SUMMARY REPORT

STATE UNIVERSITY SYSTEM CLIMATE CHANGE TASK FORCE WORKSHOP

NOVEMBER 14-15, 2011
UNIVERSITY OF FLORIDA
GAINESVILLE, FL

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STATE UNIVERSITY RESEARCH COMMERCIALIZATION ASSISTANCE GRANT
NEW FLORIDA 2010 CLUSTERING AWARD

Table of Contents

Executive Summary

This workshop was an activity of a recently awarded State University Research Commercialization Assistance Grant New Florida 2010 Clustering Award. This project focused on identifying current State University climate change expertise, research and curricula; enhancing cooperation with State and Federal agencies to bring science into climate change-related decision making; and developing a climate change information system and portal that will connect State University System (SUS) assets with these agencies and other groups to facilitate communication.

During this two-day workshop, the lead representatives from Florida Atlantic University (FAU), Florida State University (FSU), and University of Florida (UF), along with representatives from 5 other state universities, agencies, and private industry met to explore further collaboration on climate issues. As part of the ongoing collaborative process that began in early 2011, four white papers on climate science were presented on:

- Biodiversity and Land Use
- Climate Scenarios
- Water Management and Coastal County Adaptation
- Education, Training, and Outreach on Climate Change

The final white papers are available at the Florida Climate Change Task Force website at http://www.floridaclimate.org/whitepapers

The workshop served as an effective platform to unveil these research papers and to highlight the work being done in Florida on climate change. Current climate change projects were also showcased during an attended poster session that had over 65 participants. Our keynote speakers and panelists helped to further emphasize the importance of this work through their policy expertise, industry experience, national perspective, and in-depth analysis of the latest climate science.
Video of the presentations are available at http://floridaclimate.org/presentations

The white papers and presentations are both a product and a beginning of our collaboration. While they represent the latest climate-related research in Florida, they have also helped us to identify gaps in information that can inform future research and education efforts for our state. Our goal is to continue the statewide collaboration amongst the universities, local and state agencies and the private sector to more effectively address the needs of Floridians.

Introduction

The University of Florida had the prime responsibility of organizing this workshop, which was held on the Gainesville campus. Telephone conference calls among the organizing committee at FAU, FSU, and UF were used to plan the workshop and to design the agenda. The organizing committee included Dr. Len Berry (FAU), Patricia Springer (FAU), Jo Ann Jolly (FAU), Jim Jones (UF), Carolyn Cox (UF), and Eric Chassignet (FSU). Also consulted was a program committee for speaker and panel suggestions. This committee included Doug Parsons, Florida Fish and Wildlife Conservation Commission, Jayantha Obeysekera, South Florida Water Management District, Leticia Adams, Florida Chamber of Commerce, Jay Levenstein, Florida Department of Agriculture and Consumer Services, and Karl Havens, Florida Sea Grant.

175 registered attendees representing 7 SUS universities participated in the workshop: FAU, FSU, UF, Florida Agricultural & Mechanical University (FAMU), Florida International University (FIU), University of Central Florida (UCF), and University of South Florida (USF). Two faculty members from the University of Miami (UM), who are actively involved in research on climate change, also attended the workshop and are interested in contributing to this effort. The other 4 state universities were consulted and contributed to the white papers' development. Eleven state and federal agencies were represented as well as 7 industry partners. For more details about the workshop, please see http://floridaclimate.org/index.php

The collaboration for this year-long process included 2 workshops and bi-monthly conference calls with PIs and coordinators as well as working group calls for each white paper conducted by lead authors. The first workshop served as a brainstorming session to determine working group composition, research scope, and methodology. The website development evolved throughout the process to include university climate expertise, partner agencies, and businesses who would contribute to the papers. The second workshop provided a platform for the white paper presentations and further dialogue between state, federal, and industry representatives through facilitated panel discussions. It was clear that attendees found value in these collaborations as many have discussed future projects, continued collaborative activities, and a heightened awareness of the need for a centralized climate information mechanism.

Keynote Speakers

The keynote speakers began on November 14 at 6:30pm. The talks were followed by facilitated discussion questions with Thomas Ankersen, Legal Skills Professor and Director of the Conservation Clinic at the University of Florida Levin College of Law.

Steven M. Seibert, J.D.
Founder, Seibert Law Firm

Seibert has operated his own law firm, served as the Executive Director of the *Century Commission for a Sustainable Florida*, and as a Senior Vice President and Director of Strategic Visioning for the *Collins Center for Public Policy*. He had 3 main points to make in his inspiring talk:

- Relating to SLR, mitigation, climate and water issues, and sustainability, the stakes are high
- In order to address these complex issues, opportunities for purposeful dialogue must be explored
- Personal and public humility is necessary to move forward

Seibert began his address with references to Abraham Lincoln's "The Perpetuation of Our Political Institutions". This work expounds the liberties and advantages of living in this great land and our collective responsibility to future generations. Lincoln warned that danger cannot threaten us from abroad, but it will come from amongst us. "As a nation of free men, we must live through all times or die by suicide."

Seibert warned that we must care about our resource problems, regard on another's perspectives, and rise to the occasion and meet climate challenge. Throughout his talk, he stressed the need for scientists to better communicate their research and tailor their messages to their audience. The trend for greater discussions of science in public policy now was emphasized and encouraged.

A recent article that summarizes the talk can be found at
http://www.tampabay.com/opinion/columns/article1204537.ece

Virginia Burkett, Ph.D.
U.S. Geological Survey

Virginia Burkett serves as Chief Scientist for Climate and Land Use Change at the U.S. Geological Survey. She was a Lead Author of the United Nation's Intergovernmental Panel on Climate Change (IPCC) Third and Fourth Assessment Reports (2001 and 2007) and the IPCC Technical Paper on Water (2008). She was a lead author of the 2001 and 2009 National Assessments of climate change impacts produced by the United States Global Change Research Program. She is presently a Coordinating Lead Author of the IPCC Fifth Assessment Report that will be completed in 2014.

Dr. Burkett's talk titled "Climate Change Trends, Projections, and Impacts in the Southeast" covered 3 main areas: 1) Climate trends and future projections-global to regional; 2) Implications for coastal ecosystems and; 3) Adaptation and mitigation.

Beginning with historical perspectives on sea-level rise, greenhouse gases, and temperature/atmospheric change, her data showed that in the past 100 years, CO2 increased 35%, methane increased 150%, global temperature increased .74 degrees Celsius, ocean temperature increased from the surface down to 3000m, there has been an increase in hurricane activity and ocean acidity, and that global sea level has risen 1.7mm/year. From 1993-2003 the global sea level rise has been 3.1mm/year. The future projections for climate are that warming is expected to be about .4 degrees Celsius during the next 20 years and that GHG emissions, at or above the current rates, would induce climate changes during the 21st century larger than those observed during the 20th century.

Dr. Burkett also discussed changes in precipitation patterns including frequency and duration of wet/dry periods. The concept of "relative sea level rise" as a combination of changes in global sea level and local or regional land surface elevation also showed the net effect of sea level change from 1958-2008 in various locations along the US coast. In the southeastern US, rates range from 4-8" from the Texas gulf to New York.

Dr. Burkett also presented a list of possible ecological consequences as a result of her data. Warmer winters leading to the spread of invasive species, lower soil moisture leading to more wildfires, coastal ecosystems becoming more saline, coastal erosion acceleration if storms increase in intensity, and storm surge flooding increases were among the likely consequences of climate change. These changes were followed by 10 examples of adaptation including reduction of non-climate stressors, reduction risk of catastrophic fires, prevention and control invasive species, maintenance of healthy, genetically diverse fish and wildlife populations, adaption of infrastructure adaptations and modifications of the built environment, reduction of sole reliance on historical weather and species data for future projections without considering climate change, adjustment of fisheries harvest and yield models to accommodate changing environmental conditions, establishment of corridors for species migration, relocation from low-lying coastal zones, and understanding of natural processes and trends in management practice. Finally, Dr. Burkett stressed the need for education of resource managers in order to accomplish the strategies needed to adapt to a changing climate.

Jayantha Obeysekera, Ph.D., P.E., D.WRE
Chief Modeler South Florida Water Management District (SFWMD)

Jayantha Obeysekera holds a B.S. in Civil Engineering from University of Sri Lanka, M. Eng. from University of Roorkee, India, and a Ph.D. in Civil Engineering from Colorado State University. He has served as an Assistant Professor at Colorado State University and as an adjunct faculty at the University of South Florida. Dr. Obeysekera has published over 40 research articles in refereed journals and over 50 others in the field of water resources. He has taught short courses in the countries of Dominican Republic, Colombia, Spain, Sri Lanka, and U.S. He served as a member of National Research Council (NRC) committee on Klamath River and is currently a member of the NRC committee on California Bay Delta. He was appointed as an advisory team member to review the computer modeling of the New Orleans area in the aftermath of the hurricane Katrina. During his tenure at SFWMD, he managed the modeling for the development of the Comprehensive Everglades Restoration Plan (CERP). His group has also been instrumental in the application of climate outlook and projections for water resource planning and operations. Presently, he is the technical lead for climate change and sea level rise investigations at SFWMD. Recently, he was appointed to the National Climate Assessment and Development Advisory Committee (NCADAC) and as an Affiliate Research Professor at Florida Atlantic University.
Dr. Obeysekera's talk "Climate Change and Sea Level Rise in Florida" began with an outline which included planning in a "non-stationary" world, natural variability, climate modeling, projections for Florida, sea level rise, and tropical storms.

Dr. Obeysekera identifies the primary variables of interest as temperature, precipitation, evapotranspiration, and saltwater intrusion. These will all have implications for water managers, agriculture, energy, tourism, transportation, and health sectors. He goes on to propose a diagram about the use of climate information. The diagram details the inter-connection between observed climate data and the General Circulation Models (GCMs). He further explains that GCMs include both a simulation of the late 20th century and 21st century predictions which are then downscaled, using both statistical and dynamical methods, to determine how ell south Florida is represented by climate models and how the projections will affect water resource managers. The resolution of the GCMs though, is inadequate to capture the hydro-meteorology of Florida and work needs done to improve these.

The talk the shifts to seal level rise and the relationship between global mean sea level, regional variability, and vertical land movement. He offers a planning horizon of 2060 before which adaptive management strategies need implemented. After 2060, we will need contingency plans. The factors that contribute to sea level rise are outlined as terrestrial water input, vertical land movement, land based ice changes, and thermal expansion. A decision strategy which accounts for uncertainties is needed for implementing adaptation measures.

White Paper Summaries

All white papers can be found at http://floridaclimate.org/whitepapers. Presentations of each paper can be found at http://floridaclimate.org/presentations

Biodiversity: Florida Adaptation to Sea Level Rise and Climate Variability

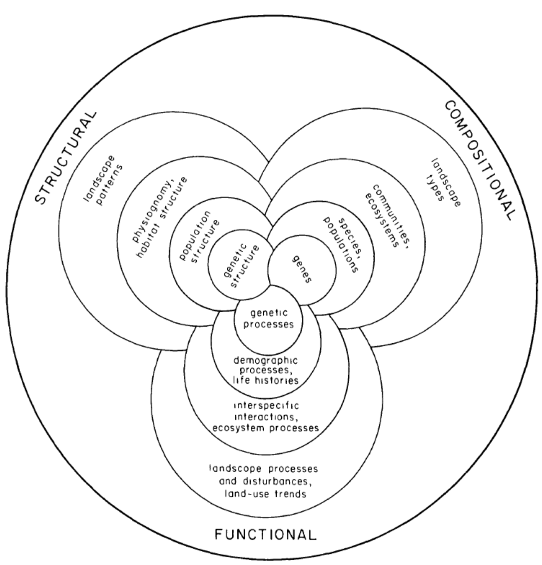
Authors: Jennifer Seavey, Ph.D. and Susan Cameron Devitt, Ph.D.
Co-Authors: Sieara Claytor M.S., Tom Hoctor, Ph.D., Reed Noss, Ph.D. Corrie Rainyn, Martin Main, Ph.D., Odemari Mbuya, Ph.D.

Purpose:

The purpose of this document is to describe the current scientific understanding of climate change induced impacts on Florida's natural resources. We offer a primer on observed and expected changes across the state. We discuss management strategies and the current challenges to effective management. While we recognize the uncertainty and difficultly of managing dynamic ecosystem change, we emphasize the need for proactive strategies in climate adaptation and mitigation to preserve Florida's natural resources.

Scope:

Experts in ecology and natural resource management from across Florida have contributed to this document and provided informed assessments of the future of Florida's biodiversity under a changing climate. The uniqueness of this document is its broad examination of the response of biodiversity to climate change. Ecological systems and associated species respond to environmental change in complex ways. Despite this complexity, we have tried to distill the information that is relevant to Florida because of the huge demand for locally applicable information. Therefore, throughout this paper we emphasize the impact of climate change on Florida's natural resources.



We have defined biodiversity in this document as hierarchy, encompassing the structural, compositional, and functional components of natural systems (From: Noss 1990).

Highlights:
Florida's abundant and unique biological resources are at particularly high risk for climate change impacts because of Florida’s low topography, extensive coastline, and frequency of large storm events. Florida's biodiversity, especially along the coastline, is already responding to climate change through changes in physiology, distribution, timing of life history events, and extinction risk. Physiological stress is being observed among marine species and northward movement is becoming more common as a result of temperature shifts. Unfortunately, for Florida, species movement brings increased risk for invasions by non-native species. Life history events, such as sea turtle nesting and tree flowering dates are shifting earlier in time to keep pace with increasing temperatures. Climate change also brings elevated extinction risks for Florida's numerous endemic species and species of conservation concern. The decline in biodiversity is of great concern because Florida’s biodiversity and natural systems provide significant ecosystem services and aesthetic values that benefit all the citizens of Florida.

Florida species at risk of extinction due to climate change. (clockwise from upper left: leatherback sea turtle, mangrove cuckoo, elkhorn coral, Florida panther, and in the center: manatee.)

Key Findings:
We recommend several strategies for maintaining Florida's biodiversity that should be carried out in an active adaptive management framework: increase and improve public outreach; promote and support long-term ecological monitoring programs; promote a broad scale, state-wide approach to climate change adaptation strategy development; reduce other anthropogenic threats to biodiversity; consider the use of assisted migration and other specific adaptation strategies; create migration corridors and buffers; and promote a dynamic view of ecosystem function and resiliency.

Gaps Identified:
To develop effective management to address climate change impacts on Florida's biodiversity, several scientific and management gaps need to be filled. Florida specific climate models are needed in a format useful for natural resources evaluation. Improvements in ecological modeling methodology that increase attention to natural disturbance regimes and interacting drivers; an increase in attention on broad scale general patterns and trends; and broader cooperation in terms of data and climate scenario sharing would promote more effective scientific understanding of biodiversity impacts. Management gaps include improved use and collection of data; use of an active adaptive management framework that incorporates uncertainty and the dynamic natural of natural systems; and finally increased public outreach.

Collaborative Opportunities:
Climate change will influence biodiversity at every hierarchical level and in complex ways, therefore, it is critical to build effective collaborative partnerships across agency, political, and land ownership lines. We identify and list major partners in climate change adaptation and natural resource management working within Florida. Federal programs such as the White House's Interagency Climate Change Adaptation Task Force and the Department of Interior's Landscape Conservation Cooperatives are being implemented to enable holistic adaptive management across broad spatial scales. At the state level, the Fish and Wildlife Commission, Water Management Districts, Florida Oceans and Coastal Council, and others should continue to expand collaborations with research scientists and non-profit organizations to promote broad scale, active adaptive management of Florida's biodiversity.

Florida Water Management and Adaptation in the Face of Climate Change: Climate Change and Florida's Water Resources

Principal/Leads: Leonard Berry, Marguerite Koch-Rose, Diana Mitsova-Boneva, Tara Root
Contributors: Frederick Bloetscher, Jorge Restrepo, Ramesh Teegavarapu, Jaap Vos, Nicole Hammer

Introduction:
Traditional planning by water managers and utilities assumes that hydrologic conditions remain relatively stationary. Under this assumption, historical hydrologic and water use patterns are adequate to design, regulate and manage water supplies, storm water runoff, and wastewater conveyance and treatment systems. As climate change progresses, however, hydrologic systems will be altered due to changes in the water cycle and rising sea levels. These fundamental changes to the water system interject uncertainty about how climate change will impact Florida's hydrologic systems and present significant difficulties for water managers attempting to develop strategies to meet long-term water supply, stormwater and wastewater treatment needs for the state. The uncertainty about how climate change will impact Florida's water resources and its infrastructure creates a challenge for most sectors of Florida's economy. Uncertainty is exacerbated by the strong human imprint on water resources through consumption of fresh water, disposal of wastewater, alterations in land cover, and control of surface water flows. Thus, in addition to climate change, shifts in the economy, demographics, consumer preferences, and

attitudes towards the environment add to the uncertainty about future water demand and infrastructure needs.

Florida's Water Use:

There remain significant uncertainties about the volume of water needed to sustain the state's surface water and groundwater aquifers now and in the future. Florida's surface waters, including major wetland ecosystems, are a significant source of recharge for the aquifers that provide most of the fresh water for residential, industrial, and agricultural uses. Florida's total water withdrawals were approximately 18 billion gallons per day in 2005, 37% from fresh groundwater and surface water sources and 63% from saline water sources. In 2005, the gross per capita water use in Florida was 158 gallons per day. Florida ranks sixth in the nation for groundwater use, using more groundwater than any other state east of the Mississippi. However, it is predicted that by the year 2025, Florida's population will increase by 57% and water consumption 30%. Many areas of the state are currently struggling to find alternative sources of water as supplies of fresh water from relatively inexpensively treated groundwater sources are dwindling because of high usage and inadequate recharge. In fact, each of the water management districts has designated Water Resource Caution Areas that have, or are expected to have, critical water supply problems within 20 years. One of these caution areas is central Florida, which is entirely dependent on groundwater. In this area, it is estimated that demand will exceed the availability of groundwater by 2014 and groundwater flows to wetlands and springs have already been significantly diminished. Demographic changes over time will put further pressure on the central part of the state requiring new water resources and public water supply infrastructure in this caution area.

Climate Change and Water Supply:

Long-term water management planning will continue to be severely challenged by the uncertainty of future demands, limited water supplies, and a changing climate. Florida's precipitation patterns are uncertain because they are dependent on large-scale global weather systems as well as being controlled by regional and local weather patterns. Climate variability, which is predicted to become more extreme, has major influences on weather in Florida. Climate oscillations control long periods of extreme drought and higher than normal precipitation through the dry and wet seasons. The responses of these global, regional and local weather patterns to climate change will dictate the amount of water recharge available to replenish Florida's aquifers and surface water sources. Higher temperatures in the state will also increase the loss of freshwater surface sources to the atmosphere (evapotranspiration) and those losses will be enhanced under prolonged droughts. Thus, there is a need to better understand how climate change will affect Florida's water supply now and in the future.

