions that are made for allocation and use of water. Policy makers and water managers are taking into account many of these supply and demand drivers, but mostly their decisions have been not taking into account future changes in climate and climate variability (Miralles-Wilhelm et al., 2005; Vorosmarty et al. 2000). Although this is true in the SECC states, water managers and users are now asking questions such as how seasonal to decadal climate forecasts could be used to improve their management of surface and ground water reservoirs. They also want to have climate change scenarios downscaled to the watershed or administrative unit in which they manage water resources, and they want to know the uncertainty associated with these scenarios. Thus, water resources managers and policy makers want to work with the SECC to develop ways to best use seasonal to decadal climate forecasts for adaptive management and climate change information to help them prepare for changes over the longer term to ensure reliable supply and quality of water to society.

The two principal goals of the water program in the SECC are to conduct research to indentify water supply and demand, quality, drought, and other water issues that are affected by climate, both climate change and seasonal climate variability, and to develop tools and delivery systems for decision support that link climate forecasts to water resources issues and help stakeholders decrease risks to water resources. We will conduct research aimed at producing information and tools that diverse stakeholder can use for seasonal to decadal adaptive management of water resources and for helping them to prepare for longer term changes in climate and climate variability.

Research questions. Specific SECC research activities will address the following questions: 1) What is the value of using downscaled seasonal to decadal climate forecasts for managing ground and surface water resources at watershed and administrative scales? 2) How do climate variability and climate change affect quality of surface and ground water in relation to land and water management, and how can this information be used to improve management to reduce risks of water contamination? 3) What approaches can be used to integrate models of water resources, climate, land use, and societal water use to increase understanding of the complex inter-relationships among these components? 4) What are the risks of water shortages associated with climate change scenarios in selected case studies and what adaptation options should be considered for reducing those risks? 5) What climate data, information, and other decision support tools are needed by water resource manager partners to use in operational water management and policy making processes? Integral to the research will be social science and extension components to ensure that we understand stakeholder needs and uses of climate information and that we make sure that our information and tools are useful.

Our partners in the water program area include water utilities, water management districts, the USGS, and the US Corps of Engineers in addition to others listed in the ecosystem adaptation sector since water issues are of importance to all other SECC program components. Research tools and data products developed in our water program area activities will be useful to: 1) water managers for increasing water availability by managing evapotranspiration, promoting infiltration, and adopting new approaches to surface and subsurface storage; 2) emergency preparedness teams to reduce the impacts of floods and hurricanes by taking advantage of innovative forecasting techniques; 3) agricultural operators and industry to prevent water pollution through better land-use practices; and 4) policy makers and planners to create behavioral, social and economic tools that minimize costs and encourage acceptance of new water management policies and technologies. Some of these partnerships have already been developed and others will be developed over the duration of the project. The water program will maintain a close working relationship with the National Integrated Drought Information System, both from our work with stakeholders and from our work on monitoring and forecasting drought.

Land

Land and energy are new areas of research for the SECC. Important issues of land resources include changes in land use and land cover, which in the SE USA are likely to have greater impact on local temperatures, rainfall, and other climate variables than are greenhouse gases, which the IPCC predicts to have little or no effect on temperatures and precipitation in the southeast (IPCC, 2007). The SECC RISA will not initiate new programs on land resources, but will include land use and land cover in our work using regional models that link land, hydrology, and climate. Additional SECC activities on land-climate interactions will be conducted in collaboration with environmental engineering firms, such as CH2MHill, and regional planners, such as MyRegion.org.

Energy

Changes in energy availability and cost affect global, national, and regional economies. There is strong interaction between energy and climate in that energy use often releases greenhouse gases that affect climate and that changing climate is likely to increase energy demands for indoor climate control. Through the use of leveraged funds the SECC is starting projects to address interactions of climate with production of biofuels, energy efficiency in agriculture, and carbon sequestration in agricultural and natural ecosystems. Our research on energy issues will be conducted in collaboration with other organizations that specialize in energy, for example the Florida Energy Sciences Consortium.

4.3.3. Application Sciences: Extension and Outreach, Human Dimensions, Integrated Systems

Extension and Outreach

Effective preparation for climate change requires the engagement of resource managers, planners, public works officials, local managers, community development specialists, businesses, residents, and property owners. They need help to understand how climate change threatens Earth's ability to continue providing goods and services fundamental to human well-being (Elliot et al., 2008). The challenge is to provide these diverse stakeholders with trusted, science-based information so that they can make informed decisions. The Extension Service, part of the Land-Grant Institutions, is a cost effective way to provide outreach and educational programming to diverse local and regional constituents, including the green industry, home owners, and others in addition to agriculture. Extension forms a link between the research community and those who must develop local adaptation and mitigation strategies for responding to climate change. During the last ten years, the focus of most extension activities was in the agricultural sector and on climate risk management information and decision support (Fraisse et al., 2005). A prototype climate risk management and decision support system, AgClimate, was developed through iterative interactions with extension agents and farmers (Fraisse et al., 2006, Roncoli, 2006; Breuer et al., 2008). AgClimate has developed into an operational system, *AgroClimate*, under the Florida Cooperative Extension Service in cooperation with the SECC. This system provides a mechanism to communicate information to stakeholders. Adding the perspective of climate change is essential given the demand for this information and our new focus on developing adaptation strategies and training of stakeholders in this area (Fraisse et al., 2009).

