Climate Change and Southeast Ecosystems

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Outline

- Climate Science Basics
- Climate Change in Southeast
- Impacts to Ecosystems
- Resources
CLIMATE SCIENCE BASICS
Weather vs. Climate

- **Weather** – short term occurrence
- **Climate** – long term occurrence

For Raleigh, NC

<table>
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<tbody>
<tr>
<td><strong>High Temperature</strong></td>
<td>65 F</td>
<td>71 F</td>
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<tr>
<td><strong>Low Temperature</strong></td>
<td>44 F</td>
<td>47 F</td>
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What drives our climate?

- Energy Balance
- Earth’s complex surface
- Location on Earth
- Earth’s atmospheric composition
Observed Land Cover Changes in the Southeast U.S.

Maps retrieved from NASA's Socioeconomic Data and Applications Center.
Latitude
Topography
Proximity to Oceans
Variations in Climate

- **Short-term** – Earth’s surface (oceans)
  - Winter
  - Summer

- **Longer-term**
  - Atmospheric composition (pollutants)
  - Earth’s surface (land use change)
Definitions

- **Global warming** – the recent and ongoing increase in global average temperatures near the Earth’s surface
- **Climate change** – change in measures of climate lasting for an extending period of time
  - Location specific
  - Changes in temperature, wind patterns, rainfall
Global land surface air temperature anomalies relative to 1961-1990

Global Surface Temperature

Source: http://www.ncdc.noaa.gov/indicators/index.html
Source: http://www.ncdc.noaa.gov/indicators/index.html

The graph shows two emission scenarios for the year 2100: a higher emissions scenario and a lower emissions scenario. The 2008 observed concentration is also marked on the graph. The x-axis represents the year, ranging from -800,000 to 0, with 2008 at the right end. The y-axis represents carbon dioxide concentration (ppm), ranging from 0 to 900.
This is the Greenhouse Effect. It is what keeps earth from being an ‘icebox’ planet.
But we are now adding much more CO$_2$ into the atmosphere which makes this effect stronger.
CLIMATE CHANGE IN THE SOUTHEAST
1991-2012 (map)
Change from 1901-1960 Average
2014 NCA
Observed Increase in Frost-Free Season Length

1991-2012 Change from 1901-1960 Average
2014 NCA

Change in Annual Number of Days

- 0-4
- 5-9
- 10-14
- 15+

- +16
- +19
- +10
- +9
- +6
Observed U.S. Precipitation Change

1991-2012 (map)
Change from 1901-1960
Average
2014 NCA
Observed Change in Very Heavy Precipitation

Defined as Heaviest 1% of all daily events

Change from 1901-1960 Average
Climate Model Projections

- Global Climate Models (GCMs) are not trying to predict the weather on any given day.
- Instead – we want to understand how weather on average will change given some changes in external forcing.
  - What happens if CO₂ doubles?

Climate Models are projections and dependent on the assumptions made about external forcing, such as changes in CO₂.
Weather Models
Incorporate only
Atmosphere and Ocean

Increasing number of physical processes are gaining representation, resolution is getting finer. But resolution is still not fine enough for local applications.
Downscaling

“the process of making the link between the state some variable representing the large space and the state of some variable representing a much smaller space.” Benestad (2008)

No one standard technique for downscaling, they broken into two categories. **Statistical** and **Dynamic**.
Local Projections

• Global Climate Models can’t provide meaningful guidance locally
  – Downscaling allows the exploration of local potential impacts.

• Multiple agencies, academia and others have many sets of local projections using downscaling
  – Google Search (30+), In House by different agencies (hundreds)
Emissions Scenarios

• Used to define changes with human action (i.e. more or less emissions from human activities in the future)

• High emissions – no restraints on emissions in the future

• Low emissions – restraints on emissions in the future
Projected Change in Average Temperature Across the Southeast United States From 1970-1999 to 2071-2099

Low Emissions

High Emissions

Temperature Change (°F)

2014 NCA
Projected Change in Number of Days Across the Southeast United States from 1971-2000 to 2041-2070

Number of Nights < 32°F

Number of Days > 95°F

2014 NCA
Projected Changes in Winter and Summer Precipitation From 1971-2000 to 2070-2099

High Emissions

Winter

Summer

Low Emissions

Winter

Summer

Precipitation Change (%)

2014 NCA
Projections regarding the number, intensity, tracks of tropical cyclones are consistent between CMIP3 and CMIP5 global climate models. Still not agreement on changes in tropical cyclone frequency globally or in the North Atlantic. (Camargo, 2013)
Predicted Change in Category 4 and 5 Hurricanes per Decade by 2100, 2013 IPCC Models

Knutson et al., 2013, J. of Climate

Change in # of Storms

-1 0 1 2 3
Future Winters

- Probably more warm days in winter
- Probably fewer very cold days
- Probably fewer days with snow at lower elevations
Future Springs

- More warm days, fewer cold
- Possibly more intense thunderstorms
  - We don’t think they will get weaker
- Perhaps more tornadoes, hail
  - Much less certain
Future Summers

• Likely more hot days
• Perhaps fewer days with rain
  – More days with intense rain
• Perhaps more drought
Future Autumns

