Rainfall Extremes in a Changing Climate

Art DeGaetano
Northeast Regional Climate Center
Department of Earth and Atmospheric Science, Cornell
Estimating Current Rainfall Extremes is like.....

Estimating the probabilities of poker hands
Without knowing the values and suits of all the cards!
Estimating FUTURE Rainfall Extremes is like…..

Estimating the probabilities of poker hands

Without knowing the values and suits of all the cards

AND

Adding more face cards to the deck at an unknown rate
**Motivation**

Change in heaviest 1% of all daily events 1958-2012

*from Karl et al. 2009*


1950-79 50 year storm = 1980-2009 33 year storm

*DeGaetano, 2009*
Motivation

NY Climate Risk and Resiliency Act CCRA

• Applies to **permitting, funding and regulatory decisions**
  
  For example
  
  Smart growth assessments  
  Wastewater treatment plant funding  
  Hazardous waste facilities siting  
  Design and construction of petroleum and chemical storage facilities  
  Oil and gas drilling  
  State acquisition of open space

• Applicants must **demonstrate** that they have taken into account **future** physical climate risks caused by storm surges, sea-level rise or **flooding**.
History

- NRCS funded
- Pre Atlas 14
- Tendency for Higher 100-yr Lower 2-yr
- Promoted beyond NRCS
- Early adaptation in New England States
Monitoring Extreme Precip Changes

Automated ANNUAL generation of updated extreme rainfall products.
Record Length??

- 5-year Storm
  - 0.01% yr\(^{-1}\)

- 10-year Storm
  - 0.007% yr\(^{-1}\)

- 25-year Storm
  - 0.004% yr\(^{-1}\)
Downscaling
1) Dynamical Downscaling (CORDEX) (also NARCCAP)
   → Regional climate models (RCMs) run at 50-km resolution and driven by atmosphere–ocean general circulation (AOGCM) models

2) “Statistical” Downscaling – Delta Method (CMIP5)
   → Compares model-simulated precipitation extremes between historical and future periods (at GCM resolution)

3) Statistical Downscaling – Analog Method (CMIP5)
   → Uses historical weather map analogues to predict the occurrence of extreme precipitation on a given day
REALITY CHECK AHEAD
Raw CMIP5  No Downscaling vs Obs.
Analog Downscaling

Coarse Resolution Future Date

Similar Historical Observed Days (coarse)

Observed Historical Days (fine)

Future Day (fine)

Develop statistical relationship between analog cases

\[ F_{Low} = b(H_{1\text{Low}}) + c(H_{2\text{Low}}) + d(H_{3\text{Low}}) + e(H_{4\text{Low}}) + a \]

Apply statistical relationship high resolution historical analogs

\[ b(H_{1\text{High}}) + c(H_{2\text{High}}) + d(H_{3\text{High}}) + e(H_{4\text{High}}) + a = F_{High} \]
Analog Method vs. Observed

Bias in 1-day 5-year Event by Model

- Mean
- bcc-csm1-1
- bcc-csm1-1-m
- bnu-esm
- canesm2
- csm4
- cnrm-cm5
- csiro-mk3-6-0
- gfdl-cm3
- gfdl-esm2g
- gfdl-esm2m
- giss-e2-h
- giss-e2-r
- ipsl-cm5a-lr
- ipsl-cm5a-mr
- ipsl-cm5b-lr
- miroc-esm
- miroc-esm-chem
- miroc5
- mri-cgcm3
- noresm1-m
Analog vs Observed Ensemble Mean Bias

Ensemble Mean Bias in 1-day 5-year Event

Mean Bias

0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8
Projected Changes in 1-day 5- and 100-Year Rainfall Amounts Relative to 1970–1999

RCP8.5: 2010-2039

Mean Percent Change (%)

-20  -10   0   10   20   30   40   50   60

5-year Event  100-year Event

Delta  Analog  CORDEX
Projected Changes in 1-day 5- and 100-Year Rainfall Amounts Relative to 1970–1999

RCP8.5: 2040-2069

Mean Percent Change (%)

-20
-10
0
10
20
30
40
50
60

5-year Event

100-year Event

Northeast Regional Climate Center
Projected Changes in 1-day 5- and 100-Year Rainfall Amounts Relative to 1970–1999

RCP8.5: 2070-2099

Mean Percent Change (%)

-20 -10 0 10 20 30 40 50 60

5-year Event 100-year Event
Projected Changes in 1-day 100-year Rainfall Amounts
2070–2099 vs. 1970–1999

10th Percentile

Mean

90th Percentile

RCP4.5

RCP8.5
Intensity Duration Frequency Curves for New York State

Future Projections for a Changing Climate

Select a Station Location by Clicking Map

Select a RETURN PERIOD
- 2-yr
- 5-yr
- 10-yr
- 25-yr
- 50-yr
- 100-yr

Select an EMISSION SCENARIO
- High RCP 8.5
- Low RCP 4.5

Select a TIME PERIOD
- 2010-2039
- 2040-2069
- 2070-2099

About this Project
Numerous studies have documented significant increases in both the frequency and magnitude of extreme precipitation in the northeastern U.S. since the mid-to-late 20th century. The most recent assessment from the Intergovernmental Panel on Climate Change (IPCC) suggests that the frequency and magnitude of extreme precipitation in this region will likely continue to increase throughout the 21st century. Such changes could greatly exacerbate the societal impacts of extreme precipitation in the future. In consideration of these impacts, the Northeast Regional Climate Center (NRCC) has partnered with the New York State Energy Research and Development Authority (NYSERDA) to downscale global climate model output and create extreme precipitation projections that will ultimately be incorporated into climate change adaptation planning for New York State. Read more...

http://ny-idf-projections.nrcc.cornell.edu
Intensity Duration Frequency Curves: 100-yr Return Period

ALBANY AP

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THANK YOU!