

## Impact of Non-Stationary Climate Conditions on Extreme Precipitation Frequency Estimates Needed for Engineering Design

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ASCE's Workshop on Engineering Methods for Precipitation Under a Changing Climate, Reston, VA, 30 May 2017

## Hydrometeorological Design Study Center (HDSC)



□ HDSC: part of the NOAA/National Weather Service's Office of Water Prediction : <u>http://www.nws.noaa.gov/ohd/hdsc/.</u>

Main HDSC responsibility: preparing national standards and updating Precipitation Frequency (PF) estimates for various parts of the USA and affiliated territories.

□ Since 2004, updates are published online as Volumes of NOAA Atlas 14: <u>hdsc.nws.noaa.gov/hdsc/pfds/index.htm</u>



Current NA14

Non-stationary NA14

Collaboration

## Where is NOAA Atlas 14 used?



#### Infrastructure design

- **Control of water:** flood mitigation, land development and construction, storm water drainage (roads, parking lots, airports, land, roofs), culverts, bridges,...
- Utilization of water for beneficial purposes: water supply, irrigation, navigation, hydrolectric-power development, ...
- Water-quality management, etc.

Background

Current NA14

Non-stationary **NA14** 

Preliminary Results



#### Where to get NOAA Atlas 14 estimates?



#### FOR A SELECTED LOCATION:



## **Current NOAA Atlas 14 process**



**Approach:** Region-of-influence regional frequency analysis approach based on GEV distribution with parameters calculated based on L-moment statistics from annual maximum series (AMS).

#### Main steps:

- Annual maximum series (AMS) extraction and QC (durations: 15 min - 60 days)
- □ Regionalization



- Calculation of regional L-moments and distribution fitting (based on AMS stationarity assumption)
- Derivation of DDF curves and confidence limits
- □ Interpolation to 30 arc-sec grid



## **Current trend testing on NOAA Atlas 14**

#### **REGIONAL ANALYSIS:**

Testing H<sub>0</sub>: no serial correlation at 5% level in normalized AMS regressed against time



#### **AT-STATION ANALYSIS:**

1. Applying parametric and non-parametric statistical tests for trends in AMS mean and variance

2. Investigating spatial patterns in tests' results



If statistical tests indicate positive trends in AMS (PDS) in less than 10-20% of randomly scattered stations, should we still try to account for non-stationary climate effects at stations where tests indicate trends?

Background

Current NA14

Non-stationary NA14 Preliminary Results

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## Accounting for non-stationary climate in NA14 requires:



#### □ Change in distribution parameterization

Replacing L-moment approach with Maximum likelihood approach

#### **Change in time series used in frequency analysis**

 Replacing AMS with PDS (AMS-based analysis not sensitive to changes in frequency of heavy precipitation events



# Pilot project on accounting for non-stationary climate in NOAA Atlas 14



- In 2015, Federal Highway Administration (FHWA) tasked HDSC to conduct a pilot project on effects of non-stationary climate on NOAA Atlas 14 precipitation frequency estimates.
- □ A pilot project looked at the effects of change in methodology on estimates.
- Preliminary findings are inconclusive (see next pages)
- As a result of this project, HDSC and FHWA expanded the project into the collaborative effort between the federal government and academia.



## **Pilot project's preliminary findings**

- Change in methodology vs. inclusion/exclusion of nonstationarity
- a) Difference due to methodology change

| LMOM (in) | MLE (in) | % change |
|-----------|----------|----------|
| 15.0      | 20.0     | 33%      |

b) Difference due to inclusion of nonstationarity

| MLE (in) | MLE(t) (in) | %change |
|----------|-------------|---------|
| 20.0     | 20.7        | 4%      |

c) Difference in 24-hr 100-yr estimate

| LMOM (in) | MLE(t) (in) | % change |
|-----------|-------------|----------|
| 15.0      | 20.7        | 38%      |

**Current NA14** 

Selection of non-stationary model









## **Pilot project's preliminary findings**



## Selection of the start of record period, the end of extrapolation time period, and the forecast of the future trend may significantly affect estimates

- □ What period of record to use in the analysis?
- □ How much extrapolation (to account for a design lifetime) is reasonable?
- □ Should we assume that the trend from the past will continue into the future or infer the future trend from climate projections?



Collaborative effort with academia on enhancing NA14 methods/products to account for non-stationary climate



**TASK 1:** Development of non-stationary methods



## In 2016, HDSC partnered with the Penn State University

(Dr. Benjamin Shaby, Gregory Bopp)



#### **TASK 2:** Using information from projected climate outlooks



HDSC is partnering with the University of Illinois, Urbana-Champaign/ Illinois State Water Survey (Dr. Momcilo Markus, Dr. James Angel)





## **THANK YOU!**

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