Complicating water supply issues under a changing climate is sea level rise. Rising sea level increases the salinity of surface water and groundwater due to inundation of low-lying coastal land and saltwater intrusion into coastal aquifers. The impact of sea level rise on saltwater intrusion is probably small at present compared to the impacts from pumping and land drainage. However, the impact from sea level rise is likely to become much more significant in the near future, particularly under a rapid sea level rise scenario. Some coastal cities in southeast Florida are already having salinization problems in their public supply wells. In these areas, canals are currently being used to move inland waters to the coast in order to sustain groundwater elevations in coastal aquifers to limit salt water intrusion. As these coastal aquifers are critical to water supplies it is important to understand where the saltwater intrusion front is and how fast it is moving in response to sea level rise and aquifer withdrawals.

As relatively low-cost aquifer sources become depleted, or contaminated with chlorides, water utilities must continue to provide uninterrupted, high-quality water to their customers, and many must also plan for rapidly growing populations. Even in the absence of climate change, Florida's existing fresh groundwater and surface water sources may not be able to meet projected future demand through 2025. The state of Florida, together with the water management districts, has been actively pursuing alternative water supplies, such as reclaimed water and desalination, in order to ensure adequate fresh water supplies for the future. Stormwater capture, artificial recharge, and aquifer storage and recovery represent other potential water sources. Although water conservation does not represent an alternative water source, it is a key component of the state's strategy for meeting future water demand and is being considered side-by-side with the more expensive engineered alternative supply options.

Climate Change and Flooding:

In Florida where topographic relief is relatively low, gravity-driven movement of water is challenging. Yet, much of Florida's stormwater is managed through gravity-driven canals. South Florida in particular relies heavily on a gravity-driven canal system in which water managers prevent flooding by discharging stormwater to tide. In low elevation areas of Florida where the flood control infrastructure was established several decades ago, water managers are already challenged by the sea level rise over the past 50 years. Although sea level changes are variable over geological time scales, and sometimes change abruptly on human time scales, sea level over the last 100 years (7.78 inches) has increased at a modest rate of 0.079 inches/yr. If sea level rise rates accelerate significantly, as predicted, and even if the slower rates of rise continue, the coastal water infrastructure will be compromised in very low-lying areas of the state in the near future. The problem with sea level rise is that it decreases the water elevation gradient along the canal system, and in so doing reduces the capacity for gravity-driven drainage through the canal network. In addition to these drainage issues from sea level rise, flooding events may occur more frequently due to potential increases in extreme precipitation events. Some of these events are likely to exceed the capacity of the current flood control system in some areas. Furthermore, as sea level rises, groundwater elevations will increase, reducing the storage capacity of the unsaturated soil zone which can temporarily hold a proportion of stormwater runoff. Thus, increases in precipitation intensity and rising sea level will make coastal zones more prone to flooding.

Climate Adaptation and Energy:

It is estimated that about 80% of all energy consumed in the United States is used to pump, transport, treat and heat water. In most Florida communities, the water and wastewater plants are the largest power consumers on the grid. Because the state's water supplies are currently not adequate to meet future demand, the need for energy intensive advanced treatment of alternative water supplies will increase utility power demands. Climate change is expected to further increase the energy requirements for water and wastewater utilities in Florida. Alternative water supplies, such as desalination and advanced treatment of wastewater for reuse, are more energy intensive than traditional water treatment. Also, more pumping of water to provide flood protection will be required with sea level rise and greater storm intensities. Power plants will also need more water for cooling as intake water temperatures rise. Thus, water management adaptation to climate change will add to the energy requirements on top of the energy needs that will be needed for cooling as temperatures rise and the warm season expands.

The Human Element of Climate Adaptation:
As climate change results in greater weather extremes and shifting weather patterns, utilities and water managers may be forced to make rapid changes in water conservation policies, such as water restrictions. Additionally, interruptions in water supply are conceivable due either to water shortages during extreme droughts or infrastructure damage during extreme storm events. With 57% of Floridians reporting that they worry only a little or not at all about global warming, it is likely that many Floridians may not take water policies related to climate change seriously. Furthermore, in the current period of slow economic growth, it could prove very difficult to gain public support for funding initiatives to upgrade or develop new water supply and flood protection infrastructure. Because the success of climate change adaptation strategies hinges in part on public perceptions and responses, adaptation strategies should explicitly include education measures to inform the public about the need for policy and infrastructure changes. Florida's coastal population growth will also make the undertaking of climate change adaptation increasingly challenging as more and more people reside, seek job opportunities and retire in coastal vulnerable areas. Over the past thirty years, Florida exhibited the fastest rate of growth in the nation together with Texas, North Carolina, Georgia and California. The 35 coastal counties bore the brunt of the most recent population increase as nearly 1.9 million new residents settled on Florida coasts in the past ten years alone. In 2010, the population of all coastal counties in Florida was approximately 14 million people or 75% of the state's total population of approximately 19 million. The inland counties are home to ~5 million and in the past 10 years the rate of growth was faster (24%) than coastal Florida (16%). The majority of the population lives along the coast where the state's water infrastructure is concentrated, but this area is vulnerable to coastal hazards and salinization of aquifers. However, inland migration would create additional challenges, as water resources and infrastructure are limited in central Florida. Changing population demographics are important to climate adaptation because Florida has a high ethnic and culturally diverse population where communicating risks associated with climate change requires cultural competence and understanding of diverse groups' perspectives, needs, languages, beliefs and norms. Further, Florida has the highest percentage of people aged 65 years and over with 3.2 million people greater than or 65 years old. Elderly populations can have limited mobility and they are susceptible to extreme high temperatures. Another vulnerable population is those from lower-income backgrounds because of their inability to relocate to areas less prone to flooding in the long-term or quickly evacuate during a natural disaster.

Summary and Conclusions:
The direct effects of climate change on water resources include increased threats on the sustainability of water supplies, flooding, salt water intrusion in coastal areas and threats to water quality. Most of the state currently relies on groundwater. However, it is clear that groundwater resources are inadequate now to meet future water demand in many parts of the state, and climate change adds to the vulnerability of groundwater supplies and uncertainty of supply and demand. Therefore, developing alternative water supplies is a priority. While a few municipalities and counties are planning to develop new surface water sources, the difficulties of

storing water in regions with little topographic relief, porous geology, and shallow water tables, and their environmental impacts limit the viability of developing significant surface water sources. Because of these limitations on traditional surface and groundwater sources, alternative sources such as desalination and reuse will be significant components of Florida's future water supplies. Conservation measures will also become increasingly important in the state's effort to maintain sustainable water supplies.

The current economic reality and other financial challenges in meeting the water needs of Florida, and protecting its infrastructure, in the face of climate change will require an unprecedented level of resource leveraging and coordination among academic, governmental, non-governmental, and private sector entities. There are multiple institutions and organizations that are currently working on sustainable water resource issues and the socio-economic implications of water security, and are capable and prepared to work together to increase the resilience of the state of Florida to the present and future challenges of planning and adapting to climate change.

Florida Climate Change Education and Training: State University System Cooperative Plan

Leader: Sebastian Galindo-Gonzalez

Contributors: Leonard Berry, Carolyn Cox, Alana Edwards, Robert Ellingson, Allan Feldman, Tracy A. Irani, James W. Jones, Julie Lambert, Christine Lockhart, Mantha Mehallis, Jeffrey G. Ryan

Synopsis:

The overall goal of this paper is to provide information on university climate change programs (research and education), university climate change institutes and centers, and climate change education initiatives statewide in Florida. The specific objectives are to: a) Describe the current status of climate change education within Florida; b) Assess the extent at which educational needs related with climate change are being addressed through available educational programs and initiatives; and c) Identify action items required to enhance climate literacy of the State's population required to inform and implement adaptation and mitigation decisions.

The main object of study of this document is the formal and non-formal educational curricula on climate change available in Florida. Therefore, an account of related outreach and professional development programs sponsored, developed, and/or delivered by governmental agencies, non-governmental organizations, and the private sector is included. However, it is not possible to claim

Figure 1: The 2nd Climate Change Task Force Workshop was held on November 14-15, 2011 at the University of Florida's Emerson Alumni Hall.

that the information presented in this document is an exhaustive account of the climate change education in Florida because there are multiple challenges to identifying all education programs on climate change. A significant challenge is that climate change education is very diverse and approached from a variety of disciplines and philosophical perspectives (e.g. quantitative courses in Meteorology vs. qualitative courses in Anthropology). The instructors of all these different courses/programs are dispersed and, in most cases, do not share other scholastic activities. This makes it very difficult to identify those who are teaching topics on climate change, how are they framing the issues, and what types of outcomes they expect from their learners.

The information collected showed that 406 courses with varying degrees of climate change content are available for the more than 330,000 students within the 12 surveyed institutions of higher education in Florida. Almost half of the 406 courses are taught in disciplines within the Earth and physical sciences, and nearly a fourth belongs to the social sciences. The rest of the courses were part of the curricula of life sciences, interdisciplinary programs, and humanities. For a list of courses gathered in this process, see www.floridaclimate.org/climatecourses

In addition, Florida possess more than 20 centers and institutes that conduct research focused on understanding the climate change, and develop strategies to both decelerate the change process and prepare for its impacts. These institutions foster the establishment and maintenance of national and regional multidisciplinary networks of scientists connecting them with a variety of stakeholders. Furthermore, multiple non-formal educational initiatives are developed and implemented by universities, governmental agencies, NGOs, and private entities. These initiatives aim to raise climate literacy across different segments of the population

A set of educational needs were identified. The most important needs are: a) promote a stronger integration of climate change education with other sciences and disciplines; b) enhance students' access to current and future courses; c) develop the skills of scientists for translating scientific concepts to lay audiences; and d) strengthen the preparation of teaching and extension faculty and K-12 science teachers to incorporate climate change concepts in their courses.

Based on these findings and on recent publications, such as the USGCRP Climate Literacy framework, the authors propose two strategies to address the identified needs. The first one contemplates the establishment of a state-wide, inter-institutional, and multidisciplinary minor/certificate on climate change. This program would enhance the access of students to a variety of courses on climate change, improve the capacity of future scientists for translating sciences, and promote the integration of climate change education into a variety of disciplines. The second strategy focuses on the development and delivery of training curricula to enhance the knowledge and skills of university faculty (both teaching and extension) and K-12 science teachers on two main areas: 1) the integration of climate change education into their courses/programs, and 2) the translation of scientific concepts to multiple audiences.

The implementation of the proposed strategies will require the collective action of multiple stakeholders (e.g. university faculty, secondary teachers, policy-makers, etc.). Future collaborative opportunities will be abundant and must be productive, focused on situating climate change education (in all its different forms) at the center of the efforts to help society in the mitigation of climate change and in adapting to its current and future impacts.

Climate Scenarios: A Florida-Centric View

Leader: Vasubandhu Misra
Contributors: Elwood Carlson, Robin K. Craig, David Enfield, Benjamin Kirtman, William Landing, Sang-Ki Lee, David Letson, Frank Marks, Jayantha Obeysekera, Mark Powell, Sang-lk Shin

Synopsis:
This document comprises the viewpoints of experts in Florida from diverse fields on climate scenarios of the future with a focus on potential impacts on the state of Florida. A general perception of climate change is associated with uncertainty that entails different viewpoints and an implied limited understanding of the impacts of climate change. This notion is amplified further when impacts of climate change are assessed locally over a region like Florida. It is the collective opinion of this group that we cannot wish away this uncertainty. The nature of the problem warrants a probabilistic projection although a deterministic answer to the impact of climate change is most desirable. In fact the uncertainty in our understanding and predictions of climate variations is a natural outcome of the increasingly complex observing and modeling methods we use to examine interactions between the biosphere, atmosphere, hydrosphere, and cryosphere.

It is shown that Florida represents a good example of a complex regional climate system, where relatively slow natural climate variations conflate or deflate the multiple sources of anthropogenic climate influences. Climate change in this document refers to all sources of anthropogenic influences, including greenhouse gas (GHG) emissions, aerosols, and land cover and land use change. In fact assessing climate change over Florida is so complex that *climate change occurring remotely may have a larger impact than the direct influence of climate change on Florida*. However the basic fact irrespective of the source of these variations and change is that Florida, with its vast and growing coastal communities and changing and growing demography will make itself more vulnerable to weather and climate events. With anticipation of further rapid increase in GHG emissions, it is prudent to act now in applying the necessary regional climate information that we have to educate the public and implement adaptation and mitigation plans. Some of the most apparent impacts of climate change and variability for Florida are as follows:

- Salt water intrusion from sea level rise is already becoming an issue for the freshwater demands of highly populated areas along the southeast coast, from the Florida Keys to Palm Beach. This issue may further worsen and become more widespread over time with climate change.
- The displacement of communities, destruction of infrastructure and terrestrial ecology, and increased prospects of damage from storm surge would be additional consequence of sea level rise.
- The likelihood of the change in the statistics of Atlantic tropical cyclone intensity has a huge implication for the sustenance of coastal and inland communities in terms of damage to infrastructure and property, human mortality, and the modulation of the accumulated fresh water source in the summer, especially in South Florida.
- Remote impacts of any perceived climate change in the characteristics of El Niño and Southern Oscillation (ENSO; although none have been conclusively found so far) will

have an implication on the seasonal climate variability over Florida, especially in winter and spring seasons.

- Likewise remote impact of climate change over North Africa can have implications on dust transport across the Atlantic Ocean, which can change the air quality and health of Florida's neighboring oceans.
- The uncertainty in the anticipated changes in Florida red tide (a harmful algal bloom) due to changes in ocean temperatures, long term variations of local scale terrestrial runoff can make the fishing industry and the human population vulnerable.
- Florida's coastal reefs, which serve as a habitat for a variety of biota, are threatened by ocean acidification from increased levels of dissolved carbon dioxide.
- There is anticipation of inevitable future increases in the wealth of Florida coastal communities, which would lead to further infrastructure development that will make the coastal regions far more susceptible to even moderate (and unanticipated) changes in climate.

It is recommended that, with existing climate information, effective climate scenarios could be developed in the near term that would be useful to plan and test sustainable strategies for adaptation and mitigation of climate-related vulnerabilities. Ongoing scientific research is bound to further improve our ability to understand and predict our climate system to meet the strident demands for accurate climate projection.

In addition the growing and aging population of Florida would make this State more vulnerable to climate variations and change. The demand for energy and water will proportionately grow, while changes in land cover, air quality, coastal waters from urbanization, industrialization and agriculture will be inevitable.

Although it is pointed out in this document that sea level rise is one of the main issues confronting Florida in terms of the immediate impact of climate change, we have not included a description of it in this document. This is because there are several reports that have recently been released on sea level rise. They are listed below for our interested readers:

Sea Level Changes in the Southeastern United States: Past, Present and Future (Mitchum 2011; available from http://coaps.fsu.edu/~mhannion/201108mitchum_sealevel.pdf)

Past and projected trends in climate and sea level for South Florida (Obeysekera et al. 2011; available from http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/ccireport_publicationversion_14jul11.pdf)

IPCC workshop on sea level rise and ice sheet instabilities (Stocker et al. 2010; available from http://www.ipcc.ch/pdf/supporting-material/SLW_WorkshopReport_kuala_lumpur.pdf)

Thirsty for answers: Preparing for the water-related impacts of climate change in American cities (Dorfman et al. 2010; available from http://www.nrdc.org/water/thirstyforanswers.asp

Panel Discussions

Video recordings or each panelists' talk as well as the facilitated discussion can be found at http://floridaclimate.org/presentations

Panel Discussion I: Environment and Natural Resources

This panel discussion included 4 panelists from a variety of backgrounds in resource management including habitat conservation, coastal ecology, water management, and real estate. The discussion that followed was facilitated by Jim Murley, Director of the South Florida Regional Planning Council.

The first panelist, Ernie Estevez, Director for Coastal Ecology at the Mote Marine Laboratory discussed the various scenarios and impacts from sea level rise on the springs along the gulf coast of Florida. He highlighted the consequences for stream flow, nitrate concentration, wetland loss.

Thomas Eason, Deputy Director of the Division of Habitat Species Conservation at the Florida Fish and Wildlife Conservation Commission gave the wildlife biologists' perspective on climate change. He outlined the major strategies which were the outcome of a recent summit hosted by FWC in Orlando. They are Customize predictive models to Florida, develop integrated data and monitoring, build broad support and action, nurture a coordinated state response, manage the landscape for wildlife resiliency, protect landscape corridors, review priorities in light of dynamic environment, build on strategic and funding opportunities, and provide inspired leadership in the face of uncertainty.

Alison Adams, Source Rotation and Environmental Protection Manager from Tampa Bay Water followed with a talk about using dynamically and statistically downscaled climate model output to drive hydrologic models and explore potential impacts of climate variability and climate change on water availability and water allocation decisions. These decisions are also impacted by sea level rise predicted at 2cm/decade and 40-80cm by 2100. Management will need adaptation plans for source water quality, source availability, infrastructure, flooding, loss of drainage system functions, and ecosystems. Alison also discussed the role of water and energy efficiency through reductions in use, reductions in greenhouse gases, and expanded alternative fuel and renewable energy programs through sustainability programs.

Todd Powell, Director of Real Estate for Plum Creek was the final speaker with his talk titled "Climate Change, Coastal Development, and Common Sense". He started with some population statistics that showed 53% of Americans live near coastal cities and 75% of Florida's population lives in coastal counties. Todd indicated that a change is needed in the way that we manage and distribute the population through incentives, planning and design criteria, encouraging compact new towns and villages, expanding existing towns in rural communities, and the support of inland development. He wraps up his talk with a common sense approach to the issues facing land use in Florida with time-sensitive suggestions to react and adapt to global warming and sea level rise, conserve and enhance our open lands, facilitate long-term agriculture, and provide economic development and diversification through inland ports, new towns, and villages.

Panel Discussion II: Economics and Policy
Video recording of each talk and the facilitated discussion of this panel can be seen at http://floridaclimate/presentations

This panel consisted of 4 members who work with climate in the context of economics and policy. The discussion that followed was facilitated by Steve Seibert, founder of the Seibert Law firm, former Pinellas County Commissioner, and former leader of the Department of Community Affairs under Jeb Bush.

