Current Climate Science and Climate Scenarios for Florida

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Water Research Foundation
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State of the Science

• International/National

• State/Regional
  – Florida Climate Action Plan released in 2008
Southeast Florida Climate

• Temperature
  – Range from an average of 67 °F in January to 83 °F in August

• Precipitation
  – Annual average of 56 in
  – Pronounced rainy and dry season

• Local climate features
  – Thunderstorms
  – Tropical cyclones
Observed Climate Trends

Temperature and sea level are rising in South Florida

Temperature data from NOAA NCDC. Sea level data from NOAA Tides and Currents. Source: Columbia University Center for Climate Systems Research
El Niño Southern Oscillation (ENSO)

SST Anomalies from 1998 El Niño
El Niño Southern Oscillation (ENSO) Teleconnections – Seasonal Averages

JFM EL NINO PRECIPITATION ANOMALIES (MM) AND FREQUENCY OF OCCURRENCE (%)
Downscaling

• Statistical downscaling produces finer scale features than Global Climate Models (GCMs) using historical relationships between the large and small spatial scales.

• Dynamical downscaling achieved by running a Regional Climate Model (RCM) RCM at high resolution over a small spatial domain driven by GCM output.
Mean Annual Changes

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>2020s</th>
<th>2050s</th>
<th>2080s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Temperature</strong></td>
<td>76 °F</td>
<td>1.0 to 2.0 °F</td>
<td>2.0 to 3.5 °F</td>
<td>3.0 to 5.5 °F</td>
</tr>
<tr>
<td><strong>Precipitation</strong></td>
<td>56 in</td>
<td>-5 to 5 %</td>
<td>-10 to 5 %</td>
<td>-10 to 5 %</td>
</tr>
</tbody>
</table>

Based on 16 GCMs and three emissions, downscaled to ~12 km resolution
Shown are the central range (middle 67%) of model-based values

Temperature and precipitation changes reflect a 30-year average centered on the specified decade. The baseline for temperature and precipitation is the most complete 30-year data period centered around the 1980s. The baseline value is an average of baseline data from the Miami, Miami Beach, Fort Lauderdale, Palm Beach, and Belle Glade stations. Temperatures are rounded to the nearest half degree, precipitation to the nearest 5%. Data are from NOAA.

Source: Columbia University Center for Climate Systems Research
Mean Annual Changes

Combined observed (black line) and projected precipitation. Projected model changes through time are applied to the observed historical data. The three thick lines (green, red, and blue) show the average for each emissions scenario across the 16 GCMs from the BCSD dataset. Shading shows the central range. The bottom and top lines, respectively, show each year’s minimum and maximum projections across the suite of simulations. A ten-year filter has been applied to the observed data and model output. The dotted area between 2005 and 2015 the period that is not covered due to the smoothing procedure. Source: CCSR
Regional Temperature Projections

16 A2 GCM Annual Temperature
2070 – 2099 (°F)

A2 2080s 16 GCM Annual Temperature Change (°F), relative to 1970-1999

Bias-corrected and spatially downscaled CMIP3 data:
Source: Columbia University Center for Climate Systems Research
Regional Precipitation Projections

16 GCM A2 Annual Precipitation
2070 – 2099 (in)

A2 2080s 16 GCM Annual Precipitation
Change (%), relative to 1970-1999

Bias-corrected and spatially downscaled CMIP3 data:
Source: Columbia University Center for Climate Systems Research
## Extreme Events

The number of days per year exceeding 90°F is projected to rise in the coming century, and the number of days with temperatures below 45°F is projected to decrease.

* For Fort Lauderdale, FL

<table>
<thead>
<tr>
<th>Daily Temperatures</th>
<th>Baseline</th>
<th>2020s</th>
<th>2050s</th>
<th>2080s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max temperature at or above 90°F (days/year)</td>
<td>60</td>
<td>84 to 98</td>
<td>107 to 139</td>
<td>130 to 174</td>
</tr>
<tr>
<td>Min temperature at or below 45°F (days/year)</td>
<td>9</td>
<td>6 to 7</td>
<td>4 to 6</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Precipitation at or above 1 inch (days/year)</td>
<td>18</td>
<td>17 to 19</td>
<td>16 to 19</td>
<td>15 to 19</td>
</tr>
</tbody>
</table>

Baseline data from NOAA
Source: Columbia University Center for Climate Systems Research
Tropical Cyclones

- Teleconnections
  - El Niño / La Niña
  - Atlantic Multidecadal Oscillation
- 2011 Seasonal Forecast
  - 12 to 18 names storms
  - 6 to 10 hurricanes
  - 3 to 6 major hurricanes
- Future Projections
  - No concrete evidence global warming will have an impact on hurricane strength and frequency
  - Warming may increasing hurricane intensity (Emanuel, 2005)
  - Other factors that influence hurricane development (i.e. wind shear) may also change with warming

