NARCCAP Model Comparison of Extreme Rainfall Intensity in the Continental US

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Introduction

• Extreme rainfall events: the design of infrastructure and facilities
  • Stormwater management
  • Erosion and sediment control
  • Flood protection (McCuen 1998; Prodanovic and Simonovic 2007; Mirhosseini et al. 2013)
Introduction

• The Generalized Extreme Value theory (GEV): Intensity-Duration-Frequency (IDF) Curves

(Mirhosseini et al. 2013)
Challenges

• **Sampling deficiencies**
  
  • the sample length is not long enough to support reliable statistical analysis (Bell, 1969; Alila, 1999)
Solution: Regional Frequency Analysis

• Substitute space for time by using observations from other local gauges to compensate the short time-series records

• Identify homogenous samplings: critical to obtain a satisfactory solution (Schaefer, 1990; Hanel Martin et al., 2009; Mirhosseini et al., 2013; Zhu et al., 2013).

Normal Distribution is used for illustration
Challenges of Climate Model Evaluation

- An objective, quantitative, repeatable, and transparent approach to identifying homogeneous regions for the evaluation of model performance across the U.S.

- Assessment is conducted within areas of particular interest (e.g. coastal California, Mississippi Valley)

- The homogeneity of heavy precipitation patterns?

- Model uncertainty in the U.S?
Objective

• Evaluate the simulation of extreme rainfall events at the **regional** scale for the continental of U.S. from different combinations of GCMs (or driving models) and RCMs in NARCCAP

• Spatial Variability
  • Model performance
  • Climate change on extreme rainfall events
## Data & Models

<table>
<thead>
<tr>
<th>Sources</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>North American Regional Reanalysis (NARR)</td>
<td>32 km</td>
<td>3 hour</td>
<td>1979 - 2000</td>
</tr>
<tr>
<td>North American Regional Climate Change Assessment Program (NARCCAP)</td>
<td>50 km</td>
<td>3 hour</td>
<td>Historic: 1968 – 2000</td>
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<tr>
<td></td>
<td></td>
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<td>Future: 2038 – 2070</td>
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</tbody>
</table>
## Models from NARCCAP

<table>
<thead>
<tr>
<th>RCM</th>
<th>Driving Model</th>
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<tbody>
<tr>
<td></td>
<td>NCEP</td>
</tr>
<tr>
<td>CRCM</td>
<td>✓</td>
</tr>
<tr>
<td>ECP2</td>
<td>✓</td>
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<tr>
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<td>MM5I</td>
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<tr>
<td>RCM3</td>
<td>✓</td>
</tr>
<tr>
<td>WRFG</td>
<td>✓</td>
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<tr>
<td>Time Slice</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Emissions scenario: A2
- NCEP is available in historic
Methods

• Annual maximum 24-hour rainfall

• Regionalization:
  • homogeneous Regions (grid clusters) from NARR having similar annual maximum rainfall patterns
Regionalization

• Each Grid
  • annual maximum 24-hour rainfall in about 30 years

• Similarity (or dissimilarity) between each pair of grids
  • Anderson–Darling distance placing more weight on observations in the tails of the distribution

• Regionalization: grid clusters
  • having similar annual maximum rainfall patterns measured by Anderson–Darling distance

• Spatial contiguity
REDCAP (Regionalization with Dynamically Constrained Agglomerative Clustering And Partitioning)

- Common: grid clusters with similar annual maximum rainfall pattern
- Uniqueness of REDCAP: spatially contiguous grids

Similarity of colors: Similarity of annual maximum rainfall patterns measured by Anderson–Darling distance

(Guo, 2008; Kupfer et al. 2012)

http://www.spatialdatamining.org/
**Methods**

- **NARR**: North American Regional Reanalysis (NARR)
- **NARCCAP**: North American Regional Climate Change Assessment Program (NARCCAP)

**Regionalization**

- **IDF**: Intensity-Duration-Frequency curves

**Assessment**: IDF from NARCCAP in historic vs. IDF from NARR

**Future change**: IDF from NARCCAP in future adjusting the bias in historic vs. IDF from NARR
1. Pacific Northwest
2. Mediterranean California
3. Intermontane West
4. Rockies
5. Northwoods
6. Central Plains
7. Texas Plains
8. Great Lakes
9. Eastern Interior
10. Gulf Coast
11. Northeast
12. Florida
Performance by Model
Performance by Model

Results

-100% -50% 0% 50% 100% 150% 200% 250% 300% 350%

CCSM  CGCM3  GFDL  HADCM3  NCEP

REG1  REG2  REG3  REG4  REG5  REG6  REG7  REG8  REG9  REG10  REG11  REG12
Future Change in Selected Regions

1. Pacific Northwest
2. Mediterranean California
3. Intermontane West
4. Rockies
5. Northwoods
6. Central Plains
7. Texas Plains
8. Great Lakes
9. Eastern Interior
10. Gulf Coast
11. Northeast
12. Florida
Results

Region 9
Eastern Interior
Results
Region 12
Florida

Results

CCSM

CGCM3

GFDL

GFDL

HADCM3

NARR

Return Period (Year)
Summary

• Assessment
  • Regions: Some models perform poorly along southeastern coast (i.e., Texas Plains, Eastern Interior, Gulf Coast, and Florida)
  • GCMs: CCSM is the best driving model
  • RCMs: CRCM and ECP2 perform best; RCM3 and WRFG perform worst; Performance of others depends on the driving GCM

• Future
  • In most regions, most models suggest intensified 24 hour rainfall events (exceptions: decreases in Florida and Texas Plains)
Discussion

- Regionalization method
  - Homogenous regions make the fitting of IDF curves more reliable
  - Reveal spatial variability of model performance