The first panelist to present was Pegeen Hanrahan, Principal, Community and Conservation Solutions, LLC, former mayor of Gainesville, and board member of ICLEI-USA. Her talk titled "Local Government Climate Change Initiatives" started with an outline of the US Conference of Mayors Climate Protection Agreement in which 1054 mayors from 50 states (78 from Florida), DC, and Puerto Rico, representing a population of 88,449,854 citizens agreed on the following actions:

- Strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns;
- Urge their state governments, and the federal government, to enact policies and programs to meet or beat the greenhouse gas emission reduction target suggested for the United States in the Kyoto Protocol -- 7% reduction from 1990 levels by 2012; and
- Urge the U.S. Congress to pass the bipartisan greenhouse gas reduction legislation, which would establish a national emission trading system

To accomplish these goals, she proposed a 3 pronged approach: 1) Maximize energy efficiency. Gainesville has been investing approx. $4 million per year in grants and incentives for insulation, HVAC, lighting, roofing, water heating, and many other options. GRU matches business investment on a 1-for-1 basis, up to $100,000 per site; 2) Dramatically increase solar deployment, up to 32 MW by 2016; 3) Shift from a power purchase contract with Progress, replace with 100 MW biomass plant using waste from forestry, urban tree trimming.

Steve Adams Senior Program Advisor for Climate Adaptation for the Institute for Sustainable Communities and former Managing Director of the Climate Leadership Initiative was our second panelist. His talk titled "Regional Climate Adaptation Initiatives" began with the guiding principles from the CEQ Adaptation Task Force Final Report to the President (Oct 2010). They are to adopt integrated approaches, prioritize the most vulnerable, use best available science, build strong partnerships, apply risk management methods and tools, apply ecosystem-based approaches, maximize mutual benefits, and continuously evaluate performance. The recommendations from this report were:

- Policy Goals & Recommendations
- Encourage & Mainstream Adaptation Planning Across Federal Agencies
- Improve Integration of Science Into Decision-Making
- Address Key Cross-Cutting Issues
- Enhance Efforts to Lead & Support International Adaptation
- Coordinate Capabilities of Federal Government to Support Adaptation

Steve outlined some notable regional cases and then discussed the significance of the SE Florida Compact. The "Resilience Regionalism" concept is one that addresses key challenges to adaptation in the US: intergovernmental coordination around the unique problems of a place, enables scaling of solutions to meet human/natural systems of significance, and also enables the development of a regional "voice" and "vision" for future prosperity. In short, he urged sector integration for localized climate impacts based on the best science, economics, and adaptation information.

Fred Bloetscher from Florida Atlantic University followed in this second panel with a talk titled "Managing Florida's Water in the Face of Climate Change: Protecting People and Infrastructure". He concludes that sea level rise has been occurring for over 100 years and we are unlikely to stop it soon so we will need to adapt to the changes or risk critical alterations to the current built and natural environment. He states that there are 3 critical issues regarding water and climate change: how increasing hydrologic variability may affect water supply and demand, flood/stormwater control and wastewater collection and treatment; how sea level rise may impact road, water, sewer and stormwater infrastructure, and; how energy usage, to treat and deliver potable water and to treat and dispose of wastewater, may contribute to climate change or variability.

Rayburn Butts, Director of Environmental Services Strategic Planning for Florida Power & Light Co. and NextEra Energy, Inc. was out final panelist to present with "Addressing Climate Change: Major Industry Policies and Programs". FPL has plans to make more than $11 billion in major capital projects for customers from 2011 through 2014, including:

- New high-efficiency, combined-cycle natural gas generation
- Increased zero-emissions nuclear capacity
- More intelligent, automated infrastructure features
- Hardened infrastructure to be more weather resistant

Closing Discussions

Dr. Berry led the wrap-up session with a discussion on Florida's concerns regarding climate change and future collaborations amongst the universities, agencies, and industries. The white papers provided focal points and are available online at http://floridaclimate.org/whitepapers.

Continued collaboration and focus on scientific research is important. One of the gaps in research that was identified is the potential range expansion of invasive species. Sea level rise remains a critical issue, but effects will be regional. Recent media headlines have raised awareness about localized flooding and salt water intrusion. A need to plan combining the big picture with other issues like uncertainty, adaptation, uneven and unexpected changes in response to extreme events, and the response of cultural groups was discussed. Both counties and universities are cooperating on this issue.

Our educational system needs internal assessment. The University of Arizona restructured and may be a good model for system change within the State University System of Florida. It was suggested that unique approaches be identified and explored for Florida.

Cultural and social issues need to be included in future research; for example, social vulnerability as an outcome of human decisions and policy. Second order adaptations may result, such as adjustments to human displacement from coastal areas. The departments of philosophy and religion as well as faith communities should be invited into this discussion. We need to engage social scientists, economists and political scientists, include social justice issues in climate discussions. It was suggested to change the language, perhaps to "actionable science."

Climate information is important to Florida and downscaling is being used by agencies in projects. However, there is not enough focus on people or the built environment. Education, research and outreach are essential. We need to get the story out and reach out to the end-user, but it is challenging to engage the public in dialogue about long-term scenarios.

Future actions in south Florida include a March 2012 workshop by USGS on the hydrologic cycle of the Everglades, evapotranspiration, future patterns, etc. and a June 2012 Sea Level Rise Summit at FAU.

Posters and Abstracts

Heather D. Alexander, Michelle C. Mack, Scott Goetz, M. Loranty, Pieter S. A. Beck, Kamala Earl, Sergey Zimov, Sergey Davydov, and Catharine C. Thompson (UF)

Climate change, fire, and carbon accumulation patterns within boreal forests of Alaska and Siberia

Global change models predict high-latitude boreal forests will become increasingly susceptible to an intensifying fire regime as climate warms and dries. This altered disturbance regime could affect global terrestrial carbon (C) stocks by decreasing stand age or altering plant demographic processes, leading to patterns of forest regrowth that differ from the pre-fire stand. To improve our understanding of post-fire C accumulation patterns within boreal forests, we evaluated temporal and spatial variations in above- and belowground C pools within 44 mid-successional stands of varying composition across interior Alaska and within 17 Cajander larch (Larix cajanderi) forest stands of far northeastern Siberia. In interior Alaska, stands are predicted to exhibit increased deciduous cover as fire severity increases. Our research indicates that if this shift occurs, landscape-scale C storage in aboveground pools will substantially increase because deciduous stands accumulate and store more C in trees/large shrub aboveground biomass and snags than stands dominated by evergreen conifers. In addition, our field-based estimates of C pools in combination with remotely-sensed data confirmed that areas across interior Alaska that burned at greater severity since the 1950's had greater deciduous biomass with potentially large feedbacks to climate warming. In Siberia, our data indicate that if an intensifying fire regime reduces the fire return interval without altering stand density, landscape-level C storage will decline, but if an altered fire regime simultaneously reduces stand age while increasing larch density, large aboveground C pools within high-density stands will likely compensate for a shorter successional cycle. Taken together, results from both Alaska and Siberia underscore the importance of forest compositional shifts on C pools under a warming climate and the need to understand fire impacts on successional processes.

Ricardo A. Alvarez (FAU)

Storm Surge and Climate Change: the Forgotten Factor

Tropical cyclones cause damage through the impact of their component wind and water on the built and natural environment in their paths. In vulnerable coastal regions most of the water damage is caused by the storm surge generated by a tropical cyclone, which is considered to be by far one of the most destructive components of said natural hazard. The potential for damage as storm surge rushes onshore is a function of several factors including maximum wind velocity of approaching hurricane, tracking velocity of tropical cyclone system, depth of water [bathymetry], underwater topography, slope of underwater continental shelf, wave height, morphology of impacted coastal region, the influence of area-specific natural or human impact modifiers, and the characteristics of the impacted community in terms of type of construction, human activity and the prevalence of protective measures and practices or lack thereof. In addition to its enormous potential for causing damage on impacted coastal communities, storm surge is one component of tropical cyclones that is directly linked to climate change through sea level

rise. Because of this linkage storm surge may be continuously exacerbated in the future, which increases its damage causing capabilities. Recent studies show some $100 billion in residential properties are at risk of storm surge impact in Long Island, NY, and close to $45 billion more in the Miami-Palm Beach coastal region. Once we consider the entire exposed USA coastline and include commercial properties and supporting infrastructure, the value at risk of being damaged by storm surge easily climbs beyond $1.0 trillion. Given this exposure to catastrophic damage and the prospect that it may continuously get worse in the future one would expect building and project owners, but especially design professionals, to have an arsenal of tools to characterize the potential impact of storm surge on a site-specific basis in order to establish design-criteria to build hazard-resistant buildings in coastal regions. However, a review of standards for structural loading and building codes reveals a lack of specifics when it comes to storm surge. In fact what is generally available is long on generalities and short on actions and guidance to quantify the impacts of storm surge. It is high time the research and building design sectors combine forces to establish clear methodology and sources of data, to allow engineers to characterize surge impact on a site-specific basis.

Melissa Ayvaz (UF)

Paleotempestology at Pineland: Developing a Proxy Method that Integrates Archaeology with Climatology

Recent climatological studies have underscored the need to establish baseline data reflecting past trends to more accurately assess climate changes in the present and future. Attempts have been made to investigate correlations between tropical cyclone activity and broader climatological patterns. Historical records have been accessed to create a record of Atlantic cyclonic activity for the past century; however, projecting these records of storm activity further into the past is more problematic. The relatively new field of paleotempestology incorporates proxy data to create records of past storm activity. The methods used tend to reflect geological scales of resolution. Archaeological sites provide an untapped record of geophysical information at a scale that is relevant to human experience. This research presents an approach to integrating the stratigraphic contexts of zoo archaeological deposits with cultural and sedimentary processes as a method for identifying lived short-term weather events. Archaeofaunal assemblages from the Citrus Ridge and South Pasture components of southwest Florida's archaeological Pineland Site Complex are compared to address the hypothesis that at least one high-intensity hurricane impacted the landscape and its inhabitants during the 4th century A.D. Storm surges associated with hurricanes leave scars and detritus in their wake that can be preserved in the archaeological record. Characterizing such events involves quantifications, identifications and distributions of vertebrate and invertebrate remains coupled with geophysical analyses. Utilizing an interdisciplinary approach, the results of this investigation have the potential to provide information at a scale and resolution rarely accessible to archaeologists or climatologists. Such techniques are relevant to issues of coastal land use, resiliency, and response to natural disaster.

Shirley Baker, John Scarpa, and Leslie Sturmer (UF)

Breeding a Better Clam: Preparing the Florida Hard Clam Aquaculture Industry for Climate Change

The goal of our research is to increase summer survival and productivity of cultured hard clams, mercenaria, in Florida and, in doing so, address continuing thermal tolerance needs related to climate change. Shellfish growers are impacted by summer crop losses when water temperatures exceed 32°C. Gulf of Mexico water temperatures have already increased by 0.3 to 2.0°C in the last 20-30 years and are predicted to continue to rise. We have been examining the utility of basic breeding techniques for increasing survival and production in Florida waters. First, we tested the hypothesis that triploid clams, as compared to diploids, would allocate greater energy into somatic growth and storage, which would be reflected in enhanced survival and production during summer environmental stressors. Growth and survival of triploid clams in the field and laboratory produced mixed results, with no major advantage of triploid clams for Florida culturists. We are currently examining the utility of interspecific hybridization and backcrossed hybrids. While hybrids and backcrosses are proving promising for increasing summer survival there are product quality concerns (e.g., excessive gaping in refrigerated storage). Therefore, we are also examining the utility of marker assisted selection, specifically cognate heat-shock proteins (Hsp), in the development of heat-tolerant clam strains. To date, we have been able to produce families from high- and low-Hsp expressing broodstock. Breeding thermally tolerant clams is an innovative approach to climate change adaptation and will help mitigate impact on domestic food security, aquaculture production, and the economic status of coastal communities in Florida.

Bartels, W., Furman, C., Fraisse, C., Zierden, D. Royce, F., Ortiz, B. (UF)

Warming up to climate change: A strategy for engaging with agricultural stakeholders in the southeast USA

Within the context of a changing climate, scientists are called to produce relevant information that can support stakeholder decision making. However, non-informational barriers, such as values, beliefs and goals shape stakeholder perceptions and actions about climate change. Therefore, simply translating climate science into neatly packaged messages that aim to convince or educate audiences about looming future impacts will not effectively guide adaptation responses. Rather, it becomes important to explore what diverse audiences currently think about climate change and how they perceive adaptation options. This study illustrates the role that participatory processes and tools can play in engaging key stakeholder groups to begin a dialog around these issues. The Florida Climate Institute and the Southeast Climate Consortium are convening farmers, scientists, and extension professionals from Florida, Alabama and Georgia through a regional climate working group. We have found that one way to broach the controversial topic of long-term climate change is to nest it within discussions about past adaptation strategies and seasonal forecasts. Working group meetings incorporate multiple time horizons to inform decisions that are affected by weather, seasonal climate variability, as well as longer-term changes in climate. This study reveals the importance of effectively framing climate-related issues in order to elicit stakeholder engagement. Participants are interested in discussing risk management and the types of research, information, and tools they need to adapt their farming systems. By inviting researchers and practitioners to be partners in adaptation science, we aim to more effectively link science with action.

Brian Benscoter (FAU)

Linking Ecosystem Form and Function: Implications of Disturbance in a Changing Climate

The function of ecological systems is directly linked to their structure from local to landscape scales. Differences among plants in their abilities to acquire resources and their response to habitat conditions interact to shape the species ecological identity. Interactions within and among species and those with their environment drive spatio-temporal vegetation distributions. These vegetation dynamics, in turn, influence community and ecosystem health and function, from nutrient cycling and wildlife habitat quality to anthropogenic ecosystem services such as groundwater recharge and flood control. In a world predicted to undergo dramatic climatic changes, it is important to understand the nature and limits of these complex, integrative interactions. Wetlands are a prime example of these complex interactions and have intrinsic value for both the natural world and human populations. Wetlands like the Florida Everglades support diverse local communities of plants and animals and are important habitats along continental migration routes of birds and mammals. Human populations are highly dependent on the healthy function of wetlands and the ecosystem services they provide, such as maintenance of freshwater availability and quality, as well as the recreational and esthetic opportunities they afford. Therefore, the maintenance and conservation of wetlands is of great societal and ecological importance. Natural and anthropogenic disturbances impact the health and function of wetland ecosystems and their incidence and impact have increased in recent decades. Development and land use change in wetlands has resulted in substantial loss of wetlands worldwide and can have indirect impacts on the hydrology of adjacent watersheds. Natural disturbances such as wildfire and drought are vital for wetland ecosystems. However, future climate change can alter the natural disturbance regime and jeopardize the resilience of wetland ecosystems and their function. As ecosystem function is the result of complex, cross-scale feedbacks among the components of wetland ecosystems, a comprehensive understanding of the drivers of wetland structure and function are imperative for assessing the potential impacts of future climate change on these vital ecosystems.

Nicole Biller, E. Martin, and B. Flower (UF)

Evidence for Meltwater Pulse 1a in the Gulf of Mexico based on radiogenic isotopes

Meltwater pulse 1a (MWP-1a) is associated with a rapid sea level rise of more than 20 m in less than 500 yrs during the last deglaciation. This event has been dated at between 14.17 and 13.6 ka based on U/Th dating of Barbados corals. The contribution of meltwater from the Antarctic ice sheet and Northern Hemisphere ice sheets is under debate. Contributions from the northern versus southern hemisphere have implications for variations in ocean surface salinity, North Atlantic Deep Water formation and related climate responses. A study of bulk sediment Î´18O values from core MD02-2550 from the anoxic Orca Basin in the Gulf of Mexico produced peak Î´18O values of -5.5 â€° during a foraminifera-barren interval dated at ca. 14.54-14.35 ka based on an age model using >40 AMS 14C dates on Globigerinoides ruber. This Î´18O value is unusual for marine sediments and has been interpreted to represent material eroded by the Laurentide Ice Sheet and delivered to the Gulf of Mexico during or just before MWP-1a. This interpretation is consistent with data from detrital carbonate grains recovered from Heinrich Events in the North Atlantic that are believed to represent lower Paleozoic basin sediments from northeastern

Canada (Hodell and Curtis, 2008). For this study, we evaluated radiogenic isotopes of Nd and Pb (Sr isotopes will be added in the near future) on dilute 0.1N HCl leachates of bulk sediments from MD02-2550 to identify changes in input sources during the foraminifera-barren interval. Leachates of older continental material sourced from Canada should contribute more radiogenic Pb and less radiogenic Nd than leachates of younger sediments derived from the Mississippi River drainage basin. Measured 206Pb/204Pb values are ~19.0 before and after the foraminifera-barren interval, with peak values of 19.7 during the foraminifera-barren interval and coinciding with the Î´18O peak. Similarly, ÎµNd values before and after the foraminifera-barren interval are ~-9.7, while a minimum value of -10.7 is obtained during the interval. We interpret these background values to represent typically Mississippi river outflow, while the maximum Pb and minimum Nd isotopic values are associated with a flux of material derived from the Laurentide Ice Sheet. Therefore, these results support the idea that the foraminifera-barren interval and Î´18O peak in the Orca Basin sediments are representative of MWP-1a, and indicate a significant contribution to MWP-1a by the Laurentide Ice Sheet during the Bolling warm interval. [Hodell, D.A., and Curtis, J.H., 2008, Chem. Geol. 256, 30-35

Stan Bronson, Nancy Beller-Sims and Paul Grosskruger (Florida Earth Foundation)

USNC: Exchanging Climate Change Adaptation Knowledge

Over the past four years, Florida Earth Foundation has led teams of agency, university, private industry and NGO professionals to the Netherlands to look at that the Dutch are doing in water management, environment and growth stewardship. The program has expanded every year as the Florida-Holland Connection Project and in 2011 became the US-Netherlands Connection (USNC) as the focus shifted to climate change adaptation by developing a working relationship with the US Global Change Research Program. A Policy Team was led by USGCRP and NOAA personnel the second week of June and a Technical Team was led by US Army Corps of Engineer personnel the third week of June. In 2012, USNC is expanding through new partnerships with the Association of Climate Change Officers (ACCO) and several academic institutions.

J. Stuart Carlton, S. K. Jacobson, T. Ruppert (UF)

Mental Models of Climate Change and Other Hazards in Citrus County, Florida

Understanding public knowledge and attitudes about climate change is essential for effective communication and policy formation. Qualitative research is an important part of climate outreach because it can reveal important, potentially hidden, local environmental concerns that might be missed in a quantitative survey. In-depth information gathered in qualitative research can be used to inform broader surveys and guide outreach and communication, providing local issue that may make discussion of climate change more salient or acceptable. One useful qualitative research technique is to analyze individuals&#39 cognitive, or mental, models about a specific concept. A mental model is the set of thoughts and beliefs someone has about how something works, informed by that person&#39s experiences, beliefs, attitudes, and values. An individual’s mental model may be thorough or basic, accurate or error-ridden. Mental models are uncovered through open-ended, probing interviews, with minimal prompting by the interviewer. This project used a mental models approach to uncover policy-maker and opinion leader attitudes toward and knowledge of climate change and other environmental hazards in Citrus County, Florida. Nine mental model interviews were conducted with county administrators, government employees, and local opinion leaders. The interviews were recorded and transcribed, and the resulting transcriptions were used to create individual mental models of environment-related hazards in Citrus County. The mental models were compared to a more general expert model of the causes, consequences, and potential mitigations of climate change created by extension staff at Florida Sea Grant. The mental model results revealed both similarities and differences with the expert model. In the mental models, climate change was typically a secondary concern compared to local environmental issues, such as water quality. While several of the subjects&#39 mental models of climate change generally mirrored the expert model, most of the mental models of climate change were incomplete or contained notable inaccuracies and didn't match up particularly well to the expert model. Many of the local concerns identified are directly or indirectly climate-related, and the results of this study can be used to match targeted climate change.