The World Meteorological Organization, NIDIS, and other groups have sought SECC partnerships with the SECC in adaptive research that addresses climate information needs and effectively integrates trusted stakeholder advisors in the delivery and use of that information. Our success is due in part to a strong partnership with Extension and the involvement of clientele throughout our program. It is also partly due to the integration of the state climatologists into our extension education and outreach efforts, bringing together those who understand both climate and agriculture and who also provide an effective link between stakeholders and our research in climate, agriculture, water, and human dimensions. This proposal builds on this tradition by continuing its partnership with Extension, but expanding the climate emphasis from climate variability and risk management to climate change, adaptation, and mitigation information and decision support. In addition, the Extension program will broaden its stakeholder base to include those in coastal and terrestrial ecosystems, and it will bring coastal extension programs into the SECC in cooperation with Sea Grant.

The overall goal of the SECC Extension program is to develop and provide information and tools to decision makers that will help them address climatic impacts in the SE USA due to climate variability and change by understanding, and perhaps reducing, the uncertainty that accompanies critical decisions. In particular, Extension seeks to: 1) provide information and tools that decision makers can use to make more informed, reliable, and defensible decisions and to improve protection of resources and efficiency of production systems; 2) develop mitigation and adaptation strategies in collaboration with stakeholders; and 3) produce outreach and education programs suitable for both professional and lay audiences.

One approach we will use is to work with climate change scenarios downscaled to the county level. We will evaluate when critical thresholds that threaten production are likely to occur, and establish a dialog with stakeholders about climate change and its implications on agriculture. In addition to investigating vulnerabilities and developing adaptation strategies we will also help develop management practices that reduce greenhouse gas emissions to the atmosphere. Ultimately we aim to understand how SE producers will react to the uncertainty of potential climate change scenarios, changes in policies that address climate change, and other important changes, such as urban development and demographics.

Human Dimensions

Climate information can affect people's behavior and, in turn, their incomes and welfare. Yet climate information must be assessed within specific decision contexts. Overlooking the role of decision contexts in defining and managing climatic risk neglects user priorities and can undermine our ability to provide useful information. An overarching theme of our Human Dimensions activities is that the fundamental structure of climate information use decisions cannot be divorced from their local content. In turn that implies that the estimated economic value of climate information loses meaning if separated from its context of use. Scientists need to know how the public is likely to respond to climate information because those responses alter the economic influence of climatic impacts. Policy makers should understand user needs, to realize the potential economic value from the emerging technology of climate prediction.. SECC RISA activities for human dimensions will have two parts: 1) economic and policy decision analysis; and 2) qualitative assessments and evaluation.

Economic and Policy Decision Analysis**:** Policy, demographics, and climate each appear to be leading to water and energy likely becoming more scarce and expensive. As a way of coping with these growing scarcities, we will have to re-think where we live and work, and reduce the energy- and water-intensity of our national economy through technical innovation. Climate information can guide these decisions. Estimating the value climate information can help compare it with other innovations, though decision contexts play a crucial role.

Climate information *value* is based on the expected outcome from an improved, climate information-assisted decision compared to the expected outcome of the decision without the climate information. What value climate information may have and under what decision circumstances (such as, in the case of agriculture: crops grown, resource conditions, production technology) have become important public policy concerns. Our decision analysis will estimate the value of climate information for a host of economic sectors and a variety of locations in the southeast. Because we will consider a variety of time scales, the error-bars on our estimates will grow, and conveying that uncertainty to our users is crucial.

How the scarcity of land, water, energy and technology, evolve together, in the context of a changing climate, will be crucial to how we will perform the economic and policy analysis. For climate services, growing resource scarcity means climate information will take on greater importance as decision makers attempt to improve energy, land and water use efficiencies. In promoting use of climate information, we draw inspiration from Schultz (1964), who argued that agricultural technology is 'location specific' and must be adapted to the cultural and resource conditions where it is to be applied. Similarly, Berry (1977) said that the problem is not one of choosing between scientific and local knowledge, but of creating conditions in which these separate realities can inform one another. The mere existence of technically innovative climate information does not ensure that the innovation is refined or adaptable enough to meet user needs (Pulwarty and Redmond 1997; Sarewitz et al. 2000; Stern and Easterling 1999).

Climate information dissemination and use are complex and may be impeded by technical, financial and cultural barriers. Many estimating the economic value of climate information assume users respond ideally to information (Letson et al., 2001). However, the economic impact of climate, anticipated by users who behave optimally, does not by itself imply a value for climate information. Psychologically plausible deviations from expected utility maximization, such as prospect theory, can lead to substantial differences in estimates of the expected value of climate information (Letson et al., in press). Cabrera et al. (2006, 2007, 2009) show how climate information value in agriculture depends upon farm programs, especially crop insurance, and the characteristics of farmers. Letson et al. (2005) showed that the value of climate information must be considered in terms of probability distributions because of interannual variability and other stochastic influences, such as shifts in agricultural commodity prices. Podestá et al., (2002) argued that effective use of climate information requires well-functioning generation, communication and application of that information.

Our economic and policy analysis will provide an empirical framework to organize how we think about climate information in an optimal portfolio of sectoral risk management options and to show how this mix reacts to plausible shifts in risk preferences, climatic variations, and economic conditions. We also focus on how new information about climate variability may affect this mix. The need for such a framework is inherent in the breadth of talents required for the study of climate information value. Multi-disciplinary collaborations, to be fruitful, must synthesize disparate worldviews. Careful consideration of climate information value necessarily engages cross-disciplinary communication because it challenges the traditional division of labor in the assessment and management of climatic risk. Standard practice for risk assessment assigns climate information quality to the natural sciences and climate information value to the social sciences. Changes in biophysical or social environment may alter the level of risk, such that risk assessment must involve both the natural and social sciences.

