Climate Means, Trends And Extremes In The Everglades: Historical Data And Future Projections

Lydia Stefanova$^1$, Vasu Misra$^{1,2}$, T. J. Smith III$^3$

$^1$Center for Ocean-Atmospheric Prediction Studies, FSU
$^2$Dept. of Earth, Ocean and Atmospheric Science, FSU
$^3$Southeast Ecological Science Center, USGS
Everglades’ Climate

How does it vary and how might it change?

Part 1: Climate variations in recent history

Part 2: Climate Projections and downscaling: A brief overview

Part 3: “La Florida” climate downscaling: Interpreting the model projections
Part 1
Historical Climate Variability
Tmin as a function of calendar day at Everglades station – all years from 1948-2009, in deg. F; note winter variability
Number of Hot summer nights (top 1% of all summer tmin)

Number of Cold winter nights (bottom 1% of all winter tmin)

Corresponding temperature threshold [°F]
Number of Hot summer days (top 1% of all summer tmax)

Cumulative rainfall deficit/surplus

Number of Cold winter days (bottom 1% of all winter tmax)
Part 2
Climate Projections and Downscaling: brief background
Climate Scenarios for the Future

**Analog scenarios**
- Draw from historical record of observations e.g. during warm regimes
- **Computationally cheap, fully consistent, realistic**
- Limited historical records, assuming qualitatively similar future

**Modeling projections**
- Socio-economic & emission scenarios → physics-based numerical models
- **Computationally expensive, limited by model deficiencies**
- Multiple realizations, can analyze physical processes, can address “what if”
Downscaling Climate: How?

**Statistical downscaling**
- Develop statistical relationship between large and small scales using model and observed histories; apply to future.
- Computationally cheap → can have many realizations
- Not necessarily physically consistent, limited variables, assumption of stationary statistics, limited by statistical model deficiencies

**“Dynamical” downscaling**
- Run regional physical-based models forced by the large-scale model projections for the future
- Computationally expensive → limited realizations; limited by global and regional model deficiencies
- Physically consistent, many variables, no assumption of stationary statistics, can trace processes
Dynamical Downscaling

Run the global model, storing output several times per day.

Interpolate global model results to initialize the regional model grid.

Continually update the regional model around its lateral boundaries using later results from the global model.
Part 3
The “La Florida” Downscaled Projections
La Florida Downscaling Project

- 21 century: A2 scenario 2039-2070 (as in NARCCAP)
- Blue (reanalyses) and Green (climate scenarios): completed
- Yellow: underway

<table>
<thead>
<tr>
<th></th>
<th>20 century</th>
<th></th>
<th>21 century (A2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Historic veg</td>
<td>Current veg</td>
<td>Future veg</td>
</tr>
<tr>
<td>R2</td>
<td>Black</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>ERA-40</td>
<td>Black</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>CCSM</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>GFDL</td>
<td>Green</td>
<td>Green</td>
<td>Yellow</td>
</tr>
<tr>
<td>HadCM3</td>
<td>Yellow</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
**CLAREnCE10**: COAPS Land-Atmosphere Regional Ensemble Climate Change Experiment, 10km resolution

**Global models**: NCAR CCSM, Hadley Centre HadCM3

**Regional model**: National Centers for Environmental (NCEP)/Experimental Climate Prediction Center (ECPC) Regional Spectral Model (RSM)

**Scenario**: Historical (1969-2000)
A2 (high emission scenario), (2039-2070)
Global model projections:

CCSM global model

Winter ⟷ Summer

Seasonal mean precipitation in the global models: lack of agreement for the Southeast

HadCM3 global model

Winter ⟷ Summer

(CMIP3 models from NARCCAP website)
Downscaled winter (DJF) changes

- **tmax2m CCSM**
- **tmin2m CCSM**
- **precip CCSM**
- **tmax2m HadCM3**
- **tmin2m HadCM3**
- **precip HadCM3**
Downscaled spring (MAM) changes

- tmax2m CCSM
- tmin2m CCSM
- precipitation CCSM
- tmax2m HadCM3
- tmin2m HadCM3
- precipitation HadCM3
Downscaled summer (JJA) changes

- $t_{\text{max}2m}^{\text{CCSM}}$
- $t_{\text{min}2m}^{\text{CCSM}}$
- $t_{\text{max}2m}^{\text{HadCM3}}$
- $t_{\text{min}2m}^{\text{HadCM3}}$
- Precipitation $^{\text{CCSM}}$
- Precipitation $^{\text{HadCM3}}$
Downscaled fall (SON) changes

- **tmax2m CCSM**
- **tmin2m CCSM**
- **precip CCSM**

- **tmax2m HadCM3**
- **tmin2m HadCM3**
- **precip HadCM3**
Change in the record
coldest/warmest/wettest monthly values

- **tmax2m**
  - CCSM
  - HadCM3

- **tmin2m**
  - CCSM
  - HadCM3

- **precip**
  - CCSM
  - HadCM3

°C

x100 [%]
In the downscaled CCSM and HadCM3 projections, the mid-to-late 21st century the Everglades under the A2 emissions scenario are warmer; summers are drier.

- **Downscaled CCSM projections**: Monthly mean Tmax increased by ~3-3.5°C in summer, 2-3°C in winter, ~3°C the rest of the year; Tmin increases by 1.5-2.5°C
- **Downscaled HadCM3 projections**: Monthly mean Tmax and Tmin increases are similar to each other, ~2.5°C in summer, ~2°C the rest of the year
- **Precipitation is reduced in the downscaled HadCM3 projections, seasonally dependent sign of change in CCSM**: In spring and summer, both models project drier Everglades
• The record warmest month in the future period is warmer than that in the historical period in both models.

• The record coldest month in the future period is not necessarily warmer than that in the historical period.

• A preliminary look at the data suggests that the above may be related to an increased variance around the mean in the future compared to the historical period.
What do these results imply for potential users:

1. Modeling uncertainties are large; downscaling is unlikely to reduce these uncertainties.
2. Both outcomes represent 'feasible' scenarios for the future, to the extent that the global models can be relied upon.
3. The two downscaled models exhibit consensus on the sign of the temperature changes and summer precipitation changes.
4. Rather than going with the average of available realizations, applications should explore the consequences of each available scenario; should more weight may be assigned to models that are better at simulating historical climate?
Thank You

Data from the La Florida regional downscaling available at
http://floridaclimateinstitute.org/resources/data-sets/regional-downscaling/

Acknowledgements

The La Florida project was funded by USGS grant C10AC00149 and supported by the USGS National Climate Change and Wildlife Science Center. Thanks to Melissa Griffin for the historical data analysis, Dr. Steven Chan for his contribution to the modeling effort, Christopher Selman for assistance with data processing, and Kris Suchedeve for managing the dataset repository.