Tim Chapin, Robert Deyle, and Harrison Higgins (FSU)

Integrating Accelerated Sea Level Rise Mitigation into Long Range Transportation Planning

Through the use of scenario planning, Long-Range Transportation Plans (LRTPs) developed by Metropolitan Planning Organizations (MPOs) can play a significant role in integrating land use and transportation planning so as to mitigate the vulnerability of regional transportation infrastructure, and associated land uses, to natural hazards. Supported by a grant from Florida DEM, we undertook a pilot project in collaboration with the Charlotte County-Punta Gorda MPO to assess the vulnerability of existing transportation infrastructure for a range of hazard scenarios. Then, using a simplified scenario planning process, we worked with local stakeholders to develop three alternative 2050 futures for the county and the City of Punta Gorda: 1) a "Business as Usual" scenario that reflects the county's tradition of low density development and continued development of areas at risk to hurricane storm surge and sea level rise; 2) a "Safe and Smart Growth" scenario that specifies a development pattern that reflects some of the density and mixed-use goals of the smart growth agenda as well as a more aggressive set of policies that limit development in hurricane and inland flood hazard zones; and 3) a "Resilient Growth" scenario that involves an even more restrictive set of policies regarding development in the hazard zones of interest, the use of structural protection of major urban areas, and the relocation of people and employment out of areas projected to be impacted by sea level rise by 2100. We modeled these scenarios by allocating projected new 2050 development by census block. We analyzed the scenarios along three dimensions: 1) transportation demand, 2) hurricane evacuation clearance times, and 3) amount of building and property damage in the year 2050.

M.L. Chu-Agor, J.A. Guzman, G.A. Kiker, R. Muñoz-Carpena, I. Linkov (UF)

Quantifying the changes in beach habitat due to long-term sea level rise, storm erosion, and re-nourishment

The vulnerability of coastal habitats to sea level rise and major storm events require the use of models that can simulate the effects of these important processes. Moreover, since these habitats undergo frequent restoration works in order to maintain their viability, these changes have to be incorporated in the model as well. This study quantified the changes in the beach habitat due to the combined effects of long-term sea level rise, historic storm events, and re-nourishment using the newly modified SLAMM (Sea Level

Affecting Marshes Model). A methodology to estimate spatial erosion was developed based on three historic storm events (Ivan, Dennis, and Katrina). In this study, the effects of the storms were found to depend on the time it occurred in the 100-year period. A given amount of erosion will result in different percentages of losses depending on the year it occurred, manifesting more loss at the later part of the century when sea level rise is accelerated. Moreover, in the case of successive storm events, the effects of a second storm following the first were more severe due to the decrease in elevation brought about by the first one. In contrast, due to the increase in elevation brought about by beach re-nourishment, losses during storm events were reduced. This is an indication that in order to preserve these habitats, certain elevation level has to be maintained at all times since reduction in elevation makes the effects of storm more severe. This study showed the capabilities of SLAMM to provide a more comprehensive set of information that decision makers and environmental managers need. Furthermore, it can provide a preliminary assessment of the changes in the habitat prior to implementing rigorous hydrodynamic models.

S.C. Claytor, J.R. Seavey, S.E. Cameron Devitt (UF)

A Review of Climate Change Impacts on Ecosystem Services in Florida

As part of the State University System Florida Climate Change Task Force white paper on biodiversity and climate change, we review the economic benefits of Florida's natural resources and potential impacts of climate change on ecosystem services. Florida's biodiversity and natural systems provide important ecosystem services, such as freshwater storage and filtration, carbon storage, and a reduction in the effects of climate change. It is now anticipated that climate change will reduce or eliminate some of Florida's ecosystem services, especially in coastal areas, rivers and lakes. Florida's natural resources are one of the major attractions of visitors to the state and approximately $65 billion annually is contributed to the economy by Florida's tourism industry. By preserving Florida's natural resources, economic benefits from tourism, recreation and fisheries are maintained. Interdisciplinary management strategies and monitoring the effects of climate change on ecosystem services are needed to preserve Florida's natural resources. We recommend the following strategies to reduce the loss of biodiversity and maintain vital ecosystem services and economic benefits. Foremost, natural resource planning should acknowledge the impacts of climate change on biodiversity. Limited resources should be applied to a range of management objectives. The value of an ecosystem, species or populations and the effects of climate change on ecosystems should also be used to set the priority of specific projects. Finally, it will also be important to monitor where disturbances caused by climate change are occurring and where they have the largest impact on human and natural systems. Such an interdisciplinary approach will help ensure persistence of vital ecosystem services into the future.

Trevor Cole and Andrea Dutton (UF)

Calibrating the timing of past changes in sea level

Understanding the dynamics of past sea level change in warm climates influences our decision-making in the context of ongoing global warming. Projecting future sea-level change is important for scientists, developers and politicians to address, particularly in regions with heavily developed coastlines. Past sea level position can be reconstructed by determining the age and elevation of fossil corals that grew near the sea surface. As corals grow in seawater they incorporate trace amounts of uranium that decays over time.

As a result, corals can be dated by measuring the ratio of various uranium and thorium isotopes. One assumption commonly made using this dating technique is that the U-isotope composition of seawater has been constant over the last several glacial-interglacial cycles. This assumption affects the interpretation of the age measurement and the assessment of whether the primary geochemistry of the coral has been preserved through time. The purpose of this investigation is to address the assumption of constant U-isotope ratios in seawater over the last full glacial cycle (for the last 130,000 years) and to test the variability of U-isotope composition in seawater geographically across the modern ocean. Hence, we are interested in establishing the possible variability of seawater U-isotope composition through space and time. We will analyze seawater samples from coral reef localities around the world, including Papua New Guinea, Bahamas, and Australia to establish modern geographic variability in U-isotope composition. In addition, we will compile data from fossil corals to determine the composition of seawater when they grew in the past, and to assess whether this composition has changed through time. The results of this project have bearing on the interpretation of fossil corals that have been dated with U-series disequilibrium techniques and has the potential to improve the chronology of past sea-level reconstructions.

Ian Comstock, C. Matyas (UF)

Comparisons of Hurricane Rainfall Totals as Estimated by Radar and Florida Automated Weather Network Rain Gauges

Hurricanes strike Florida more than any other state and are notorious producers of heavy rainfall. The accurate recording of hurricane rainfall is vital to understanding the climatology of Florida precipitation. This study compares rainfall estimates from rain gauges and radar for selected hurricane landfalls in Florida between 2000 and 2008. Rain gauge measurements are available every 15 minutes from the Florida Automated Weather Network (FAWN), while the WSR-88D scans the atmosphere every 5-6 minutes. Meteorologists employ several equations to convert the radar reflectivity values to rainfall totals. During hurricane conditions, the Tropical Z-R equation ($Z = 250R1.2$) is utilized by forecasters, thus it is also employed in this study. To make both datasets comparable, radar reflectivity values from the Level III base scan are averaged over each 15 minute sampling period of the FAWN gauges, then the Tropical Z-R equation is applied to calculate rainfall rates. Subtracting the gauge-based rainfall totals and the radar-estimates allows us to determine the difference in estimates. Distances between each FAWN gauge and radar facility were calculated to see if discrepancies between gauge measured rainfall and radar estimated rainfall act as a function of distance between the gauges and radars. Wind speed is known to significantly interfere with gauge collection and is also recorded from the FAWN station for each gauge and radar observation. Beam overshoot often results in underestimation of precipitation by radars as reflectivities are returned from higher elevations with larger distances from the radar and may not be sampling precipitation reaching the surface. Radar sampling near the freezing level can also cause overestimation that results from the brightband. This exploratory empirical study seeks consistent relationships between differences between rain gauges measured rainfall and radar estimated rainfall as a function of distance from the radar facility and wind speed observed at the rain gauges.

Manhar Dhanak, Edgar An, Pierre Beaujean, Karl von Ellenrieder (FAU)

Sensor Platforms for Ocean Observation

Ocean sensor platform development at SeaTech, Florida Atlantic University in support of in-situ observations in coastal waters is described. Understanding and assessing the complex potential impact of climate change along Florida&#39s coast will need sustained long-term monitoring of the coastal waters using a distributed network of a range of physical, chemical and biological sensors deployed from fixed and mobile platforms involving remote and in-situ observations. There is a need to understand large and small-scale oceanographic processes and how these influence a range of biological and ecological processes at smaller scales. The main potential physical and chemical variables of interest include sea surface temperature, currents, stratification, upwelling, dissolved oxygen and carbon dioxide that impact processes such as water quality, ocean acidification and sea level rise. The biological variables include, among others, phytoplankton and zooplankton count and larval supply and calcification rates of reef organisms and their impact on primary production, marine habitat and local ecology. Remote sensing from satellites and radar provide synoptic large-scale observation while in-situ observations facilitate assessments of local small-scale processes, in support of modeling the potential impact. The in-situ observations serve not only to provide the link between the regional-scale processes and the local small-scale processes, but also to facilitate verification of the synoptic observations. A range of sensor platforms, including AUVs, USVs and buoys, and associated sensor systems have been developed at SeaTech, Florida Atlantic University over the years that facilitate surface, sub-surface and benthic survey and observation. Mobile unmanned autonomous platforms provide cost-effective high spatial and temporal resolution micro-to-meso scale measurements over sustained periods. Mission-specific platforms utilizing underwater docking stations can provide energetically sustainable systems to monitor the distribution of meteorological and ocean conditions over a long-term period. Remote Supervisory Control strategies on mobile platforms enable capabilities for adaptive sampling and mission realignment directives to reflect changing operating and environmental conditions. These and other platform developments, including results from example case studies will be presented.

Nicholas DiGruttolo and Dr. Ahmed Mohamed (UF)

Marrying Topography and Tides; a High Resolution Tidal Datum and Intertidal zone Elevation Model for Improved Determination of Short term Sea Level Rise Impacts in Florida Bays

One of the greatest challenges coastal regions of the world face is the threat of the rising sea. Current geospatial models of coastal areas at risk of inundation by sea level rise (SLR) typically depict a 50 year timescale. The relatively long time of 50 years is due to a lack of data accurate enough to support shorter term predictions. I hypothesize that a geodetic-grade digital elevation model (DEM) of the intertidal zone overlaid onto a high resolution model of the mean high-water (MHW) tidal datum will allow for mapping the mean high-water line (MHWL) at an accuracy of less than 40 mm; this level of accuracy will allow the effects of SLR on property boundaries and infrastructure to be determined on a 20 year timescale. The need for a high resolution model of the MHW tidal datum is especially important in Florida’s bays. Over 11,000 km of Florida’s tidal coastline are to some extent disconnected from the open water, resulting in a need for precise tidal data to accurately determine the effects of less than 40 mm of SLR. The study

demonstrates the need for geodetic-grade elevation data and densely spaced tide level measurements for intertidal zone modeling. This level of detail is required for mapping the MHWL and existing data do not provide the necessary detail. This work shows the potential for acquisition of elevation data to produce a high resolution intertidal zone DEM with a remote sensing system carried by an unmanned aerial vehicle (UAV). Finally, I developed and tested a low-cost, easily deployable, Close-range Aerial Remote Sensing (CARS) system capable of obtaining geodetic-grade elevation data. I describe system design considerations and discuss preliminary results from simulation and field testing. I conclude that a low-cost CARS system weighing less than 200 grams that consumes less than 4 watts meet the requirements to map the effects of SLR on a 20 year timescale.

Dan Dourte, Clyde Fraisse (UF)

Climate Variability to Climate Change: Extension Challenges and Opportunities in the Southeast USA

Managing climate-related risks is something very familiar to agricultural producers, and we believe that strategies for adapting to climate change and variability become much more accessible when education and outreach happens in the familiar context of climate-related risk management. There are two parts to climate extension: education and the successful application of gained knowledge for reducing risk. This project is improving both aspects, advancing the science and application of climate information for agricultural risk management in the Southeast U.S. The goal of this project is to improve and broaden the Climate Extension efforts in agriculture for the Southeast in order to contribute to the existence of a vibrant and sustainable agricultural industry in the region that is capable of adapting to and mitigating risks associated with climate variability and change. By using participatory approaches and taking advantage of our established partnerships within the agricultural industry, we aim to find and develop climate adaptation and mitigation strategies with increased chance of adoption by producers in the southeastern USA. The work of this project can be organized into five major components. (1) Education & Outreach: delivering information in a variety of formats to improve climate literacy among agricultural decision makers. (2) Agricultural Systems Research: presenting the observations and projections of climate change and climate variability in ways that are closely linked to agricultural management problems and opportunities. (3) AgroClimate Tools: advancing the quality and availability of Web-based tools to connect management decisions to climate information. (4) Policies and Insurance: connecting the economic and policy frameworks to adaptation and mitigation strategies. (5) Evaluation & Social Science: assessing information needs of decision-makers and measuring project outcomes and producer engagement. Major deliverables will include a Southeast Climate Handbook that describes climate basics, variability, change, and impacts on agriculture. Another significant output will be Web-based water, carbon, and nitrogen footprint tools that will be available for comparing the resource-use efficiency of different risk-management strategies in agricultural systems. A variety of reports, fact sheets, and workshops will also be delivered under this project to contribute to improved climate extension for agriculture in the Southeast U.S.

Dr. Julie Lambert, Dr. Brian Soden, Dr. Robert Bleicher, Alana Edwards (FAU)

Climate Science Investigations (CSI): South Florida Using NASA Data to Improve Young Adults' Climate and Science Literacy

Climate Science Investigations (CSI): South Florida is a project that is currently under development through funding by the NASA's Innovations in Climate Education Program. The objectives are to develop and pilot online, interactive modules that will teach high school and undergraduate non-science major students to analyze and use NASA data to address the public's questions and commonly held misconceptions about climate change. The project's approach is not simply to teach students the answer to common questions about climate change, but to use the questions themselves as a basis for teaching the nature of science and the critical thinking skills inherent. In the first module, students will be provided with the background information necessary to understand climate change and our approach to the curriculum. In the second module, students explore the question of whether Earth is really warming. In the second module, students analyze the evidence of a warmer Earth. Once students are convinced that the Earth is warmer and there is much evidence that supports this theory, they will begin to analyze some of the causes of climate change, ultimately learning that it has to be the human-caused. In module four, the potential impacts of climate change are investigated, following by a final module on what the unknowns and uncertainties are and why denial of climate change has persisted, but also why this is an urgent issue to address. CSI will introduce student to three elements of argumentation: claims, data, and justifications. For this component, students will be able to choose a claim, do research using data resources that are provided in each module, and then construct verbal and written arguments that use their research as supporting evidence to justify their claim. By the final module, students will have the skill sets not only necessary to effectively develop scientific arguments, but also a deeper understanding of the evidence, causes, and impacts of climate change.

Chelsea Fenn, Ellen. E Martin, Chandranath Basak (UF)

Seawater and Detrital Marine Pb Isotopes as Monitors of Antarctic Weathering Following Ice Sheet Development

Comparisons of seawater and detrital Pb isotopes from sites proximal to Antarctica at the Eocene/Oligocene transition (EOT) are being used to understand variations in continental weathering associated with the development of the East Antarctic Ice Sheet (EAIS). Previous work has shown that similar values for the two Pb archives during Eocene warmth have been interpreted to represent congruent chemical weathering of the continent, while distinct values for the two phases at the EOT represents increased incongruent mechanical weathering during ice sheet initiation. For this study we expanded beyond the initial glaciation at the EOT to determine whether less dramatic changes in ice volume and climate also produce variations in weathering and intensity that are recorded by seawater and detrital Pb isotopes. We collected Nd and Pb isotope data from the extractions of Fe-Mn oxide coatings of bulk decarbonated marine sediments that record a seawater signal and from the complete dissolution of the remaining silicate fraction for Ocean Drilling Program Site 748 on Kerguelen Plateau (1300 m modern water depth). The data spans an interval of deglaciation from ~23.5-27 Ma documented by ?18O that has been equated to a ~30% decrease in ice volume on Antarctica (Pekar et al. 2008). Initial results from Site 748 include the first epsilon Nd for intermediate waters in the Oligocene Southern Ocean and reveal a value of ~-8 over the entire 3.5 m.y. interval. A decrease of residue 206Pb/204Pb values suggests the composition of source materials entering the ocean became less radiogenic as the ice sheet waned. The increase in seawater 206Pb/204Pb may record enhanced leaching of rock flour created during the preceding glacial advance, which is supported by previous studies suggesting that initial weathering leaches Pb isotopes that are more radiogenic than the parent rock. Alternatively, seawater values during warming in the late Oligocene approach values recorded during initial ice sheet expansion at the EOT in Site 738, which may suggest Pb isotope variation in seawater and residues may not be sensitive during less dramatic intervals of climate change and ice sheet dynamics. We plan to continue this study into the Pliocene to see if we can identify the evolution from a wet-based to dry-based EAIS, which may have had profound consequences for weathering on Antarctica and the offset between the two Pb isotope archives.

Eduardo Gelcer, Tiago Zortea and Clyde Fraisse (UF)

An AgroClimate web tool for ARID (Agricultural Reference Index for Drought) monitoring

Agriculture is an economic activity directly affected by drought. With the constant increase of food demand and the need of high efficiency in food production, drought effects gain importance. The Agricultural Reference Index for Drought (ARID) was developed in order to quantify drought and better understand its effect in agriculture. ARID values range from 0 to 1 where zero is transpiration occurring at potential rate and one is full water deficit. El NiÃ±o Southern Oscillation (ENSO) phenomenon is the main factor of climate variability and has strong influence in Florida's climate. As ARID indicates how dry the soil is, historical studies are important to determine the risk of drought in certain region and the influence of ENSO in soil moisture enabling ARID seasonal forecast. ARID can also be used to indicate agricultural losses caused by water stress. In this study historical values of ARID are compared with daily calculations allowing monitor soil moisture and calculate deviations from normal conditions. The main objective of this study is to create scientific support for a tool on AgroClimate website with ARID seasonal forecast and monitoring and crop losses estimation.