- More intense hurricanes
- Later first frost, fewer frost / freeze days
IMPACTS TO ECOSYSTEMS
Impacts to Ecosystems

• Droughts plus increasing ET
  – Increased risk for wildfires and stream drying

• Less frequent cold temperatures
  – Increase in non-native invasive species

• Sea Level Rise
  – Increasing vulnerability of coastal wetlands to erosion and inundation, possible conversion to open water
“While warmer winter temperatures may benefit longleaf pine ecosystems in the northern range margin, the majority of longleaf pine savannas will fare less well due to increasing summertime droughts.” – NCA Southeast Technical Report
Henderson and Grissio-Mayer, 2009

Relationship of longleaf pine tree ring widths to climate variables
Black bars = statistically significant

Precipitation
Summer is critical for temperature and precipitation.
Summer and Fall for drought

Temperature

Texas

South Carolina
RCWs and Climate Change

• 1,000 RCWs examined (30,000 observations) in the Sandhills of NC and Camp Lejeune

• Preliminary results:
  • Laying date earlier
  • Clutch size increased
  • Annual fecundity (# fledglings per group) increased

• Still evaluating survival data

Slide courtesy of Jeff Walters (Virginia Tech)
Speer et al, 2009

Tree ring width relationship to climate variables, oak species in the Southern Appalachians

Strong relationship with summer PDSI, but also a strong relationship with May / June temperatures and rainfall (negative for temperatures, positive for rainfall)

Western NC – 2001
Red Spruce – southern pine beetle colonization, result of long term acid rain and drought in the years whose combined influence made the spruce forest susceptible (McNulty and Boggs, 2010)

Ayres and Lombardero, 2000
Past and Projected Changes in Global Sea Level

Current Levels – NOAA SLR Viewer

Legend

- Water
- Unconsolidated Shore
- Saltwater Marsh
- Brackish/Transitional Marsh
- Freshwater Emergent Wetland
- Freshwater Shrub Wetland
- Freshwater Forested Wetland
- Developed Open Space
- Upland
- Low Intensity Developed
- Medium Intensity Developed
- High Intensity Developed
- Area Not Mapped
- Visualization Location
- Low-lying Areas

Water Depth

Figure: 2014 NCA

Sea Level Change (feet)

Year
1800 1850 1900 1950 2000 2050 2100
Proxy Records
Tide Gauge Data
Satellite Data

Sea Level Change:
- 0.66 ft
- 1 ft
- 4 ft
- 6.6 ft
3ft Sea Level Rise – NOAA SLR Viewer
Past and Projected Changes in Global Sea Level

2014 NCA

Legend
- Water Depth
  - Low-lying Areas
  - Area Not Mapped
  - Visualization Location

Sea Level Change (feet)

Year

1800 1850 1900 1950 2000 2050 2100

Proxy Records
Tide Gauge Data
Satellite Data

4 ft

1 ft

0.66 ft

6ft Sea Level Rise -- NOAA SLR Viewer
Some warm-water fishes have moved northwards, and some tropical and subtropical fishes in the northern Gulf of Mexico have increased in temperate ocean habitat.

Higher nighttime temperatures and cumulative seasonal rainfalls were correlated with changes in the arrival times of amphibians to breeding sites in South Carolina.

Seedling survival of nearly 20 resident and migrant tree species decreased during years of lower rainfall in the Southern Appalachians and the Piedmont areas, indicating that reductions in native species were likely under climate change.
Dynamic reserve design in the face of climate change and urbanization

An adaptive landscape planning and decision framework for gopher tortoise (*Gopherus polyphemus*) conservation

Connectivity for Climate Change in the Southeastern US
Spatial Decision Support System

Research being done by DCERP to drive this system to assist base management.

To incorporate both ecosystem information and climate data (historical and projections)

Courtesy Pat Halpin (Duke University)
Seedling Markets (more information about this tool)

Map Display:  
- Historical Temperatures
- Projected Temperatures

Future Emissions: Current Levels (High)

Current and Projected 13.2°F Temperature Ranges

Location: In Newberry County, SC (34.3°N 81.74°W)

To select a location, click on the map or enter your coordinates: 34.3°N, 81.74°W

Other Resources
- USDA Plant Hardiness Zones
Resources

Why? Because there is so much available information and data on climate and climate change!

• People
• Training Materials / Tools
• Reports / Guides
Training Materials / Tools

- Climate Education Modules - NCSCCO
- Climate Change Basics – EPA
- Sea Level Rise Viewer – NOAA
- Climate Resilience Toolkit – NOAA
- Climate Adaptation Knowledge Exchange
Reports / Guides

Observed and Projected Changes

• 2014 National Climate Assessment

Impacts

• NCA Southeast Technical Report

Using Climate Projection Data

• USGS Open File Report – Use of Downscaled Projections in the SE
Closing

• The climate in the Southeast is changing
  – More heat waves, less cold snaps
  – If you’ve seen it in the past, you’ll see it in the future, but the frequency will change

• Many potential impacts to ecosystems
  – Temperatures, rainfall, SLR

• Much information – seek out guidance to help you with your decisions!
http://globalchange.ncsu.edu/secsc/
http://www.climate.ncsu.edu

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