Assessments and Evaluations: In spite of the high potential economic value for climate services, simply documenting the climate impacts and providing better climate outlooks are not sufficient. Because of the complexities of decision contexts, comprehensive research, extension and education programs are needed to bridge the gap that now exists between research on climate forecasts and sustainable applications in our target sectors. This new technology must be integrated into existing institutions.

Effective applications of climate information depend upon (1) the availability of the information, (2) an understanding by the user of its accuracy, (3) the existence and awareness of options for modifying decisions, (4) an understanding of the expected value and risks associated with changing decisions, (5) and a capability and willingness to modify decisions based on available information (Sonka et al., 1987; Mjelde et al., 1993).

Most assessment activities conducted by the SECC have addressed the immediate needs for reconnaissance information and user feedback on the development and presentation of SECC tools for agriculture. While we will continue to provide information to agricultural target audiences, including Cooperative Extension, ranchers, State Departments of Forestry, small-scale farmers, Latino farmers, tomato, strawberry and blueberry growers, we will also conduct assessments for coastal and other terrestrial ecosystems.

Assessment and evaluation activities will focus on four research issues:

1. Identifying decision makers, understanding decision processes, and the role of climate information.

2. Assessing the accessibility, relevance, utility of SECC tools and information from the point of view of end-users and decision-makers, that is, product feedback to those who develop new decision support tools.
3. Evaluating SECC tools and activities in terms of their actual use and impacts in agriculture and water resources management and implications of such decisions at various scales.
4. Eliciting lessons learned by SECC, facilitating monitoring and evaluation processes, and integration with other RISAs.

Integrated Systems Analysis

Integration of research among scientific disciplines is essential to address the complex issues associated with climate change. Responses of agricultural, coastal, and terrestrial ecosystems depend not only on their complex biophysical and ecological interactions with climate but also on decisions and policies made by a wide range of individuals, businesses, and public policy agencies. Scientists in one discipline address relatively narrow aspects of these issues and thus are not able to analyze potential solutions that would include the range of important factors that stakeholders face. Methods are needed to integrate knowledge and methods across scientific disciplines to address the complexities of holistic systems that include physical, biological, economic, and social aspects.

In the SECC, we use integrated systems analysis methods to address important interactions among physical, biological, and economic components in agricultural systems; this is one measure of our success to date. This emphasis on integrated systems analysis has provided an effective framework for SECC scientists to conduct research on common activities across disciplines and institutions. Our experiences have enabled us to move along the continuum from multidisciplinary to interdisciplinary research approaches (Schneider, 1997) in which investigators address issues from perspectives of multiple disciplines offering insights beyond the capability of these disciplines working independently. This success has been due in part to the fact that SECC researchers in each discipline have developed applied models in their respective disciplines and each has had a background of interdisciplinary systems analysis. For example, we have linked climate and crop models for studying the potential value of using climate forecasts from regional climate models for forecasting or optimizing crop yield (e.g., Royce et al., 2001; Podestá et al., 2001; Bellow, 2006; Shin et al., 2006; Baigorria et al., 2007), for analysis of crop insurance decisions (Cabrera a et al., 2006; 2009), and for studying water resources issues (e.g., Miralles-Wilhelm et al., 2005; Keener et al., 2007; Hwang et al., 2009). We combined crop and economic models to study implications of using climate forecasts for crop production management, taking into account both climate and economic uncertainty effects on value of forecast use (Letson et al., 2001; Messina et al., 2006). We linked crop, climate forecast, and farm scale economic models for evaluating benefits of using climate forecasts to increase profits from dairy operations while reducing nitrate pollution of water resources (Cabrera et al., 2006). Stakeholders participated in these studies, both to help formulate the problem and to consider the results from the research. These and other case studies have facilitated communication between users and researchers and between researchers of various disciplines. One of the goals of the SECC RISA is to extend this integrated participatory systems analysis approach to facilitate more interdisciplinary research that leads to information and tools needed by society to make effective use of climate change and climate forecast information in their decision and policy making processes.

There are many questions that need to be addressed using our integrated participatory systems approaches. Research questions that will guide our integrated systems analysis efforts will be based on needs from the ecosystems and water resources program sectors to make sure that our efforts are based on needs for information and tools that help stakeholders. For example, activities will be undertaken by: 1) climate and agricultural researchers to study implications of changes in land use on crop production and feedbacks on local to regional climate; 2) climate and hydrology scientists to develop a Water Resource Prediction Platform needed by water managers to incorporate climate forecast and climate change information into their planning and operational processes; and 3) economic, agriculture, and climate scientists to evaluate adaptation options for managing agriculture under various climate change scenarios and policies. These are only a few examples. As research needs are identified in all sectors, we will design integrated systems analysis activities to address those needs. These methods are embraced as a core part of the SECC culture for integrating across physical, biological, hydrological, economic, and social science disciplines and stakeholders.