Hurricane Frances

Source: NASA, 2004
## Qualitative Extremes

### Qualitative Changes in Extreme Events During this Century

<table>
<thead>
<tr>
<th>Event</th>
<th>Direction of Change</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Stress</td>
<td>↑</td>
<td>Very Likely</td>
</tr>
<tr>
<td>Downpours</td>
<td>↑</td>
<td>Likely</td>
</tr>
<tr>
<td>Intense storms</td>
<td>↑</td>
<td>More likely than not</td>
</tr>
<tr>
<td>Drought*</td>
<td>↑</td>
<td>More likely than not</td>
</tr>
<tr>
<td>Extreme winds</td>
<td>↑</td>
<td>More likely than not</td>
</tr>
</tbody>
</table>

Likelihood categories based on IPCC WG1, 2007.

- Very likely = >90% probability of occurrence
- Likely = >66% probability of occurrence
- More likely than not = >50% probability of occurrence

*The scenarios presented here can be used to produce quantitative estimates of drought frequency

Source: Columbia University Center for Climate Systems Research
Land water storage
- Groundwater mining,
- Impoundment in reservoirs,
- Urban runoff, deforestation,
- Seepage into aquifers

Vertical land motions
- Subsidence/uplift due to
- Glacial isostatic adjustment,
- Tectonics

Mass changes
- Glaciers and ice sheets

Thermal expansion
- Ocean water

Local water mass density
- Temperature, salinity, ocean currents
Sea Level Rise Methods

• IPCC-based approach
  – Global thermal expansion
  – Local land subsidence (GIA)
  – Meltwater from glaciers, ice caps, and ice sheets
  – Local water surface elevation

• Rapid ice-melt approach
  – Based on acceleration of recent rates of ice melt in the Greenland and West Antarctic ice sheets and paleoclimate studies
  – Rationale:
    • Observed sea level slightly above high end IPCC projections
    • Climate models cannot yet fully capture processes such as:
      – Surface ponding and basal lubrication of glaciers
      – Thinning of ice shelves that buttress land ice
      – Thinning of ice at grounding lines
Sea levels are averages for the specified decade. Changes are relative to the 2000 to 2004 base period. The central range (middle 67% of values from model-base probabilities) across the 7 GCMs and 3 GHG emissions scenarios is shown; sea level rise rounded to the nearest inch. “Rapid ice melt scenario” is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic ice sheets and paleoclimatic studies. The scenario assumes a 1 meter rise in sea level due to ice melt alone.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Baseline</th>
<th>2020s</th>
<th>2050s</th>
<th>2080s</th>
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<tbody>
<tr>
<td>IPCC-based</td>
<td>NA</td>
<td>+ 2 to 4 in</td>
<td>+ 6 to 9 in</td>
<td>+ 10 to 19 in</td>
</tr>
<tr>
<td>Rapid ice-melt scenario</td>
<td>NA</td>
<td>~ 4 to 6 in</td>
<td>~ 18 to 21 in</td>
<td>~ 39 to 48 in</td>
</tr>
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Source: Columbia University Center for Climate Systems Research
Sea Level Rise Projections

Combined observed (black line) and projected sea level rise for two future sea level rise scenarios. Projected model changes through time are applied to the observed historical data. The darker shaded blue shows the full range of projections for the rapid ice-melt scenario while the lighter shade of blue shows the full range of projections for the GCM-based sea level rise approach. The three thick lines (green, red, and blue) within each sea level rise scenario show the average for each emissions scenario across the 7 GCMs. A ten-year filter has been applied to the observed data and modeled output. The dotted area between 2004 and 2015 the period that is not covered due to the smoothing procedure. Source: CCSR
Sea Level Rise Comparison

Relative Sea Level Rise Scenarios for South Florida

Notes: Projections are for historic, modified National Research Council (NRC) Curve I and modified NRC Curve III rates of sea level change developed for South Florida per USACE Engineering Circular (EC) 1155-2-211. This EC is based on guidance in the NRC report “Responding to Changes in Sea Level: Engineering Implications” dated September, 1987. The projection is developed using the historic rate of sea level rise at Key West as reported by NOAA (2.24 mm/yr). The dashed line indicates that the EC equation is being used past the year 2100. The underlying documents supporting the EC do not address data beyond 2100.

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<th>Year</th>
<th>Relative Sea Level Rise, inches</th>
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<td></td>
<td>Historic</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
</tr>
<tr>
<td>2030</td>
<td>2</td>
</tr>
<tr>
<td>2060</td>
<td>4</td>
</tr>
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<td>2100</td>
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