Carlos A. Gonzalez Benecke, Timothy A. Martin, Eric J. Jokela, Wendell P. Cropper Jr., and Rafael De La Torre (UF)

Flexible Hybrid Models of Life Cycle Carbon Balance for Southern Pines Plantations

University of Florida's Carbon Resources Science Center has developed a flexible modeling system for even-aged pine forest carbon sequestration which combines growth and yield models with biometric equations to estimate fluxes and stocks of carbon for Pinus elliottii (slash pine) and Pinus taeda (loblolly pine). The hybrid models integrate even-aged growth and yield models based on equations reported in peer reviewed literature. These models account for multiple choices of silvicultural treatments (e.g., site preparation, weed control, fertilization and thinning). At each age, allometric equations were used to estimate above and below ground stand biomass from quadratic mean diameter and number of surviving trees simulated by the growth and yield model. Dynamics of litterfall biomass accumulation on forest floor was determined using a 25-year time-series of pine needle fall, leaf area index (LAI) and inventory measured yearly on permanent plots that received different silvicultural treatments. LAI was estimated as a function of Stand Density Index (SDI) and Site Index (that includes the effects of silvicultural treatments) and litterfall and understory biomass were estimated as a function of stand LAI. At the time of thinning, reductions in LAI were set to be proportional to changes in SDI due to thinning and therefore forest floor and understory biomass were affected due to their LAI-dependence. The modeling system also tracks the fate of harvested carbon removed from the site and processed into forest products. The models used current values of forest product conversion efficiencies and forest product decay rates to calculate ex situ C pool. The models were validated from a variety of sources, accurately simulating C estimates based on multiple measurement techniques and sites. For example, when simulated total stand biomass was compared with reported values on 14 stands ranging from age 3 to 48 years, the overall difference was less than 2.5% and the slope of the 1:1 relationship was not different from one. The models were also compared to data from eddy-covariance and biometric net ecosystem exchange data from long-term plantation eddy-covariance sites.

Jaclyn Hall, Eric Lambin (University of Louvain-la-Neuve)

Forest increase and ecosystem services- Is it always win-win?

This study determines the landscape scale impact of increase in tree cover area (i.e., natural and planted-tree land covers), and changes in above ground carbon storage and ability to support native biodiversity at the landscape level. We conducted a meta-analysis of four areas experiencing an increase in tree cover: northwestern Costa Rica, northern Vietnam, southern Chile and highland Ecuador, and considered areal extent and distribution of tree cover in the landscape to determine relative outcomes for floristic biodiversity. Published estimates for forest and plantation carbon stocks were used for each study region. Landscapes of Costa Rica and Vietnam, experiencing increases in natural secondary forest also experienced an increase in carbon stored above and below ground by 227% and 286%. Study sites in Chile and Ecuador experiencing an expansion of exotic plantations saw their carbon stock decrease by 13% and 16%. Similarly, the potential to support native biodiversity increased in the study regions experiencing natural regeneration of forest, and decreased significantly in the study areas experiencing an expansion of plantations. This study shows that an increase in forest area does not necessarily imply an increased provision of ecosystem services when landscapes are reforesting with mono-culture plantations of exotic tree species. Tradeoffs between biodiversity and the carbon stored in pulp rotation plantations, along with other ecosystem services, should be fully considered in reforestation projects.

Barry N. Heimlich (FAU)

A Probabilistic Method for Estimating Sea Level Rise Exceedances

A method for estimating the probability of exceeding given stages of sea level rise at given times during the 21st Century is presented based on published semi-empirical correlations of historic sea level rise and global climate change model forecasts for a range of plausible IPCC scenarios. Tide gauge measurements in Florida are shown to be statistically indistinguishable from global average sea level rise. Projected probabilities that sea level could rise by 3, 4, and 5 feet by 2100 are approximately 89%, 42%, and 6% respectively. Sea level rise of 3 feet or more could have dire consequences to Florida’s coasts, the Everglades, the Keys, and low-lying urban South Florida.

G. Hollander, P. Harlem, M. Ross, H. Gladwin, B. Hall, S. Mic, E. Eisehnauer (FIU)

Anticipating Sea Level Rise: Looking to the Past and the Future in Miami-Dade

Miami-Dade County is a unique locus of multiple interacting socio-cultural, political, economic, and ecological forces due to rapid urbanization, largely driven by private enterprise, and increasing vulnerability to climate change events, most notably, sea level rise. With an average elevation of only six feet, the city of Miami is ranked, according to the Organization for Economic Cooperation and Development, as the world's most vulnerable urban region in terms of assets exposed to coastal flooding and fourth in the world in terms of population exposed. The built environment of greater Miami sits adjacent to two national parks, home to highly diverse ecological communities, which lure tourists from all over the world and yet, face escalating threats from saltwater intrusion and tropical storms. Thus, while Miami's coastal, subtropical locale has always been one its main attractions, it may soon be its curse. Moreover, sea level rise will impact a demographically diverse population in a city characterized by residential segregation and a widening gap between rich and poor. This poster presents key themes of research from the NSF-funded Urban Long Term Research Area (ULTRA) project collaborators who are exploring how both climate change and the framing of climate change may impact Miami's future water supply, economic development, tourism industries, and ecosystems, and how these impacts will manifest within an already economically, racially, and ethnically stratified and segregated city. We use a combination of geospatial technologies, including geo-referenced historical aerial photography, LiDAR imagery and geographic information system (GIS) mapping to examine change over time in the vegetation, land cover, settlement patterns, water management, and built environment of Miami-Dade. The poster highlights some of the complex conditions mentioned above and visually illustrates, through GIS mapped projections, Miami's vulnerability to both tropical storm surge events and gradual saltwater intrusion and inundation based on different sea level rise scenarios. The poster will also include recent plans for future development in Miami and examine how these developments may or may not be responding to projections of future climate change. We consider some of the social justice implications posed by sea level rise in an already socioeconomically stratified city and ask how meaningful public engagement can be fostered, in part through existing community based organizations. Finally, we show how looking to the past through geo-spatial imaging that illustrates the region's environmental history may help point the way toward a potentially more sustainable future for Miami-Dade.

Josh Horn, F. Escobedo, R. Hinkle, and M. Hostetler (UF)

Urban forest change and greenspace management in Orlando, Florida

Urban forests are important resources in affecting carbon dynamics in cities as they are capable of reducing and emitting atmospheric carbon through a number of mechanisms. Lawn management and maintenance practices can increase carbon emissions and alter these dynamics, reducing the net positive impact of urban forests on carbon cycling. Trees, shrubs and ground cover store and sequester carbon for extended periods of time, and decrease residential energy demands via shading, thus reducing carbon emissions from energy production; their net impact must also include maintenance emissions from common landscaping activities, such as pruning, mowing, mulching, fertilizing, and watering. The University of Central Florida (UCF) has been quantifying carbon dynamics with an Eddy Flux Tower in east Orlando, Florida since 2008. In 2008-2009, 95 Urban Forest Effects (UFORE) plots were established and measured inside the Eddy Flux Tower footprint area and a sub-sample of 44 plots was re-measured in 2011. Lawn and garden management and carbon emission characterization surveys of residential homeowners were also conducted in 2011 to categorize species based on resource inputs and native status. Eddy Flux data and urban forest structure were used to characterize ecosystem services and current carbon dynamics near UCF. These data along with growth and mortality rates from other long-term urban forest research sites were used to model carbon dynamics of different landcovers and tree species under various management and maintenance scenarios. The modeling information presented here about long-term carbon dynamics can be used by planners and land managers as a tool for managing urban forests with the goal of reducing atmospheric carbon emissions and maximizing social benefits.

Jing Hu, Kanika S. Inglett, Mark W. Clark, K. Ramesh Reddy (UF)

Hydrological and biogeochemical controls on the nitrous oxide (N2O) production and consumption in subtropical isolated wetlands

Wetlands are potential sources of greenhouse gases including nitrous oxide (N2O). N2O emissions are highly regulated by the wetland hydroperiod and water-table fluctuations. To reduce N2O emissions and to develop mitigation strategies, it is important to understand the effect of hydrology and biogeochemical factors on production and consumption of N2O in soils. The objective of this study was to quantify the potential soil N2O production and consumption rates within soil profile. Laboratory incubation experiments were carried out using soils from an isolated wetland located in agricultural watershed in the Okeechobee Drainage Basin. Soil samples were collected at four depths (0-10cm, 10-30cm, 30-50cm, and 50-70cm) from three areas with different hydroperiods. Soil physical and chemical properties and microbial biomass were performed on soil subsamples. Potential rates of N2O production from nitrification (PN2O-nit), and denitrification (PN2O-den) and consumption (PN2O-con) were determined for all soil samples. The results indicated higher N2O potential production rate in soils from location with higher water table. Most of the N2O production (~70%) and consumption (~80%) in soils occurred in the upper layer (0-10cm) and N2O was mainly produced by denitrification. Furthermore, microbial biomass and nitrate content were two critical factors that controlled N2O production and consumption along the soil profile.

David Keellings and Peter Waylen (UF)

Investigating Drivers of Maximum Daily Temperatures in Florida using Extreme Value Analysis

Maximum daily temperatures from the second half of the 20th century are examined using a high resolution dataset of 833 grid cells across the state of Florida. The temperature dataset is combined with indices of the El Niño-Southern Oscillation (ENSO) and the Atlantic Multi-decadal Oscillation (AMO) to explore the influence of these oscillations on maximum daily temperatures in Florida. An Extreme Value Analysis Point Process approach is used to model the frequency, magnitude, and duration of periods or "hot spells" where daily maximum temperatures are above a high threshold. In order to investigate the influence of a time varying signal (ENSO and AMO) on the occurrence of maximum daily temperatures the signals are introduced into non-stationary models as covariates in the location and log-transformed scale parameters. The improvements to the model obtained by introducing covariates are examined using the deviance statistic whereby the difference in negative log-likelihood values between two models is tested for significance using a Chi-squared distribution. Preliminary results show some improvement in the models with the AMO covariate indicating that the AMO has some influence on maximum daily temperatures while those with the ENSO covariate exhibit little improvement.

Joshua Filina, Marguerite S. Koch, Katherine E. Peach, Marisa E. Charneco, Elizabeth Durta (FAU)

Elevated temperature/pCO2 synergistic effects on tropical marine macroalgae and seagrasses

Ocean pCO2 is expected to rise up to ~1,010 ppm and temperatures increase ~4oC by 2100. We present data on the physiological responses of tropical calcifying (Halimeda, Udotea, Penicillus, Crustose Coralline) and non-calcifying (Caulerpa, Sargassum) macroalgae and seagrass (Thalassia, Syringodium) with important ecological roles in reef, lagoon, estuarine and open-water systems (e.g., Sargasso Sea) to the interactive effects of elevated pCO2 and temperature. Our ongoing research is evaluating metabolic effects and growth of elevated pCO2 across seasons using a well-tested mesocosm facility (16 500L tanks) with a fully automated, web-controlled monitoring system that injects CO2 to maintain pH (±0.03; verified CO2SYS & measuring pCO2aq). In May/August 2011, we evaluated elevated temperature (28/34oC), using the Florida reef tract as a reference (24/30oC), and 2100 pCO2 (pH 7.69) compared to controls (pH 8.07). Productivity and respiration were measured over a range of irradiances and photosynthesis/irradiance (P/I) parameters (Pmax, Ic, Ik, and ?) determined. At high pCO2 and ambient temperature, Pmax was elevated in all species examined. An increase in production was also observed in Halimeda at high pCO2 x high temperature in the spring; however, high pCO2 x high temperature in summer significantly lowered production. Respiration rates were lower in the spring under high pCO2 x high temperature, suggesting a positive CO2 effect on respiration before thermal limits are approached. Thus, our data indicate that macroalgae and seagrass will seasonally adjust to elevated pCO2 and +4oC through temperature controls on respiration and photophysiology, and threshold responses will be observed approaching thermal limits.

Leonard Berry, F. Bloetscher, E. Kaisar, J. Rodriques-Seda, R. Teegavarapu and N. Hammer (FAU)

Development of a Methodology for the Assessment and Mitigation of Sea Level Rise Impacts on Florida’s Transportation Modes and Infrastructure

The greatest sea level rise impact on transportation infrastructures in Florida will be flooding of coastal roads, transit systems, freight railways, seaports and runways. Based on measurements at the tide station in Key West, Florida, sea level has risen about nine inches in the last 50 years (NOAA 2008), and is projected to continue and accelerate in the future. A comparison of sea level rise projections and predictions is presented. As identified in Heimlich, et al., 2010, sea level rise can diminish the ability of the drainage systems and coastal flood control structures to control flooding. This will lead to transportation infrastructure structural and functional failures. Among the major findings of this report are that sea level rise will lead to significant loss of soil storage capacity, which will lead to the potential flooding of large areas after relatively minimal storm events. This creates a potential disruption of transportation as well as potential damage to roadway beds as a result of soil saturation. Over time, sea level rise and its associated tidal ranges, and storm surge will have impacts on roadways, bridge access points, rail, airports, and other transportation infrastructure. The low-lying topography of some regions of Florida makes transportation infrastructures along the coastline and low lying areas vulnerable to sea level rise. The Florida Department of Transportation (FDOT) is in need of a comprehensive listing of infrastructures that are vulnerable to sea level rise, and development and implementation of strategies for improving transportation infrastructures resiliency, preventing adverse impacts, and adapting to climate change event.

Mantha Mehallis, L. Berry and N. Hammer (FAU)

Florida Atlantic University's Role in Developing a National Climate Change Curriculum

The National Council for Science and the Environment (NCSE) is dedicated to improving the scientific basis for environmental decision-making. Florida Atlantic University (FAU) is a partner with NCSE to participate in research and education with environmental, business and governmental entities, and to achieve solutions for environmental challenges. Through a grant from the National Science Foundation, NCSE is building a nationwide learning community called CAMEL (Climate, Adaptation, and Mitigation E-Learning), to transform climate education into an interdisciplinary enterprise including mitigation and adaptation. FAU is participating with NCSE to develop a Master's Degree in Climate Change to prepare a climate change work force for the future, and in-service training to prepare current professionals to create solutions for tomorrow's challenges related to climate change and sustainability.

Leonard Berry, M. Koch and N. Hammer (FAU)

Overview of FAU Research Priority Area: Climate Change â€“ Research, Engineering and Adaptation to a Changing Climate

Globally, sea level rise has the potential to impact two billion people living along the coastline. In South Florida, sea level rise is already a threat to coastal infrastructure and will continue to require new engineering solutions. Research universities, particularly those with strengths in hydrology, engineer, and ocean sciences, will play a major role in human adaptation to a rapidly changing climate. FAU can be one of these institutions with its current interdisciplinary climate change research. FAUâ€™s premier engineering program provides opportunities to develop and apply new technologies to ascertain climate change impacts and develop solutions to assist in adaptation. FAU Civil Engineers are on the front lines of developing sea level rise adaption strategies for water utilities and counties in South Florida. Faculty in the Geosciences Department are developing models and applying GIS to assess sea level rise and saltwater intrusion into South Florida's aquifer, and measuring greenhouse gas fluxes from wetlands. The College of Architecture, Urban and Public Affairs is running models to evaluate/visualize sea level rise impacts to urban populations for planning. Harbor Branch oceanographic Institution, and SeaTech are developing new tools to assess ocean acidification on marine ecosystems and acoustics for the U.S. Navy. Biologists from the College of Science and HBOI are using genetics, ecological models and molecular indicators of stress to identify thresholds of ecosystems and species resilience to climate change. FAU is developing climate change curricula, K through graduate applying unique computer gaming approaches. These examples highlight the depth and breadth of expertise and research at FAU addressing climate change, which if coalesced into a collaborative program, would put FAU on the map for climate change research and education. FAU climate change program is organized into three themes: Human System

Problem Assessment and Sustainability through Re-Engineering and Adaptation, Natural System Assessment and Education and Outreach.

Aline Lopes, M. Kohmann, C. Fraisse (UF)

Simulation of carbon storage scenarios using different forestry systems to offset greenhouse gas emissions from a typical cow-calf operation in Florida

It is known that worldwide initiatives to reduce or offset greenhouse gas (GHG) emissions are not only occurring at the international level, as the Kyoto Protocol. Society is also starting to pressure for actions related to mitigating climate change. As a result, companies and organizations are expected to assume higher responsibilities in protecting the climate. Stabilizing GHG concentrations in the atmosphere requires efforts to achieve a more efficient energy use, utilization of clean technologies and changes in people's habits. When reducing GHG emissions is not possible, good alternatives to compensate emissions are to create or increase forest carbon stocks by combining sustainable forest management, forest regeneration, reforestation of degraded areas and agroforestry practices. The objective of this study is to simulate carbon storage scenarios using different forestry systems to determine seedling number and planted area needed to offset GHG emissions from Buck Island Ranch, which runs a typical cow-calf operation in Florida. The following alternatives of carbon storage will be evaluated: (i) restoration planting, (ii) pine silvopastoral system, (iii) wooded cattle pasture, and (iv) typical pine and eucalyptus plantations. GHG emissions from Buck Island Ranch were estimated using the Intergovernmental Panel on Climate Change methodology and the Inventory of Greenhouse Gas Emissions and Sinks: 1990-2006 and data from Buck Island Ranch, resulting in an average emission of 11,554.6 tons of CO2eq/year. Calculations of carbon storage in forest stands will be based on the fourth chapter of the volume Agriculture, Forestry and Other Land Use (AFOLU) of the Guidelines for National Greenhouse Gas Inventories. If available, more specific data will be consulted to refine results, as suggested by IPCC. These data are referred to yield of forest biomass, growth and carbon fractions of all forest compartments.

Jessica Lovering and Peter Adams (UF)

Influence of Sea Level Rise and Marsh Hypsometry on the Equilibrium Morphology of Tidal Inlets

As global sea-level is predicted to rise between 0.18 and 1.9 meters by the end of the 21st century, it is critical to understand how the geomorphology and ecology of coastal regions worldwide will be affected for a range of sea-level rise rate scenarios. Tidal inlets along sandy, passive margin coasts are sensitive to water levels, nearshore currents, and wave fields, so changes in environmental conditions in the vicinity of inlets should drive a morphologic response. The widely accepted conceptual model of tidal inlet evolution predicts that, as sea-level rises, salt marshes in the lagoon become drowned and converted to subtidal environments, increasing accommodation space in the back barrier basin. This conversion increases the tidal prism, inlet cross-sectional area, and ebb shoal volume. The purpose of this study is to quantify the relationship between sea-level rise, the ecomorphodynamic environment of the back barrier basin, and the resulting changes in equilibrium tidal inlet morphology. We explored various marsh conversion scenarios using Escoffier equilibrium curve calculations, in order to predict changes in tidal inlet equilibrium cross-sectional area. There is an inundation threshold for the relative rate of sea-level rise which is dependent on the accretion rate of the marsh plants; the difference in these rates sets the duration of root submergence and hence the opportunity for oxygen access by marsh plants, which is critical for plant survival. Initial results, using a simplified tidal inlet with vertical basin walls and morphologic and hydrodynamic characteristics typical of Florida Atlantic coast inlets, indicate that when sea-level rise rate is not fast enough to outpace vertical marsh growth, the equilibrium cross-sectional area of the tidal inlet remains unchanged. For sea-level rise rates that exceed the ability of marsh vegetation to remain stable, the change in cross-sectional area appears to be dependent on the sea-level rise rate and the marsh-to-channel ratio within the back barrier basin. We tested three cases in which tidal inlets start with identical morphologic and hydrodynamic characteristics, but vary in initial marsh coverage (10%, 20%, and 30%). The inlet cross-sectional area grows toward equilibrium states that are 12%, 26%, and 43% larger than the initial cross-sectional areas, for the three initial marsh conversion scenarios, respectively. The areal extent of the marsh system and marsh plant vulnerability to sea-level rise plays a critical role in how tidal inlets will respond to changes in sea-level.