4.4. Scientific Objectives

In order to meet the growing demands for climate information, including that for climate change and from new ecosystems, we will pursue four objectives:

1. Working with boundary organizations, planners, regional data clearinghouses, and other stakeholders, assess the needs of decision makers for climate information, their access to and applications of climate information, and time-scales for needed information.
2. Based on stakeholder assessments, develop partnerships with appropriate boundary organizations to meet the climate information needs of stakeholders, particularly in coastal and other terrestrial ecosystems.
3. Provide reliable, timely, probabilistic, and local climate information according to stakeholder needs for adaptation and resilience to climate change and climate variability. Providing this information will require production of downscaled forecasts at the local level and at 1- to 30-year time scales, as well as maintaining and providing historical data and analyses for the region.
4. Through integrated, multi-disciplinary activities, develop decision support tools and information delivery systems that give decision makers access to climate information that will help decision makers manage risks associated with climate change at various time scales.

4.5. Proposed Methodology

The SECC has developed a culture of multi-disciplinary, multi-institutional collaboration to address the complex problems facing the application of climate information to our region. While the various institutions of the SECC have specific activities planned that address all of these scientific objectives as well as the goals for the different application sectors, natural resources sciences, and application sciences, space limitations do not allow us to present all proposed projects here. Following are examples of two projects. Four additional example projects are presented in the Appendix, which begins on page 25: 1) stakeholder assessment; 2) extension and outreach; 3) bioenergy; and 4) water resources management. Plans of work for each SECC RISA institution, which show the full range of proposed projects, are posted on SEClimate.org.

4.5.1. Downscaling of climate change scenarios: FSU, UAH, UF

There is a large gap between what climate scientists produce as climate change scenarios or forecasts and what farmers, water managers, and others can use in their decision making process. Daily weather station data are widely used by individuals and managers, whereas climate change and climate forecast information is produced over large areas at a spatial scale of hundreds of km. Many applications in agriculture use dynamic models that require daily weather data input whereas climate models generally provide only monthly or annual data (Mearns et al., 1997; Shin et al., 2006, Baigorria et al., 2007b). Our experience shows that stakeholders relate to climate forecasts when they are based on historical weather data from weather stations in their area, typically using categorical sets of observed weather data for different ENSO phases. These past weather records provide a basis for stakeholders to understand forecast uncertainty and for using the data for decisions. Farmers use weather data from nearby stations to compute chill units, degree days, drought indices, crop yields or other information that help them make decisions. Water resources managers in the SE USA, such as our partner the Tampa Bay Water utility, use current and historical daily weather data from weather stations in models that guide their decisions on water allocation and reservoir management.

Although most of our prior applications have used categorical forecasts based on historical weather data, a new approach is needed in the new RISA. Recent NOAA climate forecast products and climate change scenarios are based on climate model outputs (IPCC, 2007). We will evaluate methods for downscaling these climate forecasts and scenarios to weather station locations to provide information that is consistent with what users understand and use. Although regional climate models have been used for downscaling GCM results, their outputs do not provide daily weather data at points that are needed for most of our applications. Statistical methods are used to downscale GCM and RCM outputs for applications, and weather generators may be used to create multiple realizations of daily weather data at points for applications in crop and hydrology models (Podesta et al., 2002; Cabrera et al., 2006; Keener et al., 2007; Romero et al., 2009). However, most generators independently create realizations for a single point, which is not a reliable representation of rainfall variability over space and time (Baigorria et al., 2007a; Baigorria and Jones, 2009). Spatial weather generators have been developed to create realizations of daily weather data at points, taking into account the correlation among weather stations (Wilks, 1998; Khalili et al., 2006; Apipattanavis et al., 2007; Quian et al., 2002; Cannon, 2008; Baigorria and Jones, 2009). Our research questions for this project are:

- What are the best methods for using spatial weather generators to downscale regional climate forecasts?
- What are the uncertainties created by using these downscaled weather sequences to simulate crop yields and drought index results at points and aggregate scales?

Activity 1. An agricultural area in southern Georgia and Alabama and northern Florida will be used in the study. Available historical weather data for this area will be used to estimate temporal and spatial parameters for the geospatial weather generator developed by Baigorria and Jones (2009). NOAA’s reanalysis data for this area will be obtained and used for downscaling daily weather at points in the area and for time periods not used in estimating weather generator parameters. We will compare rainfall and temperature results at station and aggregate scales. We will then use the DSSAT cropping system model (Jones et al., 2003) to simulate yields using historical weather data for those independent sites and years and using downscaled daily weather realizations. Comparisons will help us understand the uncertainties associated with the downscaling of Reanalysis data for the same period relative to the use of independent daily weather observations for those same sites and years. We will compare results from leaving out different numbers of years to ensure robustness of our results and work with Extension to get feedback from users on the scenarios.

Activity 2. We will obtain IPCC climate change scenarios in for the same area as above. We will then use parameters from activity 1 to downscale the scenarios using the geospatial weather generator. We will also obtain scenarios based on historical daily weather data created by our climate team. Our approach will be to compare different downscaling methods by analyzing point and aggregate weather variables and by using these downscaled realizations to simulate crop yields for the study area.

Anticipated Benefits. These activities will provide information needed to determine the best methods for downscaling climate forecasts and climate change scenarios for use in the SE USA. Although emphasis in this activity will be on use of downscaled climate information in agriculture, it will be as important for other stakeholders, such as water managers who need point-based climate forecasts and scenarios for managing watersheds and reservoirs. This information will also be used by extension investigators to communicate with stakeholders for broader interpretation and use.

