Comparison of Statistical and Dynamic Downscaling methods for Hydrologic Applications in West Central Florida

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Goal of the research

• To compare the ability of three statistical downscaling methods and one dynamic downscaling to generate precipitation fields at hydrologically relevant space-time scales over the Tampa Bay region of west-central Florida.

In this research we…

• quantitatively evaluate the skills of existing methods in terms of both temporal and spatial precipitation patterns.

• develop a new stochastic downscaling technique which improves over the existing statistical downscaling methods in reproducing observed spatiotemporal variability of daily precipitation

• evaluate hydrologic implications of differences in downscaled climate scenarios over the study area using an existing integrated hydrologic model.
Evaluation of climate information

General circulation models

Reanalysis data
1 GCM

RCM (Misra et al)
10 km resolution

4 GCMs

BC SD, SDBC, BC SA
12 km resolution

Evaluation of climate information

Integrated Hydrologic Model

Applications

The impact assessment
Data

GCMs used in this study

<table>
<thead>
<tr>
<th>Modeling Group, Country</th>
<th>WCRP CMIP3* I.D.</th>
<th>Primary Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjerknes Centre for Climate Research, Norway</td>
<td>BCCR-BCM2.0</td>
<td>Furevik et al., 2003</td>
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<tr>
<td>US Dept. of Commerce/NOAA/Geophysical Fluid Dynamics Laboratory, USA</td>
<td>GFDL-CM2.0</td>
<td>Delworth et al., 2006</td>
</tr>
<tr>
<td>Canadian Centre for Climate Modeling &amp; Analysis, Canada</td>
<td>CGCM3.1</td>
<td>Flato and Boer, 2001</td>
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<tr>
<td>National Center for Atmospheric Research, USA</td>
<td>CCSM</td>
<td>Collins et al., 2006</td>
</tr>
</tbody>
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*WCRP CMIP3: World Climate Research Programme's Coupled Model Inter-comparison Project phase 3

Gridded observations

12x12km², 1/8 degree resolution: Maurer et al., 2002
Method

Schematic representation of the methodology

CMIP3 GCM predictions

Method 1. BCSD
- Bias correction
  - CDF mapping

Method 2. SDBC
- Spatial downscaling
  - IDW interpolation

CMIP3 GCM predictions

Method 3. BCSA to generated spatially correlated precipitation field

172 sub-basin scale obs.
- Normal score transformation
- Estimate spatial correlation structure of obs.

Generate random field sequences for 172 stations
- Using correlation matrix of normal score

Bias correction
- CDF mapping

Spatially correlated field
- Library of spatially distributed precipitation fields
- Back transformation (CDF mapping)

Evaluate against observation

Method 2 results
- SDBC GCMs

Method 1 results
- BCSD GCMs

Method 3 results
- BCSA GCMs

Select field from library
Temporal Statistics

Mean daily precipitation

Std Dev daily precipitation
Transition Probability

Wet to Wet

Dry to Wet
**Variograms** (spatial variability analysis)

*Wet season (Jun.-Sep.)*

*Dry season (Oct.-May)*
Evaluation of climate information

General circulation models

- 1 GCM reanalysis data
- 4 GCMs

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Evaluation of climate information

Integrated Hydrologic Model

The impact assessment

Applications
**Method**

**Integrated Hydrologic Model**

- TBW and SWFWMD commissioned the development and application of an integrated surface water/groundwater model for the Tampa Bay Region.
- The Integrated Hydrologic Model (IHM) was developed which integrates the EPA Hydrologic Simulation Program-Fortran for surface-water modeling with the US Geological Survey MODFLOW96 for groundwater modeling.

Ross et al., 2004 (IHM theory manual)
Method

Study domain
Monthly average streamflow

Alafia River

Streamflow (m³/s)

BCSD

SDBC

BCSA

Cypress Creek

Streamflow (m³/s)

BCSD

SDBC

BCSA
Mean of errors (simulated-calibrated) for monthly average streamflow over four GCM results for each target station

**Mean of errors** for monthly average streamflow over four GCM results for each target station.

- **Alafia River**
  - BCSD
  - SDBC
  - BCSA

- **Cypress Creek**
  - BCSD
  - SDBC
  - BCSA
Mean of errors (simulated-calibrated) for daily streamflow standard deviation over four GCM results for each target station

Alafia River

Cypress Creek

Mean errors for daily streamflow standard deviation
The frequency of daily streamflow was not reproduced by SDBC as closely as for the BCSA results. Comparing the, it is evident that the under/overestimations of extreme events is canceled out when evaluating only the monthly mean streamflow.
Conclusions

• Commonly used **BCSD** method underestimates spatial and temporal variability of rainfall, and over estimates number of low precipitation days. These errors propagate into hydrologic predictions producing **higher ET and lower streamflow predictions in summer months**.

• **SDBC** method improves estimates of day-to-day temporal variability at fine grid-scale, but underestimates spatial variability of rainfall and thus overestimates temporal variability of spatially averaged rainfall. As a result SDBC successfully reproduces mean monthly streamflow, but **significantly overestimates magnitude of peak streamflow events**.

• **BCSA** method reproduces spatial and temporal variability of rainfall accurately and successfully reproduces mean monthly streamflow. However BCSA slightly **overestimates magnitude of peak streamflow events for the larger river**.
Conclusions

• Dynamically downscaled results show promise, especially when driven by reanalysis data. Hydrologic implications of higher than observed spatial variability and temporal variability of local rainfall will be investigated.

• Dynamically downscaled retrospective GCM predictions are way off! Does it make sense to both dynamically downscale AND bias-correct these results?
Future work

• Evaluate the utility of using various downscaling methods with seasonal GCM predictions and long-term projections of climate change scenarios in the Tampa Bay region.

• Assess the potential to use downscaled seasonal predictions to reduce risk for water management operations in the Tampa Bay region.

• Assess potential future climate change impacts on the hydrologic system in west-central Florida.