Qing-Chang Lu, Zhong-Ren Peng, Fei Yang (UF)

Sea-level Rise Impacts on Transportation and Economic Analysis of Its Adaptation Strategies

Because of the significant potential impacts of sea-level rise on coastal transportation infrastructures, understanding the impacts of different sea-level rise scenarios, as well as economic costs and benefits of adaptation strategies are critical, particularly in the coastal areas. This paper first develops an accessibility-based transportation network vulnerability analysis process to quantify network-wide vulnerability and identify the most vulnerable segments of the transportation networks under different sea-level rise scenarios. The accessibility reduction rate before and after inundation is calculated to measure the potential consequences. The south Miami road network is used as a case study under two different sea-level rise scenarios for the year 2060. The extent of road network vulnerability and accessibility reduction of individual traffic analysis zones are estimated for two scenarios. The results show that there is almost 100 percent accessibility reduction for traffic analysis zones with all roads inundated and as high as 30 percent accessibility reduction in zones with some or no road directly affected. This information can help local transportation planners, engineers and decision makers identify the most vulnerable areas and transportation facilities as a result of sea-level rise in the adaptation planning process. Second, this study also aims to quantify the economic impacts of sea-level rise as well as costs and benefits of adaptation strategies by using cost-benefit analysis at the local level. Hillsborough County, Florida is used as a case study area. Three adaptation strategies are proposed to the two scenarios and costs-benefits analysis is conducted for each strategy under each scenario by considering both direct inundation and indirect travel time cost impacts. The adaptation strategies are then prioritized based on cost-benefit analysis results. Finally, adaptation suggestions are made to Hillsborough County decision-makers in response to sea-level rise.

Matyas, Corene J. (UF)

Forcings associated with changes in the areal coverage of tropical cyclone rain fields after landfall

As recently witnessed after the landfalls of Hurricane Irene and Tropical Storm Lee (2011), tropical cyclones (TCs) can produce heavy rainfall that leads to flooding. TCs with rain fields that increase in

areal extent produce rainfall of a longer duration over a wider area than TCs with rain fields that decrease in size. Thus, it is important to identify the environmental conditions associated with the horizontal growth or decay of TC rain fields after landfall. To accomplish this task, this study examines radar reflectivity values to establish the spatial dimensions of the rain fields of 45 TCs making landfall in the U.S. during 1995-2008. The radar data are processed within a GIS to calculate the sizes of the total raining area represented by reflectivity values of 20 dBZ and greater and heavy rainfall regions represented by reflectivity values of 40 dBZ and greater at the time of landfall, and 12 and 24 hours post-landfall. Observations are grouped according to whether size increased or decreased for statistical analysis utilizing Mann-Whitney U tests. Predictors are obtained from several sources. Data pertaining to environmental conditions such as vertical wind shear, upper-tropospheric temperatures, and near-surface temperature and relative humidity are taken from the Statistical Hurricane Intensity Prediction Scheme (SHIPS) database. The distance between the storm center and nearest segment of the coastline is calculated in the GIS. Additionally, the time of landfall is converted into sine and cosine values, and storm intensity, latitude, and longitude are also examined as predictors. The cosine of the time of landfall yields the most statistically significant result. TCs making landfall closer to midnight tend to grow in size during the first 12 hours, then decay over the second 12 hours, while the opposite is true for TCs making landfall closer to noon. High significance values of near-surface temperature and relative humidity also suggest that the diurnal cycle affects rain field size. Other predictors found to be significant are the distance from the coastline, longitude, and the westerly component of the deep-layer vertical wind shear. These variables represent the availability of moisture and interactions with middle-latitude troughs.

Evan Flugman, Pallab Mozumder (FIU)

Enhancing Coastal Resilience: Synergies in Hurricane Mitigation, Insurance Reform, and Climate Change Adaptation Initiatives

Coastal communities are disproportionately impacted by extreme hydro-meteorological events, and this is exacerbated by global climate change. Given its location in the middle of hurricane alley, the State of Florida faces the highest risk in the U.S. of being hit by a major hurricane in a given year. The low-lying, mega-urban, coastal population and economic centers of South Florida, Tampa Bay and Jacksonville are at high-risk of potentially catastrophic losses from hurricanes and floods, today and increasingly, for the foreseeable future. Against this backdrop, we investigated perceptions of coastal vulnerability and preferences to facilitate hurricane mitigation, insurance reform and climate change adaptation initiatives, including willingness to support a proposed â€˜Florida Adaptation Fundâ€™, among a diverse group of 555 Florida experts and decision makers (state, regional, county, and municipal government personnel). We also tested the feasibility of diverse financing mechanisms to contribute to the proposed adaptation fund. Transitioning our institutions and our coastal communities to address these emerging challenges will require a combination of novel decision-making criteria; public-private partnerships; regulatory and market-based mechanisms; and significant investments in physical and social infrastructure.

Karthik Nagarajan, Jasmeet Judge (UF)

Impact of climate variability on spatial distribution of soil moisture and crop growth at field scales under dynamic land cover conditions

Local changes in climate patterns such as precipitation, temperature, humidity, and wind, play a fundamental role in shaping natural ecosystems, and severely impact water availability and agricultural productivity. Hydrologic variables such as soil moisture and agricultural variables such as leaf area index (LAI) and biomass can be simulated at field scales (typically 200m), by coupling hydro-meteorological models to crop growth models, to study the impacts of land surface heterogeneity, climate variability, and dynamic vegetation. Unfortunately, a dense network of meteorological stations is typically unavailable to initialize models at such fine scales. An effective alternative is to develop an Observing System Simulation Experiment (OSSE) for simulating soil moisture and LAI at field scales, by embedding dynamics in climate, land cover, and vegetation. Also, the availability of remote sensing products of climate patterns at spatial resolutions of about 25-50 km offers the possibility of obtaining estimates at fine scales using downscaling algorithms. In this study, an OSSE framework was developed for simulating soil moisture and LAI at multiple scales under heterogeneous land cover and dynamic vegetation and climatic conditions. Simulations were generated over an area of 50x50km2 in North Central Florida for land covers comprising of growing sweet-corn and cotton at resolutions of 200m and 10km, the former representative of agricultural fields and the latter that of the Soil Moisture Active Passive (SMAP) soil moisture pixel. The interplay of vegetation and climatic conditions in affecting spatial variations in soil moisture fields was illustrated using the OSSE simulations. Maximum differences of 0.032?0.055 m3/m3 in soil moisture were observed between estimates obtained over vegetated and bare soil regions during precipitation and dry conditions, respectively. A downscaling methodology was also developed using the Principle of Relevant Information (PRI) to downscale remote sensing products available at 25 km to 200 m. The PRI provides a hierarchical decomposition of image data that is optimal in terms of the transfer of information across scales and is therefore a better alternative to methods that use second-order statistics only. The OSSE simulations of soil moisture and LAI generated at multiple scales were used to evaluate the downscaling algorithm based upon PRI.

Susan M. Natali, Edward A.G. Schuur (UF)

Effects of permafrost degradation on tundra carbon balance

Northern permafrost systems play a critical role in global carbon (C) cycling because of the vast pool of thermally-protected C stored in these ecosystems and the strong potential for changes in C storage in a warmer climate. Increased decomposition of previously frozen organic C may result in a significant positive feedback to global climate change; however, some respiratory C losses may be offset, in part, by warming-mediated increases in plant productivity. To determine the magnitude of warming effects on ecosystem C balance, we established a new warming experiment—the Carbon in Permafrost Experimental Heating Research (CiPEHR) project—where we increased air and soil temperatures and degraded surface permafrost. We used snow fences coupled with spring snow removal to increase deep-soil temperatures and thaw depth (winter warming) and open top chambers to increase summer air temperatures (summer warming). Here we present ecosystem C balance results from three years of experimental warming and permafrost degradation of upland tundra in Interior Alaska and describe our efforts to incorporate these results into ecosystem models. Winter warming significantly increased net annual CO_2 loss from the ecosystem, which was driven by a two-fold increase in ecosystem respiration during the snow-covered period. While most changes to the abiotic environment at CiPEHR were caused by the winter warming treatment, summer warming effects on plant and soil processes resulted in 20% increases in both gross primary productivity and growing season ecosystem respiration and significantly altered the age and sources of CO_2 respired from this ecosystem. These results demonstrate the vulnerability of organic C stored in near surface permafrost to increasing temperature and the strong potential for warming tundra to serve as a positive feedback to global climate change. Future research efforts will focus on combining these field observations with laboratory incubation results and using data assimilation techniques to both modify the Terrestrial Ecosystem (TECO) model for use in permafrost ecosystems, and to parameterize this model in order to make projections of the response of tundra ecosystem C balance to future climate scenarios.

C.A. Nettleman, III, A. Abd-Elrahman, G. Barnes, T. Ruppert, B. Dewitt, T. Fik (UF)

Understanding How Climate Change Will Affect Title to Coastal Property

Coastal boundaries are in continual contention due to increasing population density and inflating land values while the while the zone is exposed to increased risks from storm surge, sea level rise and pollution. Property stakeholders since the beginning of the twentieth century have sought judicial clarifications of boundary ownership between exposed and submerged coastal ground. Judicial clarification involves definitions that use mean high or mean low tide using some form of scientific methodology. The early twentieth century court ruling of Borax v. Los Angeles (296 U.S. 10, 1935) wasn't the first case to do so, it is widely considered as the inflection point where the court shifted from defining coastal boundaries in generic terms to setting concrete, scientifically-based locations of the tidal boundary. While many concur the Borax ruling is flawed it has become a foundation in such consideration of costal boundaries. One obvious question stemming unanswered for the case is does Borax fill the knowledge gap between legally defining the seaward property boundary and a reasonable surveyor being able to locate it on-the-ground?

James J. O'Brien, Steven Armstrong, Preston Leftwich, and David Zierden (FSU)

A Web Link to Probability of the Number of Big Rain Events in Florida

Big rain events, defined here as two or more inches in a two-day period, have important effects on many aspects of human welfare. Further, the El Nino - Southern Oscillation (ENSO) affects the number of big rain events in Florida. Current research at the Center for Ocean-Atmospheric Prediction Studies (COAPS) addresses probabilities of the number of big rain events for each month during each ENSO phase. Rainfall data are from stations in Florida for the period 1950-2009. Phases of ENSO are designated via historical ranks of the Multivariate ENSO Index (MEI). The poster briefly discusses the methodology to obtain probabilities. However, the primary focus is a new web link that facilitates display of probabilities for stations throughout Florida. Site selection is made via an interactive map that displays an icon at the location of each station. Clicking on the icon displays a window that contains the station name and provides further links to graphs of monthly probabilities of the number of big rain events during each ENSO phase. A visual outline of the link procedure and examples of graphs of probabilities are presented via the poster.

Danielle E. Ogurcak and M. S. Ross (FIU)

The Influence of Disturbance, Seasonality, and Hydrologic Controls on Plant Community Boundary Dynamics in the Lower Florida Keys

Lowland coastal forests worldwide are being threatened by the possibility of rapid increases in sea level and the impacts of hurricanes. Anticipated changes to vegetation communities and the resources that structure them as a result of climate change are at the forefront of current ecosystem research. While Florida's coastal forests have evolved along with sea-level rise and a particular frequency of hurricane activity, the increased sea-level rise of the past century (~23cm at Key West, NOAA 2001) combined with possible increases in the frequency of major hurricanes will favor more salt-tolerant species at the expense of species reliant on fresh water. Plant succession leading to changes in communities and community boundaries will be driven by the legacies (nutrient pools and vegetation) remaining from disturbance events, set against a background of seasonal changes in the ever-dwindling freshwater resource supply. This research addresses the spatial and temporal relationships between pine rockland, hardwood hammock, and buttonwood community boundaries and nutrient and water availability on the low-lying islands of Big Pine and Sugarloaf Keys. Specific objectives to be addressed by this research include the following: a comparison of current and historic plant community boundaries and quantification of storm surge effects by community type from both Hurricane Wilma (2005) and Hurricane Georges (1998), identification of the seasonal lateral extent of the freshwater lens and its spatial relationship to vegetation community boundaries, and a determination of how water and nutrient availability vary with seasonal changes in freshwater lens extent and how this is reflected in terms of plant stress within the dominant species comprising each community type. The results of this research will provide insight into the inter-relationships and feedback mechanisms between community boundaries, available water and nutrient resources, and disturbance regimes in the face of accelerated sea level rise.

Gisselle Guerra, Sabrina Parra (UF)

Storm surge and water current comparison at Mobile Bay between Hurricanes Katrina and Ivan

The Gulf Coast is highly vulnerable to damage from storm surges generated by tropical cyclones; therefore it is imperative to understand what conditions generate greater storm surges, and the subsequent widespread damage. This project's main purpose is to determine the causes of storm surge and water current velocity differences between hurricanes Ivan (2004) and Katrina (2005) at Mobile Bay, AL. Hurricane Ivan made landfall on September 16th, 2004 on the east side of Mobile Bay producing maximum storm surges between 2-2.5 meters within the bay. At landfall Ivan had maximum sustained wind speeds of about 54 m/s. At the time of landfall, Mobile Bay was experiencing a neap tide (smallest range between high and low tide) cycle. Hurricane Katrina made its final landfall near the Louisiana and Mississippi border on August 29th, 2005 west of Mobile Bay. At landfall Katrina had maximum sustained wind speeds of 63 m/s. At the time of landfall, Mobile Bay was experiencing a spring tide (greatest range between high and low tide) cycle. Even though the storm surge was higher with Katrina, water current velocities within Mobile Bay were 30-50% weaker than during Ivan. It is expected that storm surge differences between the two hurricanes is caused by differing tide stages at landfall, different angles of approach taken by the hurricanes, and changes in wind speed and direction throughout the hurricane's passage. Preliminary results show that the cause for contrasting water current velocities was a combination of the different tide stages during each landfall, as well as the differences in storm size, wind distribution, and angle of approach to the coastline. Further research related to wave setup within Mobile Bay needs to be done to better understand the complex distribution of storm surge.

Leonard Pearlstine, Steve Friedman, Matthew Supernaw, and Eric Swain (National Park Service)

Landscape vegetation succession modeling for Everglades restoration and sea level rise

The Everglades Landscape Vegetation Succession (ELVeS Version 1.1) model is a new tool designed to simulate succession following changes to ecological state conditions. Its use is intended to enhance understanding of projected vegetation response patterns to changes in landscape hydrology, soil biogeochemisty, climate and other environmental conditions, allowing informed management and policy decisions. . The model uses the joint probability distribution functions to classify the likelihood for each vegetation community. ELVeS has been parameterized for Everglades fresh water marsh and coastal vegetation communities and run against the BIscayne SouthEastern Coastal Transport (BISECT) coupled ground and surface water model. BISECT was used to generate a series of sea level rise projections that spatially portray change in salinities and water depths. Using BISECT sea level rise and restoration alternatives as input to ELVeS provides a mechanism to spatially examine community responses to competition between fresh water inflows and salt water intrusion.

Emily R. Pugh, Ellen E.Martin (UF)

Verification of Nd isotopes as a water mass tracer based on isotopic evaluation of Cretaceous detrital residues from Demerara Rise

The Late Cretaceous was a major greenhouse interval, but little is known about how ocean circulation contributed and responded to this event. Nd isotopes of fossil fish teeth/debris are believed to preserve a record of water mass distributions and recent data from deep sea sites on Demerara Rise highlight the presence of unusual, persistent, nonradiogenic eNd values (-14 to -17) that span the Cenomanian to Santonian and continue in the Campanian and Maastrichtian following an ~10 my hiatus. This value is interrupted by a dramatic positive excursion of 8 eNd units during Ocean Anoxic Event 2 and has been interpreted to represent local formation of a warm, saline bottom water mass [Demerara Bottom Water (DBW)]. The positive eNd excursion is attributed to a temporary shutdown of DBW production or enhanced input of a North Atlantic/Tethyan water mass associated with peak greenhouse conditions. This study evaluated Nd and Pb isotopic compositions of detrital silicates from ODP sites 1260 and 1261 to verify that Nd isotopes preserved in fish debris record a water mass signal rather than sediment-seawater interactions. Results demonstrate no correlation between seawater and residue Nd isotopes for the Cenomanian to Maastrichtian. In particular, residue eNd values record no change during the dramatic increase in seawater values at OAE2. Residue Pb isotopes document a change in source rock composition following the hiatus that is not accompanied by a change in seawater values. The lack of correlation between seawater and residue Nd isotopes throughout most of the record argues against boundary exchange or sediment diagenesis as the source of nonradiogenic values preserved in fish teeth. Together detrital Nd and Pb isotopic records from the Late Cretaceous at Demerara Rise support the idea that fish debris Nd isotopes record water mass compositions, thereby supporting local bottom water mass formation at low latitudes and changes in circulation associated with OAE2.