4.5.2. Sea level rise and storm surge, Risk perception and public policy: UF, FSU, UGA

Sea level rise and storm surges along the coastline are major concerns of residents and business owners in low-lying coastal areas. The gradual nature of sea level rise coupled with the length of the planning horizon for most climate change issues may cloud coastal stakeholder perceptions of the risk it presents. Risk perceptions are further confounded by activities that mask the immediate impact of sea level rise, such as beach nourishment and shoreline hardening, or subsidies that redistribute the cost of shoreline development, such as insurance and new infrastructure. Perceptions of risk from sea level rise, intensified storm surge, and climate change are further confounded by the ideological discourse that underlies the debate over climate change and the role of humans in causing climate change. In light of these factors, it is important to understand how the coastal property owners and other stakeholders, including policymakers, perceive the risk of sea level rise and storm surges to coastal property, coastal infrastructure and coastal ecosystems. Part of the current policy paralysis regarding sea level rise stems from the tremendous difficulty and possible costs of addressing rising seas coupled with reticence of policy makers and elected officials to do so absent strong public demand for such action. This project will enhance our understanding of property owner and stakeholder perceptions of sea level rise and storm surge, and help us to identify and design appropriate policies that property owners, coastal stakeholders, and policymakers will accept. This understanding is necessary to guide the development of constructive public policies to address the effect of sea level rise.

Research questions. Has coastal erosion notice legislation (Florida Law 2006-273) been incorporated into the real estate transaction process and is it recognized in transaction decisions made by property purchasers? Does the public understand the tangible effects sea level rise is likely to have on their communities? How do activities that mask sea level rise and erosion, such as beach nourishment and armoring, affect public attitudes about sea level rise impacts? Are coastal policymakers prepared to adopt proactive policies that address sea level rise at the state and local level, and if so what policies are most appropriate given the perception of risk?

Our objectives are: 1) To establish how and to what extent coastal property owners perceive sea level rise as a risk to their own property both as a home and as an investment; 2) To establish the extent to which coastal erosion notice legislation (Florida Law 2006-273) has been incorporated into the real estate transaction process and is recognized in transaction decisions made by property purchasers; and 3) To understand how the expectation of future public investments in coastal property protection, coastal development subsidies, and the availability of post-disaster mitigation affect coastal property owners' assessment of the risks posed by sea level rise; the extent to which coastal community stakeholders and leaders perceive sea level rise as a significant risk. We will use the data provided by sea level rise and storm surge impact perception surveys to inform coastal policy decision-making through widespread dissemination of the results in appropriate venues.

<u>Activity 1.</u> Design and execute survey of coastal property owners that have purchased their property on critically-eroding beaches subsequent to enactment of Florida Law 2006-273. Recruit and engage focus groups to assess stakeholder and policymakers' sea level rise and storm surge risk perception. Draft report on results.

<u>Activity 2.</u> Develop policy recommendations (including proposed regulatory and/or statutory changes in response to survey/focus group results. Develop specific legal/policy recommendations for local government planners. Develop outreach materials for coastal property owners (in conjunction with social scientist/social marketing expert).

<u>Activity 3.</u> Cooperate with University of Florida Extension Service and Florida Sea Grant to conduct 2 parallel tracks of workshops. Track one will be for local government attorneys and planners (in conjunction with the Florida Association of Counties and Florida Chapter of the American Planning Association). Track two will focus on public outreach. (Years 3-5)

We will partner with Florida Association of Counties; Florida League of Municipalities; Florida Chapter of the American Planning Association; Florida Sea Grant (contributing cost share); The Florida Bar, Florida Association of Realtors, Florida Local Environmental Resources Agencies, Caribbean Conservation Corporation, Surfrider Foundation, Ocean Conservancy & other advocacy organizations

Anticipated benefits. This research will provide valuable information to help guide policy makers on issues of sea level rise and storm surge to help coastal communities prepare for climate change. It will also engage a new set of stakeholders in the SECC RISA.

4.6. SECC MANAGEMENT

Lead Principal Investigator: Distinguished Professor James W. Jones will have overall responsibility for vision and leadership of this project.

Executive Committee: The guiding body of the SECC has been its Executive Committee, which includes the lead Principal Investigator from each SECC institution and the SECC Coordinator. The Executive Committee meets approximately monthly by video and tele-conference in order to maintain open and regular communications among members.

Steering Committee: With our new structure, we will develop a new leadership group to address programmatic issues. This committee will include a leader for the principal elements of our three-dimensional structure. The following have agreed to serve on this committee:

- Coastal ecosystems: Michael Spranger, Associate Dean for Sea Grant Extension, UF
- Agricultural ecosystems: Gerrit Hoogenboom, Professor, Biological & Agricultural Engineering, UGA
- Terrestrial ecosystems: John Hayes, Professor, Wildlife Ecology, UF
- Climate: James J. O'Brien, Lawton Professor Emeritus, Oceanography & Meteorology, FSU
- Water: Puneet Srivastava, Associate Professor, Biosystems Engineering, AU

- Land and Energy: As these programs are small, we do not propose a member for the steering committee, rather, the SECC Coordinator will serve as liaison to other organizations conducting research and extension in these areas.
- Human Dimensions: David Letson, Professor, Agricultural Economics, UM
- Integrated Systems Analysis: James W. Jones, Distinguished Professor, Agricultural & Biological Engineering, UF
- Extension and Outreach: Clyde W Fraisse, Assistant Professor and lead developer of *AgroClimate*, Agricultural & Biological Engineering, UF

SECC Coordinator: The SECC coordinator is Keith T. Ingram, and responsible for: 1) communication and liaison within the SECC and between the SECC and partners, program managers, and other institutions; 2) development of new partnerships, including boundary organizations and regional or national organizations that provide or disseminate climate information; 3) strategic planning and managing the diverse SECC grants to assure that activities are complementary and not redundant; 4) editing and publishing SECC documents and reports; and 5) helping organize twice yearly meetings of SECC participants for internal review and planning, as well as international meetings on the application of climate information.