Elizabeth Radke, Vasu Misra, Lynn Grattan, Sparkle Roberts, Margaret Abbott, Glenn Morris (UF)

Ciguatera fish poisoning and seawater temperature in St. Thomas, USVI

Ciguatera fish poisoning (CFP) is a significant public health concern in tropical and subtropical areas worldwide, particularly on islands that rely on local fish for nutrition. Global incidence estimates range from 50-500,000 cases per year (Fleming 1998). It is hypothesized that there may be an increase in CFP incidence associated with increasing seawater temperatures (SWT). Hales et al. found a strong positive correlation between annual incidence of CFP in the south Pacific and increased SWT during El Nino events, with a decrease in CFP on islands that experienced cooling during the events (Hales 1999). Others have published similar results (Chateau-Degat 2005, Tester 2010). Llewellyn reported that there may also be an upper temperature threshold at which CFP incidence would decrease (Llewellyn 2010). These findings are concerning because of the potential increase in incidence that could occur with warmer waters caused by climate change. To further investigate the association between CFP and SWT in the Caribbean, we performed a medical record review to identify cases of CFP presenting to the Roy Schneider Hospital emergency room in St. Thomas, U.S. Virgin Islands. We abstracted data on 454 cases between 2002 and 2011. We also obtained publicly available data on SWT in the Virgin Islands for the same time frame from the National Oceanic and Atmospheric Administration's Earth System Research Laboratory Physical Science Division. We correlated the number of cases with the mean SWT for each month. We performed the same analysis with one, three, and six month lags between the temperature and case counts to account for the time it takes for the toxin to move through the reef trophic levels. We identified a weak positive correlation with marginal significance between cases of CFP and mean seawater temperature with a one month lag ($r=0.19$, $p=0.077$) and with no lag ($r=0.17$, $p=0.097$). There was no association when accounting for a three or six month lag. This low level association suggests that SWT alone is not responsible for most of the variability in CFP case incidence in the Caribbean. Future studies will attempt to identify additional environmental factors, such as coral reef health, wind and wave speed, light, salinity, and nutrient level that, with temperature, may predict incidence of CFP and better model the potential effect of climate change.

Donielle Rouse, Britany Ziems, and Corene Matyas (UF)

Comparison of storm-total rainfall among tropical cyclones with tracks similar to Irene (2011)

When tropical cyclones make landfall, they can produce heavy rainfall that leads to flooding, especially over areas where terrain is not flat and when soils are already moist. Hurricane Irene (2011) produced rainfall totals ranging from 15 inches in North Carolina to 7-10 inches over New England. The rainfall from Irene combined with above average rainfall totals from prior months produced record flooding in several states within the region. The goal of this research was to compare the rainfall patterns produced by Hurricane Irene to other tropical cyclones that took similar paths over the U.S. Utilizing a GIS, Irene's track was buffered by 100 km, and tracks of previous storms featuring a long segment within this buffer were selected for the rainfall analysis. Daily rainfall totals were obtained from the National Centers for

Environmental Prediction–Climate Prediction Center (NCEP–CPC) Unified Precipitation Dataset (UPD), which is a gridded dataset at 0.25° spatial resolution available beginning in 1948. To determine the storm-total rainfall for each tropical cyclone, daily rainfall totals were summed within the GIS over the period encompassing the day before the storm made landfall until the day after it left the U.S. The spatial patterns of these rainfall estimates were then compared to that of Irene (2011). Hurricanes Floyd (1999) and Donna (1960) had the most similar tracks to that of Irene. We found that rainfall patterns produced by Hurricane Floyd (1999) most closely resemble those of Irene in both rainfall amount and spatial pattern, although Floyd produced a higher maximum in North Carolina. Donna's rainfall totals were much lower. The highest rainfall totals produced within New England were from Hurricane Diane (1955), as several states received more than ten inches of rainfall. Future work will relate these rainfall totals to available atmospheric moisture through an analysis of total precipitable water data.

Alessio Russo, F. Escobedo, and S. Zerbe (UF)

Green spaces and urban climate regulation in cities of South Tyrol, Italy

Cities are home to over 50% of the world's population. Average temperatures in large metropolitan areas of 100,000 - 1,000,000 people can be 5 - 10Â°C warmer than surrounding rural areas and result in a phenomenon known as the 'urban heat island'. Incidences of longer, warmer summer temperatures are increasing and this is likely due to climate change. These increased temperatures are resulting in increased mortalities during summer heat waves. Additionally increased temperatures are resulting in more energy use for summer cooling and winter heating and subsequently increasing carbon emission from energy production. Several studies have demonstrated the effectiveness of using urban greening (i.e. urban vegetation and natural landscapes) to mitigate the human health consequences of increased urban temperatures resulting from climate change. Specifically, urban green spaces provide services such as air pollution removal, carbon sequestration, and climate regulation through shading and evapo-transpiration. Vegetation in cities also reduces cooling energy use in buildings and indirectly reduce CO2 emissions. However, there is little information on the role of public green spaces on localized urban climates in mid-sized cities in northern Italy. Thus, a holistic approach is needed to better design and plan urban streetscapes for improved thermal regulation and carbon storage. To address this need, we will explore the effect of different streetscape designs on mitigating local-scale temperatures and offsetting carbon dioxide emissions in Bolzano, Italy using the ENVI-met and Urban Forest Effects model. This approach will also assess the ecosystem services provided by urban vegetation according to 'streetscape types' • . The specific ecosystem services that we will quantifying include: total air pollution removed at the individual tree and streetscape-level, and the total carbon stored and sequestered by urban streetscapes and their role in offsetting carbon emission from the transportation sector. We will also study the cooling effect and thermal comfort provided by trees and streetscapes.

Ryan, J.G., Feldman A., Muller-Karger F., Gilbes, F., Stone, D., Plank, L., Peterson, M., Herman, B., Trotz, M., Meisels, G., and Reynolds, C.J. Trotz (USF)

The Coastal Areas Climate Change Education (CACCE) Partnership Development and Planning Efforts for Climate Change Education in Florida and the Caribbean

The Coastal Areas Climate Change Education (CACCE) Partnership, whose funded members include the University of South Florida, the University of Puerto Rico at Mayaguez, the University of the Virgin

Islands, the Florida Aquarium, and the Hillsborough County Public Schools, is one of 15 NSF-funded Climate Change Education Partnership (CCEP) Program Phase 1 projects, tasked with developing a network of partnering organizations and a comprehensive plan for climate education serving a US region and/or addressing a critical issue. The CACCE Partnership focuses on the impacts of climate change in the built environments of low-lying coastal areas, emphasizing Florida and the Caribbean. CACCE is targeting several key stakeholder audiences: 1)Professionals working in the built environment. CACCE cooperating partners include key urban planning and development organizations (SW FL Regional Planning Council, APA-FL, ICLEI, HOK), the Department of Urban and Regional Planning at FSU, and the Florida Center for Environmental Studies at FAU, aimed at providing education resources for professionals and urban decision-makers. Related outreach to communities is being pursued through NOAA Sea Grant partners in PR and FL. We currently seek to engage key players in the Caribbean tourism industry. 2) K-12 educators and students. Educator surveys reveal climate change education in Florida and Puerto Rico needs greater time and attention. We seek to bring climate change content into high school marine science courses, working with FL district science supervisors and their PR counterparts to provide teacher professional development. Other K-12 classes are participating in Multiple Outcomes Interdisciplinary Research and Learning (MOIRL) projects that engage them in climate change learning through participation in researcher-led, climate-related investigations. 3) Informal science education. Working through the Florida Aquarium, we are reaching out to informal science providers in our region to assay needs and identify effective communication strategies. 4) International Partners. Efforts led by the University of Puerto Rico at Mayaguez seek cooperation on climate education and communication with Spanish-speaking nations around the Caribbean. We are also cooperating with the Caribbean Community Climate Change Center and the Inter-American Development Bank on expanding to the wider Caribbean basin. Current CACCE efforts focus on developing detailed education plans for each targeted stakeholder group and identifying partner teams that will provide sustainable means for education delivery. We are seeking NSF-CCEP Phase 2 support to continue and expand our efforts.

Robert Schroeder, A. Serna, L. Scinto (FIU)

Estimating Net Carbon Sequestration or Release from Simulated Everglades Tree Islands Using Soil CO2 Efflux and Litter Mass

Peatlands and wetlands worldwide are under threat from anthropogenic alteration and climate change. These systems store large quantities of carbon (C) that could potentially be released by altered rain patterns, temperatures, and species composition. The Everglades ecosystem is no less different. Developing a model for predicting Everglades tree island CO_2 sequestration or release based on the yearly relative water depth fluctuations can contribute to filling the gaps in current climate-carbon models. Water level, or water saturation, is one of the main drivers of respiration in tropical, sub tropical and temperate peatlands and wetlands. Understanding how Everglades' tree island respiration responds to water level fluctuations coupled to plant biomass estimation (C sequestration) can be used by managers to slow, or reverse, tree island loss. An experiment was carried out in the Loxahatchee Impoundment Landscape Assessment (LILA) experimental landscape located at the Arthur R. Marshall Loxahatchee National Wildlife Refuge in Boynton Beach, FL. LILA was created to mimic the ridges, sloughs and tree islands characteristic of the Everglades in a semi-controlled system. Soil CO_2 efflux measurements were conducted using an infrared gas analyzer LICOR LI-8100 and chamber system. Efflux measurements were taken from two different island elevations, on two LILA tree islands on a quarterly basis between May 2010 and March 2011, coinciding with major water level changes. Relative water depth (RWD) has an influence on soil CO_2 efflux which varied from 0.13 to 18.49 umol CO_2 m^{-2} s^{-1} with low efflux rates during the peak wet season and high efflux rates during peak dry season. C sequestration or release was determined in conjunction with biomass C by estimating rates of litter fall addition to the soil surface. Data collected from litter traps in triplicates bimonthly from August 2010-2011 indicate variations in litter production with time, elevation, and island. The mass collected from these traps is assumed C input. This study will help to balance present-day C inputs and outputs in the altered Everglades ecosystem and can be applied to environmental management and climate change models.

Edward AG Schuur, A.D. McGuire, J. Canadell, J. Harden, P. Kuhry, V. Romanovsky, M. Turetsky, and C. Schaedel (UF)

Vulnerability of Permafrost Carbon Research Coordination Network

Approximately 1700 Pg (billion tons) of soil carbon are stored in the northern circumpolar permafrost zone, more than twice as much carbon than currently contained in the atmosphere. Permafrost thaw, and the microbial decomposition of previously frozen organic carbon, is considered one of the most likely positive feedbacks from terrestrial ecosystems to the atmosphere in a warmer world. Yet, the rate and form of release is highly uncertain but crucial for predicting the strength and timing of this carbon cycle feedback this century and beyond. Here we report on the formation of a new research coordination network (RCN) whose objective is to link biological C cycle research with well-developed networks in the physical sciences focused on the thermal state of permafrost. We found that published literature in the Science Citation Index identified with the search terms ‘permafrost’ and ‘carbon’ have increased dramatically in the last decade. Of total publications including those keywords, 86% were published since 2000, 65% since 2005, and 36% since 2008. Interconnection through this RCN is designed to produce new knowledge through research synthesis that can be used to quantify the role of permafrost carbon in driving climate change in the 21st century and beyond. An expert elicitation conducted as part of the RCN activities revealed that the total effect of carbon release from permafrost zone soils on climate is expected to be up to 30-46 Pg C over the next three decades, reaching 242-324 Pg C by 2100 and potentially up to 551-710 Pg C over the next several centuries under the strongest warming scenario presented to the group. These values, expressed in billions of tons of C in CO_2 equivalents, combine the effect of C released both as CO_2 and as CH_4 by accounting for the greater heat-trapping capacity of CH_4. Much of the actual C release by weight is expected to be in the form of CO_2, with only about 3.5% of that in the form of CH_4. However, the higher global warming potential of CH_4 means that almost half of the effect of future permafrost zone carbon emissions on climate forcing was expected by this group to be a result of CH_4 emissions from wetlands, lakes, and other oxygen-limited environments where organic matter will be decomposing. These results demonstrate the vulnerability of organic C stored in near surface permafrost to increasing temperatures. Future activities of this network include synthesizing information for IPCC assessments.

Jennifer Seavey and Susan Cameron Devitt (UF)

Between the river and the deep blue sea: how freshwater limitations aggravate sea level rise impacts.

Along Florida&#39s coastlines, scientists are documenting dramatic changes in ecosystems as a result of a combination of reduced freshwater input and sea level rise. The interplay between fresh and salt water are critical to the sustainability and functioning of many coastal ecosystems. We highlight two case studies along Florida&#39s Big Bend coast- oyster reefs and wetland forests- to demonstrate how freshwater limitation and rising sea level are working together to impact biodiversity and important ecosystem services provided by these habitats to Florida&#39s coastal communities. While both sea level rise and variability in precipitation are global problems with global solutions, there are opportunities for improving freshwater input into Florida&#39s coastlines at regional and local scales. We explore options for local policy makers to improve freshwater availability to coastal ecosystems.

Suwan Shen, Zhong Ren Peng (UF)

Impact Analysis Based Land Use and Infrastructure Adaptation Planning to Climate Change

The National Research Council recently announced that climate change would greatly affect the performance of urban infrastructures. Rising sea levels, more frequent precipitations, and storms will significantly increase the frequency and magnitude of flooding, which in turn threatens the reliability of urban infrastructures. Despite the increase attention to climate change, there are several research gaps in current climate change adaptation planning. For example, no accurate flood map could be used to assist the planning practice. Few studies address the frequency and magnitude of extreme events as a changing variable. And further analysis is still needed to help decision makers at the local level to better utilize existing visualization tools in adaptation planning process. Our research group has devoted a large amount of research efforts in this field, trying to bridge these research gaps. This poster exhibits our research findings through two case studies. One case study focuses on the impacts of changing riverine flood caused by precipitation change, and another focuses on sea level rise’s impacts on coastal communities. In the first case, to assist local planning, the possibility to use downscaled global climate model output to conduct quantitative impact analysis are explored. Areas and infrastructures within projected floodplain are identified, and future flood exceedance probability is calculated and compared. The estimated flood map could be used as a guide for land use and infrastructure planning, and the calculated frequency increase could help to adjust the drainage design frequency standard. In the second example, with intent to help local decision makers better develop and select adaptation options, Tampa Bay metropolitan area is used as the study area to evaluate the applicability and efficacy of existing impact visualization tools in adaptation planning. The study expands upon the existing NOAA impact assessment tool to estimate system vulnerability under a series of sea level rise scenarios, and to provide a methodology to prioritize adaptation options. It helps the decision makers to identify the relative importance of various vulnerability indicators (i.e. ecosystem, urban infrastructure, and socio-economic impacts), and quantify the benefits of specific adaptation strategies in terms of reducing overall system vulnerability for localities. The two studies shown here significantly improve the traditional adaptation planning, by providing, a quantitative way to estimate the impacts of climate change and compare the potential benefits of adaptation options to the whole system.

DW Shin, G. Baigorria, S. Cocke, J. J. OBrien, J. W. Jones, D. Letson, D. Solis, and N. Breuer (UF, FSU)

A new framework for an integrated climate application system

We integrate state of the art climate projections, crop modeling systems and economic assessment to develop a tool for studying and assessing agricultural production in the southeast United States. This integrated framework will enable us to assess the potential impact of future climate variability and trend on the production of economically valuable crops in the southeast United States where climate has major effects on agricultural yields. Downscaling systems suitable for application to dynamical crop models will be evaluated, extended and or developed. Optimally weighted multimodel ensemble (MME) approaches will be used in order to improve the projection of future regional crop yield. This research will enhance the current knowledge of linking climate and process models, with an economic evaluation, as a demonstration of an approach that can be applied for other settings, problems, etc.

Thomas J. Smith III, Lydia Stefanova, Vasubandhu Misra, Paul R. Nelson, and Ginger Tiling-Range (FSU)

Will non-native, exotic mangroves in south Florida expand their ranges? An assessment using down scaled AOGCM climate model projections

Thirteen non-native mangrove species were introduced in south Florida during the past 60 yrs. Six are currently alive and actively producing viable propagules. One has been declared invasive by the Florida Council on Exotic Plants. Previous research indicates that several of these exotics can compete quite successfully with Florida's three native mangroves. We assessed the potential invasiveness and spread of these species with a scenario of future climate based on the down scaling of general circulation model output to regional scales. The future climate scenario was one of a hotter and dryer southeast United States particularly in June, July and August. The down scaled climate outputs were used as inputs for climate envelop models developed for each species. Observations of the effects of extreme events (two freezes) on the extant populations were also made. Our results indicate that all of these non-native mangroves have traits which could lead to invasiveness and spread in south Florida. Range expansions northward along both Florida coastlines are also a possibility. Propagules of all of these non-native mangroves are readily dispersed by water currents and tides. Additionally there is an abundant availability of suitable substrate, coastal salt marshes, for establishment. Northward spread will also depend on changing frequencies of extreme events and individual species responses. Observations after the January and December 2010 freeze events indicated 40-70% mortality, which was dependent on stem diameter, in a stand of the Indo-west Pacific mangrove species Bruguiera gymnorhiza. No mortality was observed for Heritiera littoralis, Nypa fruticans or Lumnitzera racemosa. All of these non-native, exotic mangroves are capable of growth and reproduction in the forecast warmer and dryer southeast US.

Stefanova Lydia, P. Sura, and M. Griffin.(FSU)

Non-gaussian distribution of wintertime daily minimum and maximum temperatures

We use a 50-year record of quality-controlled observations collected from 217 National Weather Serivce's (NWS) Cooperative Observing Network (COOP) stations throughout Florida, Georgia, Alabama, and South and North Carolina. We show that over the Southeast the anomalies of winter minimum and maximum temperature are not Gaussian. We find that warm/cold ENSO regimes and warm/cold AO regimes affect the minimum and maximum daily temperature distributions not only by shifting the distributions&#39 mean, but also by changing the distributions&#39 shapes in a geographically coherent manner.

Lydia Stefanova and Catherine Langtimm (FSU)

Winter cold outbreaks and manatee mortality

The U. S. Fish and Wildlife Service requires information on effects of future climate change on the population dynamics of the Florida manatee when making status and listing assessments under the Endangered Species Act. Demographic models to estimate survival and reproductive rates and Population Viability Analysis (PVA) models to project future quasi-extinction probabilities can incorporate weather and climate scenarios. We discuss an approach to develop such scenarios for unusual mortality events (UME) due to winter cold outbreaks. We are analyzing the historical winter climate record and its association with annual manatee survival, with a particular focus on the cold outbreaks of the past two winter seasons. We also consider projected future climate patterns and their frequency and intensity and the possible consequences for the manatee population along the Gulf of Mexico and the Atlantic coast.