4.7. Relevance to Climate Program Goals and Priorities

In the proposed work we will work in partnership with boundary organizations that serve coastal, agricultural, and other terrestrial ecosystems. Our goal is to understand climate risks and climate information needs for these stakeholders and to provide them the information that can help them adapt as well as to pursue climate-related opportunities for economic growth.

Our State Climatologists and Extension specialists work closely with Cooperative Extension. We are developing new partnerships with: 1) regional planning groups, such as the FL Association of Counties and MyRegion.org; 2) with extension and education groups, such as FL Sea Grant and GA Marine Extension; 3) with water management districts, water providers, municipal water managers, and NIDIS; and 4) with environmental protection agencies, such as State Fish and Wildlife Commissions, State Environmental Protection Agencies, and NGOs.

SECC RISA research on human dimensions will address both issues of economic and policy decisions and assessments of stakeholder information needs and climate vulnerabilities. Through these programs we will engage stakeholders throughout the research and development process to assure relevance and value of SECC products.

The multi-disciplinary, multi-institution approach of the SECC is designed to bring together the best, most complementary team of scientists possible in order to integrate their knowledge in the design, development, and testing of decision support systems that help users manage risks and benefit from opportunities in response to climate change and climate variability.

Membership of the SECC includes State Climatologists of AL, FL, GA, and NC. They are members of the SECC Extension Team and contribute greatly to our ability to provide timely, reliable, and valuable climate information and forecasts to our citizens. We also work with the Southern Region Climate Center, NWS Southern Region Climate Office, NIDIS Pilot program, NOAA CPC, and others in the provision of these climate data and analyses.

The SECC has made great progress in the transition of *AgroClimate* to the FL Cooperative Extension, though work remains to be done through other projects to assure the sustainability of *AgroClimate*, We will follow a similar approach in the development of prototype decision support systems for water managers (SEWaterClimate.org) and coastal communities (CoastalClimate.org).

APPENDIX

Additional examples of research projects

A.1. Identifying decision makers and understanding decision processes (UM, UGA, UF)

To ensure that the development of SECC products is demand-driven and valuable, we need to identify end-users and understand how they make decisions and how they use climate information. We also need to identify how SECC products could be potentially used by various types of decision makers in different sectors and how decision makers understand and respond to available SECC tools and information. Finally, we need to elucidate how SECC products are used in decisions, what the implications of those decisions are for various stakeholders and sectors, and assess their impacts on stakeholder livelihood and environmental health.

Stakeholders for climate information are diverse, including large and small agricultural producers, socially disadvantaged producers, water managers, and policy-makers. For key stakeholder groups, we elucidate current knowledge about climate, key vulnerabilities and opportunities, points of entry into the decision making process, and potential (negative and positive) impacts of climate adaptations. We envision that this knowledge will inform the climate information systems and decision support tools directed to these stakeholders. In terms of target sectors, we will capitalize on our comparative advantage: a) SECC is the only RISA that has a strong focus on agriculture; and b) members of the assessment team have extensive experience in the application of climate information to agriculture both in the USA and in developing countries. In keeping with our new emphasis on climate change, we will include assessments for climate change information needed by stakeholders in agriculture.

Because of the diversity of decision-makers across areas, sectors, production systems, and social groups, we will focus our efforts on geographic areas where climate forecasts are greatest, on sectors that are most vulnerable to climate variability and climate change, on socially disadvantaged decision makers, as well as understanding boundary organizations that have capacity to provide information to a large number of decision makers.

Working with all stakeholders, especially potential end-users, is an integral component of our scientific paradigm. However, not all communities or sectors of society have equal access or the ability to use such information (Stern and Easterling, 1999). Targeting underserved groups is difficult given the scarcity of data on them and the diversity of their livelihood systems. Socially disadvantaged farmers in the SE USA typically face greater obstacles than do other farmers. Many of these farmers have less education and lack sufficient resources to participate in alternative methods of production and marketing. To gain their attention, we must persuade them we have value to offer. One specific opportunity that warrants mention is for a two-way interaction to develop forecast products that are spatially-, temporally-, and activity-specific for socially disadvantaged farmers. Socially disadvantaged farmers will be engaged to participate in the development of these products so that the products respond to their felt needs and to help reduce their vulnerability to climate risks. We have already developed partnerships with NGO and government outreach programs that target these end users.

Research questions: 1) What are the climate information needs of socially disadvantaged, particularly resource-limited farmers, organic farmers, and African American farmers, and how can we best meet those needs? 2) What are the current sources of information for socially disadvantaged farmers? 3) How do these farmers assess the value and potential impact of extant tools and information produced by the SECC? 4) How does our assessment for the agriculture sector transfer to other sectors?