Di Tian and Christopher J. Martinez (UF)

Forecasting regional reference evapotranspiration using Global Forecast System reforecasts

Accurate estimation of reference evapotranspiration (RET) is needed for determining agricultural water demand, reservoir losses, and driving hydrologic simulation models. This study was conducted to explore the application of downscaled NCEP's Global Forecast System (GFS) reforecast dataset combined with NCEP-DOE Reanalysis 2 dataset to forecast RET over the states of Alabama, Georgia, Florida, North Carolina, and South Carolina in the southeast United States. Since only 12-hour temperature, wind speed, and relative humidity are available in the GFS reforecast dataset, six approaches of estimating RET using the Penman-Monteith (PM) and Thornthwaite equations were evaluated by substituting or adding the climatological mean values of variables including temperature, solar radiation, and wind speed from the Reanalysis 2 dataset. Both GFS and Reanalysis 2 datasets have coarse resolution with roughly 200-km grid spacing. Forecasts were downscaled using forecast analogs and the North American Regional Reanalysis (NARR) dataset (approximately 32-km per grid cell). Two evaluation criterion: Linear Error in Probability Space (LEPS) score and Brier Skill Score (BSS), were used to evaluate the overall forecast skill and the categorical forecast skill, respectively. The skill of both terciles and extremes (10th and 90th percentiles) were evaluated. The RET methods that combined Reanalysis 2 solar radiation data with GFS temperature and wind speed data to estimate parameters in the PM equation showed better skill compared to those that estimated these parameters from GFS outputs only. Most of the forecasts are skillful in the first 8 lead days. From a temporal and spatial aspect, the upper extreme forecasts in coastal areas demonstrated better skill than in inland; on the contrary, the lower extreme forecasts in inland areas demonstrated better skill than in coastal areas. Although the five categorical forecasts are skillful, we found the skills of upper and lower terciles forecasts are better than those of lower and upper extreme forecasts and middle terciles forecasts.

HuiPing Tsai, Jane Southworth, Peter R. Waylen, Youliang Qiu (UF)

An assessment of vegetation responses to precipitation variability in Florida

Understanding how inter- and intra-annual precipitation affects seasonal vegetation dynamics is critical for assessing potential impacts of climate variability on landscape structure and composition. This is especially important in Florida ecosystems where precipitation patterns vary across the landscape, and across different times of the year. This study presents a spatial and temporal analysis that correlates the response of photosynthetic activity with inter- and intra-annual precipitation variability in Florida at a monthly time-step over the years 1981-2010. We estimate monthly precipitation using the parameter-elevation regression on independent slopes model (PRISM) dataset and monthly vegetation responses using the 0.05 Degree MODIS Normalized Difference Vegetation Index (NDVI) and 0.1 Degree AVHRR Normalized Difference Vegetation Index (NDVI) from Clark Lab's product as a proxy for vegetation productivity. We present a mean-variance analysis of NDVI and characterize the vegetation dynamics through a two-dimensional plane. Initial mean-variance analyses show an increasing trend of mean values of NDVI and most of the months show an increasing trend of variance across the landscape indicating more vegetation, and more variability in vegetation type and structure over time. However, the spatial variations are of interest and do need to be addressed. We present a persistence analysis of NDVI at a finer spatial extent (0.05 degree). Initial persistence analyses show a diverse spatial variation of NDVI across the landscape. Further time-series models that account for monthly lags and seasonal effects to estimate the NDVI response to precipitation will be performed. Our research contributes to climate-environment interaction studies by examining how vegetation dynamics respond to precipitation at multiple spatial and temporal scales and is a vital element to understanding shifting dynamics of Florida ecosystems.

Tom Hoctor, UF Reed Noss, UCF, Jon Oetting, Florida Natural Areas Inventory, Michael Volk, UF

Predicting and Mitigating the Effects of Sea-Level Rise and Land-Use Change on Imperiled Species and Natural Communities in Florida

The goal of this project is to assess the potential impacts of sea-level rise and land-use change on natural communities and species of high conservation concern in Florida. Such an assessment is necessary for determining vulnerability and developing conservation and adaptation strategies that will avoid, minimize, and mitigate anticipated impacts. This work will form the foundation for revising conservation land acquisition priorities, land-use planning and management strategies, and adaptation measures for at-risk species and natural communities to promote resistance and resilience to climate change. The specific objectives for this project include: Objective 1 Data Collection and Development: Collect and develop data for assessing the combined impacts of sea-level rise and land-use changes on imperiled species in coastal areas and in upland zones that might serve as dispersal corridors and refugia. This objective includes development of a range of sea-level rise projection models (scenarios), future land-use scenarios, updated habitat and distribution models for imperiled species, and a literature review on the habitat requirements, autecology, adaptability, and risk factors for particular species. Objective 2 Impacts Assessment: Based on the updated habitat models and literature review, assess the potential impacts of sea-level and land-use scenarios on imperiled taxa, natural communities, and habitat corridors as a basis for defining specific adaptation strategies. Objective 3 Strategy Recommendations: Based on projected impacts to imperiled species and communities, identify a range of options for mitigating the effects of sea-level rise and facilitating adaptation, which will provide a spatially explicit, scientific basis for future land-use policy and planning decisions. Objective 4 Stakeholder Engagement: The final component of this study, education and outreach to decision makers, land-use planners, and the public, is intended to facilitate the dissemination and use of the information produced in this study. User-friendly information will summarize the &#39state of the science&#39 of sea-level rise vulnerability and adaptation options in Florida, as a necessary backdrop to policy decisions.

P.Waylen, C. Annear and Y. Qiu (UF)

Estimating Historic Precipitation Inputs into Lake Mweru, Zambia.

Historic rainfall records from 67 stations in and around the basin contributing to Lake Mweru, Zambia, are combined to produce a time series of estimated man basin inputs 1925-1986. Mapping of the simple statistics of annual precipitation across the basin, emphasize the bowl-like structure of the basin resulting from its geologic past. Mean annual precipitation and its standard deviation are inversely related to elevation, with the highest values of both statistics being experienced over the complex of lakes and wetlands on the centrally located Bangweulu Plateau. The continued presence of high variability when expressed as a coefficient of variation suggests that this geographic region is disproportionately responsible for the noted variability in the time series. This conclusion is further emphasized by the examination of composite maps based on the 10 years of maximum and minimum inputs respectively. Very high interannual variability is noted over the period 1943-1963, along with a high degree of persistence. The wavelet diagram of the input series is compared to those of the three major prposed causes of global scale forcing of climate in the region, the Southern Oscillation Index, the Northa Atlantic Oscillation Index and the Di-pole Mode of the Indian Ocean. No clear candidate emerges, although the NAO diagram provides similar, but inverted, temporal behavior. It is postulated that the absence of such global forcings (notable in terms of the amplitudes of the indices) during this 20 year period may actually have given rise to the greater interannual variability and persistence of the estimated input series, by permitting the enhancement of precipitation recycling above the region.

Ming Ye, Heng Dai, Alan Niedoroda, Dejun Feng, Steve Kish, Joseph Donoghue (FSU)

Coastal Zone Responses to Sea-Level Rise: Numerical Modeling and Uncertainty Analysis

Large-scale coastal systems consisting of several morphological components (e.g., beach, surf zone, dune, inlet, shoreface, and estuary) can be expected to exhibit complex and interacting responses to sea level and climate changes. We have developed a numerical Model of Complex Coastal Systems (MoCCS), derived from earlier morphdynamic models, to represent the large-scale time-averaged physical processes that shape each component and govern the component interactions. These control the ongoing evolution of the barrier islands, beach and dune erosion, shoal formation and sand withdrawal at tidal inlets, depth changes in the bay, and changes in storm flooding. The model has been used to study the response of an idealized coastal system with physical characteristics and storm climatology similar to Santa Rosa Island on the Florida Panhandle coast. Five SLR scenarios have been used, covering the range of recently published projections for the next century. Each scenario has been input with a constant and then a time-varying storm climate. The results indicate that substantial increases in the rate of beach erosion are largely due to increased sand transfer to inlet shoals with increased rates of sea level rise. The barrier island undergoes cycles of dune destruction and regrowth, leading to sand deposition. This largely maintains island freeboard but is progressively less effective in offsetting bayside inundation and marsh habitat loss at accelerated sea level rise rates. A hierarchical method of uncertainty analysis has been developed to address uncertainty in sea-level scenarios and storm parameters. The model predicts morphologic change to the barrier island and quantifies uncertainty in the simulated beach dune heights, dune width, and backshore positions under multiple sea-level rise scenarios. The outcomes of this study will be used to evaluate how to make reliable predictions of the effects of future climate change on coastal infrastructure and natural coastal systems. The expected result will be to enable cost-effective mitigation and adaptation strategies to prepare for future climate change.

Griffin, M. L., Preston L., and O'Brien J.J. (FSU)

The Florida Climate Center

The Florida Climate Center is part of three-tiered system that serves to provide climate data and information for the United States. Affiliated with the National Climatic Data Center (NCDC) in Asheville, NC and the Southeast Regional Climate Center (SERCC) in Columbia, SC, the Florida Climate Center is the first stop for climate data and information for citizens, organizations, educational institutions and private businesses in the state of Florida. We seek to serve the state of Florida by providing historical weather observations for a variety of weather stations throughout the state, including long-term averages and information and analysis about extreme events that impact the state, such as hurricanes, freezes and droughts. In addition to providing data, the Florida Climate Center is a leading authority on climate variability in Florida, particularly as related to the El Nino Southern Oscillation (ENSO). The Florida Climate Center has been an active partner with the Southeast Climate Consortium (SECC) one of the Regional Integrated Science and Assessment (RISA) teams funded by NOAA’s Office of Global Programs. Through this involvement, we conduct research into downscaled and local climate forecasts and their application to the sectors of agriculture, forestry and water resources, as well as other state and regional climate issues. The Florida Climate Center is also active in the Community Collaborative Rain Hail and Snow Network (CoCoRaHS), a non-profit organization that stresses training and educating its volunteers about precipitation across the United States. The members of the office staff take part in numerous outreach events across portions of Florida, including weather and climate classrooms at elementary and middle schools, university open houses and summer camps, promoting the education of the climate of Florida.

Christa Zweig, H.F. Percival, M. Allen, W. Kitchens, and M. DeSa (UF)

Climate Change Effects in the Big Bend of Florida

The Florida Cooperative Fish and Wildlife Research Unit, University of Florida, has been conducting climate change research at the Lower Suwannee National Wildlife Refuge for the last 2 years. Researchers are using a combination of small mammal, salt marsh, fisheries and regional climate data to understand current population patterns and how climate change may impact the system. The endangered Florida salt marsh vole resides in the refuge and was an earlier research target of the Unit. The vole has only been captured 43 times since 1979 and its rarity makes it extremely difficult to study in a statistically meaningful way. So, while efforts continue to learn more about M. pennyslvanicus, focus has shifted towards more common small mammal marsh inhabitants. The rice rat (Oryzomys palustris) and cotton rat (Sigmodon hispidus) are known to occupy the marshes in higher numbers and represent an important class of herbivores that influence their vegetative environment. Baseline vegetation information will also be collected and methods developed for continued monitoring to inform a succession model. Remote sensing will be used to extend the period of record for habitat and link hydrologic and vegetation relationships at multiple scales. Fisheries data have been collected over several years through the Fisheries Independent Monitoring program through the Fish and Wildlife Conservation Commission in the Lower Suwannee River. Discharge from the river has been shown to influence growth and survival of juvenile fishes inhabiting the estuary. Predictions of future river discharge scenarios from down-scaled climate models will be tied to models of fish recruitment and occurrence in the estuary.

Appendices

Appendix A. Workshop Agenda

November 14, 2011	
Evening Session	
5:00 pm	Reception and Poster Session
6:15pm	Welcoming Remarks: James Jones, University of Florida, Leonard Berry, Florida Atlantic University, and Lynn Dudley, Florida State University
6:30pm	Keynote Address: Steve Seibert of Seibert Law, Tallahassee, Florida
7:30pm	Keynote Presentation: Virginia Burkett, Senior Science Advisor for Climate and Land Use Change, U.S. Geological Survey
8:30 pm	Adjourn
November 15, 2011	
Opening session	
8:30am	Welcoming Remarks: Dr. Win Phillips, Vice President for Research at UF
8:45am	Keynote Presentation: "Climate Change and Sea Level Rise in Florida" Jayantha Obeysekera, Department Director Hydrologic & Environmental Systems Modeling, South Florida Water Management District
9:30am	Presentations of White Papers Biodiversity and Land Use Climate Scenarios for Florida Education, Training, and Outreach on Climate Change Water Management and Coastal County Adaptation
10:30am	Break
Panel 1 (Environment and Natural Resources)	
10:45am	Coastal Ecosystems: Ernie Estevez, Director, Center for Coastal Ecology, Mote Marine Laboratory
11:00am	Biodiversity: Thomas Eason, Deputy Director, Division of Habitat and Species Conservation, Florida Fish and Wildlife Conservation Commission
11:15am	Water Management: Alison Adams, Source Rotation and Environmental Protection Manager, Tampa Bay Water
11:30am	Land Management: Todd Powell, Director-Real Estate, Plum Creek
11:45am	Facilitated Discussion with Jim Murley, Interim Executive Director, South Florida Regional Planning Council
12:15pm	Lunch
Panel 2 (Economics and Policy)	
1:45pm	City/County Climate Change Initiatives: Pegeen Hanrahan, Secretary of Board, ICLEI and former mayor of Gainesville, Florida
2:00pm	Regional Climate Change Initiatives: Steve Adams, Senior Advisor - Climate Adaptation, Institute for Sustainable Communities
2:15pm	Major Sector Climate Change Responses: Fred Bloetscher, Assistant Professor, Department of Civil, Environmental and Geomatics Engineering, Florida Atlantic University
2:30pm	Major Industry Climate Change Programs: Ray Butts, Director Strategic and Regulatory Planning, Florida Power & Light Co.
2:45pm	Facilitated Discussion: Steve Seibert of Seibert Law, Tallahassee, Florida
3:15pm	Break
Wrap – up session	
3:30-4:30pm	Discussion, Final Comments, Adjourn

Appendix B. University Climate Change Institutes, Centers & Initiatives in Florida

Coastal Areas Climate Change Education Partnership	http://cacce.net
AgroClimate	www.agroclimate.org
American College and University Presidents' Climate Commitment	http://www.presidentsclimatecommitment.org/
Center for Environmental and Sustainability Education	http://www.fgcu.edu/cese/
Center for Environmental Diagnosis and Bioremediation	http://uwf.edu/cedb/index.cfm
Center for Environmental Equity and Justice	http://www.famu.edu/index.cfm?environmentalscience&CEEJ
Center for Marine Ecosystem Health	http://www.fau.edu/hboi/OceanHealth/index.php
Center for Ocean-Atmospheric Prediction Studies	http://coaps.fsu.edu/
Coastal Hydroscience Analysis, Modeling and Predictive Simulations	http://champs.cecs.ucf.edu/
Cooperative Institute for Marine and Atmospheric Studies	http://cimas.rsmas.miami.edu/index.html
Environmental Center	http://www.unf.edu/ecenter/
Environmental Cooperative Science Center	http://www.ecsc.famu.edu/
Environmental Science Institute at Florida A&M University	http://www.famu.edu/index.cfm?environmentalscience&ESIHome
Florida Aquarium, Inc	http://www.flaquarium.org/
Florida Center for Environmental Studies	http://www.ces.fau.edu/
Florida Climate Center	http://coaps.fsu.edu/climate_center/index.shtml
Florida Climate Change Task Force	http://floridaclimate.org/
Florida Climate Institute	http://floridaclimateinstitute.org/
Florida Institute of Oceanography	http://fio.usf.edu/Home.aspx
FSU Coastal and Marine Laboratory	http://www.marinelab.fsu.edu/
Global Water for Sustainability	http://www.globalwaters.net/
GLOBE program	http://www.globe.gov/
Institute for Energy Systems, Economics, and Sustainability	http://www.ieses.fsu.edu/
Integrative Collaborative on Climate & Energy	http://www.ces.fau.edu/climate_change/icce
International Hurricane Center	http://www.ihc.fiu.edu/
NASA / Waterscapes	http://web.eng.fiu.edu/waterscapes/WaterSCAPES_web/WaterSCAPES.html
Patel School of Global; Sustainability	http://sgs.usf.edu/ma-courses.php
Public Water Supply Utilities Climate Impacts Working Group	http://waterinstitute.ufl.edu/workshops_panels/PWSU-CIWG.html
R.J. Dunlap Marine Conservation Program	http://rjd.miami.edu/
Rosenstiel School of Marine and Atmospheric Science	http://www.rsmas.miami.edu/about-rsmas/
Scripps Howard Institute on the Environment	http://www.fau.edu/scrippsjournalism/
Southeast Climate Consortium	http://seclimate.org/
Southeastern Environmental Research Center	http://casgroup.fiu.edu/serc/pages.php?id=1737
University of Florida Water Institute	http://waterinstitute.ufl.edu/

Appendix C. Key State and Federal Agencies

Abbreviation	Agency Name
ABS	Archbold Biological Station
DCA	Florida Dept. of Community Affairs
DEM	Florida Department of Emergency Management
DOE	U.S. Dept. of Energy
DOI	U.S. Dept. of Interior, Southeast Climate Science Center
ERTF	Everglades Restoration Task Force
FDACS	Florida Dept. of Agriculture and Consumer Services
FDEP	Florida Dept. of Environmental Protection
FDOT	Florida Dept. of Transportation
FEMA	Federal Emergency Management Agency
FWC	Florida Fish and Wildlife Conservation Commission
GRACE	NASA’s Gravity Recovery and Climate Experiment
HOA	Homeowner Association
LCC	FWC coordinator: Landscape Conservation Cooperatives
NARCCAP	North American Regional Climate Change Assessment Program
NCDC	National Climatic Data Center
NCFRPC	North Central Florida Regional Planning Council
NOAA	National Oceanic and Atmospheric Administration
NRCS	USDA National Resources Conservation Service
NWFWMD	Northwest Florida Water Management District
SFWMD	South Florida Water Management District
SJRWMD	St. John's River Water Management District
SRWMD	Suwannee River Water Management District
SWFRPC	Southwest Florida Regional Planning Council

SWFWMD	Southwest Florida Water Management District
TNC	The Nature Conservancy
UCAR	UCAR, University Corporation for Atmospheric Research
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	US Forest Service
USFWS, FWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
	1,000 Friends of Florida
	Audubon Society

Appendix D. List of Acronyms

AMO	Atlantic Decadal Oscillation
AR4	IPCC Fourth Assessment Report
ARGO	http://www.argo.ucsd.edu (ocean temperature/salinity float data)
CDF	Cumulative Distribution Function
CLIP	Critical Lands and Waters Identification Project
COMET	Cooperative Program for Operational Meteorology, Education and Training
ENSO	El Nino Southern Oscillation
GLOBE	Global Learning and Observations to Benefit the Environment
GRACE	Gravity Recovery and Climate Experiment
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
LCC	Landscape Conservation Cooperatives
LTER	Long Term Ecological Research Network

NAO	North American Oscillation
NARCCAP	North American Regional Climate Change Assessment Program
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NEON	National Ecological Observatory Network
NHC	National Hurricane Center
PCMDI	Program Climate Model Diagnosis and Intercomparison
PDF	Probability Density Function
SLR	Sea Level Rise
SPICE	Stanford Program on International and Cross-Cultural Education
SST	Sea Surface Temperature
STC	Science and Technology Center
UCAR	University Cooperative for Atmospheric Research
ULTRA	Urban Long Term Research Areas