Activity 1. In collaboration with the SECC Extension team, conduct surveys of participants in Extension workshops and training programs. These surveys, conducted before and after the each event, will contribute to the growing database on user needs for, understanding of, and use of climate information.
Activity 2. Conduct interviews with farmers, focusing on socially disadvantaged farmers. These interviews will be conducted in partnership with extension agents from historically black colleges and universities or with appropriate representatives for NGOs, particularly the Federation of Southern Cooperatives, which serves African American farmers, Hispanics, Native Americans, and migrant workers.
Activity 3. Conduct surveys and interviews to assess the impacts of *AgroClimate*. We conducted a baseline survey in 2005 to quantify farmers understanding of climate, needs for climate information, and how farmers might use of climate information. We will conduct a follow up survey and targeted interviews to assess the impact that SECC information products, particularly *AgroClimate* have had on the agricultural sector.
Anticipated benefits. This research will provide feedback to guide both research and extension activities of the SECC regarding the needs for new climate information products and forms of delivery. It will also contribute to the assessment of impacts and values of SECC research products as well as providing information that will enable other SECC scientists to increase those impacts and values.

A2. Extension and outreach: UF, UGA, AU, FSU

Agriculture in the SE USA is highly diverse due to favorable climate conditions with temperatures above freezing most of the year and high, although variable, rainfall amounts. However, climate change could cause major disruptions in production of the major crops grown this region, thereby affecting a major sector with annual sales in the billions of dollars. Farmers in Florida have recently started to ask questions about potential impacts of climate change on their livelihoods, how these changes will affect their crop production, and what adaptation strategies they should consider in response to anticipated changes. Recent press coverage of carbon-offset markets also sparked an interest in potential opportunities for farmers and foresters to generate additional income. Some extension agents have also are planning to engage farmers in climate change education, even if risks that climate change poses to farmers are still uncertain (Fraisse et al., 2008). A better understanding of decision-making patterns under changing climate conditions is urgently needed in the region and across different sectors of society. Coastal areas, especially in Florida, are extremely susceptible to the effects of sea-level rise due to a combination of low land elevations, a high water table, peninsular geography, vulnerability to tropical storms, and a large and growing human population that is largely concentrated near the coasts (Mulkey, 2007). We can benefit from the established SECC extension program that currently focuses on climate variability and agriculture to address educational and outreach needs related to not only agricultural but also coastal extension programs.
Research questions. Our research questions are: 1) What are the decisions and associated time scales important to stakeholders? 2) What educational and outreach programs are needed to serve these stakeholders? 3) What climate change decision support tools are needed to serve a diverse set of clientele?
Our objectives are: 1) Introduce climate change information into extension meetings, expanding what is already being done in SECC extension meetings that are funded by a partner USDA project; 2) Define educational needs and design outreach and educational programs for

agricultural and coastal extension, starting in year 3; and 3) Develop decision support information and tools for use by county agents in agriculture and Sea Grant programs

Approach. Extension programs are already being planned under a project sponsored by USDA and our SECC universities to increase communication with the agricultural community, with focus groups, and workshops. Climate extension specialists and state climatologists in FL, GA, and AL will lead this effort, considering the changes in content and objectives that match our new emphasis in the SECC RISA. Specific activities are:

Activity 1. Develop preliminary plans for information and tools (web-based and other formats) for stakeholders on climate change issues; discuss this in meetings with extension agents who will make use of the information and tools

Activity 2. Implement web based tools on *AgroClimate*.org or a similar site that emphasizes climate change and will be made available throughout our state extension services.

Activity 3. Hold workshops in years 4 – 5 to help refine the information and tools.

Anticipated benefits. Anticipated benefits of the proposed Extension program include better understanding of the vulnerability of the agricultural industry and coastal communities to climate change, the development of education and outreach extension programs that effectively respond to stakeholder needs and integrate upland, more agricultural areas with more urbanized coastal areas. We also anticipate that an important benefit of the assessment activities to be conducted across different areas and sectors of society will help guide research activities to better address existing knowledge gaps that are relevant to stakeholders.

A3. Bioenergy: UGA, UF, FSU, UAH

There has been an increased interest in using ethanol produced from various plant sources as a renewable substitute for fossil fuels in the USA (Shapouri et al., 2002; Hill et al., 2006, Shapouri and Salassi, 2006). The production of bio-ethanol in the USA has increased from 4.16 billion l in 1996 to 24.6 billion liters in 2007 (Renewable Fuels Association, 2008), and the target annual use of biofuels by 2022 specified in the 2007 Energy Independence and Security Act is 136 billion liters, of which 56.7 billion l could consist of ethanol from maize starch (United States Department of Energy, 2007). The SE USA has a favorable climate for the production for not only crops for food for humans and feed for animals, but also for fuel. As an example, an ethanol plant was recently placed in production in Camilla, Georgia. It currently uses corn grain as the main feedstock source, but there is potential for the use of other crops once the conversion process of ethanol from cellulosic material has been further advanced. Studies conducted by Persson et al. (2009a, b) have shown that the net energy value, i.e. the net gain in energy after accounting for all energy costs of the production and processing processes, is positive for corn grown under irrigated conditions in Georgia, Alabama, and Georgia. There are various other crops that are being evaluated, such as sweet sorghum, switchgrass, Miscanthus, and other crops that traditionally produce a lot of biomass.

The use of crops for biofuel has raised several questions. First of all there is competition between the use of crops for food and feed versus biofuel. There is a potential for increase in prices, which will benefit farmers who are normally working with very small margins, but has a negative impact on consumers. There is also a need for additional resources, such as water, to grow these crops and to reduce the risks associated with climate variability. Finally there is an issue of a stable feedstock supply. Early research has shown that there is a large variability in the net energy value of bioethanol from corn grain (Persson et al., 2009b).

Research Questions

- How does the annual climate variability and climate change affect the potential for growing crops for biofuel in Georgia, Florida, and Alabama?
- Which crops have the greatest potential to provide for a sustainable supply of feedstock for biofuel production?
- What are the interactions are among crop production, resource use and environmental impact in a changing climate?

Objectives

- Determine the potential impact of climate change on crop production in the SE USA and evaluate potential options for adaptation.
- Evaluate the potential for growing alternate crops for biofuel production.
- Determine water requirements for supplemental irrigation under drought conditions

Activity 1. Climate scenarios developed through the climate program will be used as input for crop simulation models (Jones et al, 2003) of DSSAT (Hoogenboom et al., 2004) to estimate county yields of important agronomic crops. As in previous studies, local soil data and Extension recommended crop management practices will provide soil and management input for the model. Cultivar information will be obtained from state-wide variety trials for model evaluation (Guerra et al, 2008) and to characterize varieties that are adapted to climate change conditions. Outcomes will be provided to extension specialists for dissemination to local stakeholders.

Activity 2. Stakeholders recommend or identify new crops for biofuel production on a continuous basis as part of their risk management strategy. In most cases, it is difficult to determine the potential for growing these crops using field experiments. Systems analysis and models, however, can play a key role in determining ecological zones for new crops. Based on the need for alternate crops as identified by stakeholders in the human dimensions program, we will use existing models to determine the potential for growing new crops at a local level, using site specific information for weather, soils and management.

Activity 3. Drought has a significant impact on crop production in the SE USA. One mechanism to cope with drought is supplemental irrigation. However, it is highly likely that water use by agriculture for irrigation will be limited or restricted. With changes in cropping and management systems as identified under Activities 1 and 2, there will be an increased need for water for supplemental irrigation. Using the scenarios of task 1 and task 2, we will determine the water requirements for irrigation at a local level and evaluate options for water conservation. The outcomes will be disseminated to local farmers through the local extension office as well as well as to politicians and regulators for future planning.

A4. Using climate forecasts to manage pollution and protect water quality: AU, FSU, CPC

Natural climate variability has considerable impact on agriculture and water resources. Natural climate variations can significantly alter the behavior of extreme events, including floods, droughts, hurricanes, and cold waves (IPCC 2001). Streamflow is sensitive to changes in temperature and evapotranspiration that are influenced by ENSO (Dutta et al., 2006). Even small precipitation decreases could be very significant in terms of runoff reductions (Karl and Riebsame, 1989). This runoff and stream flow reduction in areas where point source discharge is significant increases pollutant concentrations in streams because streams do not have sufficient flows to dilute contaminants discharged continuously by point sources.

Nearly every waterside community continuously discharges some type of pollutant to surface waters,. The Water Permits Division of the Environment Protection Agency has a National

Pollutant Discharge Elimination System (NPDES) permit program to control water pollution by regulating point sources that discharge pollutants into waters of the United States. The existing NPDES permitting process does not account for seasonal climate variability and effect of seasonal forcing, such as, ENSO on the quality of a water body. The standard permitting process generally allows a point discharger to discharge into a stream at a continuous rate based on the Total Maximum Daily Load of the water body.

Based on the above, we hypothesize that water quality of a stream is affected by seasonal climate variability in the SE USA and that incorporating seasonal climate information in the permitting process will reduce threats to water quality. Specific objectives of this study are: 1) study the effect of ENSO on stream flow and water quality of a watershed in which point sources are significant contributors of contaminants; 2) propose an improved permitting process that accounts for seasonal climate variability; and 3) quantify the value of climate forecast use in reducing water quality.

Approach. The Sougahatchee Creek Watershed in Auburn, AL is the watershed for this investigation. Recent 2006-2007 La Niña-induced drought resulted in point source-dominated stream flows during spring and summer months in many streams of this watershed. The City of Auburn has NPDES permits for two wastewater treatment plants that discharge directly to streams of this watershed. The aim of the NPDES permit is to reduce the adverse impacts on water quality and aquatic habitat by instituting the use of controls on the discharges from these wastewater treatment plants.

We will study the details of these permits and evaluate the quality of the streams under various ENSO phases using monitored and modeled data. Because this watershed includes Auburn University, many water quality data are available. Effects of climate will be modeled using a watershed scale model (Soil and Water Assessment Tool), calibrated and validated using existing flow and water quality data. We will first analyze how stream flows in this region are affected by low precipitation and high temperature, and exacerbated by ENSO-induced climate variability. Working with the city water manager, feasible alternatives will be developed that consider ENSO-induced climate variability when setting limits for discharging wastewater. These alternatives will then be evaluated to quantify benefits to water quality resulting from the use of ENSO-based climate variability in the permitting process. We will develop recommend-ations for regulating the permissible amount that can be discharged into a water body depending upon climate variability effects on stream flow. Instead of issuing continuous discharge permits for point sources, permissible discharge can be tailored to utilize ENSO forecasts. In addition, a non-economic measure assessment of value of SI forecasts will be conducted using precipitation and temperature reforecasts generated by NOAA NCEP CFS.

Expected Outcomes. Expected outcomes of this project include quantification of water quality benefits that can be derived through incorporation of SI climate information in NPDES permitting process. The positive outcome of this research could alter the ways in which thousands of NPDES are issued every year.