PROPOSAL FOR UPDATING PRECIPITATION FREQUENCY ESTIMATES FOR TEXAS

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TOPICS

1. BACKGROUND
2. AVAILABLE PRODUCTS
3. UNDERLYING DATA
4. FREQUENCY ANALYSIS TECHNIQUES

BACKGROUND
HDSC and NOAA Atlas 14

- Hydrometeorological Design Studies Center (HDSC)/NWS/NOAA is responsible for updating precipitation frequency (PF) estimates.
- Since 2004, updates are published as Volumes of NOAA Atlas 14
Precipitation frequency data server

http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

Why NOAA Atlas 14?

- History: In early 1950s NWS chosen to prepare IDF curves for federal government. NWS is independent and does not regulate or design
- NOAA Atlas 14 estimates are de-facto national standards
  - endorsed by Advisory Committee on Water Information (ACWI), federal water agencies
  - referenced in many federal, state, and local regulations
- Estimates are peer reviewed; considered more accurate, reliable and robust
  - more observing locations, longer period of records
  - wide range of return periods and durations
  - statistical methods address uncertainty
  - objective, high resolution spatial interpolation (30-arc second)
- Consistency between states
- Web based electronic delivery
- Ease of use

Data inquiry locations and monthly statistics
NOAA Atlas 14 Funding

- Work not funded from NOAA/NWS budget
- Performed at request of users and funded by users

Example:
FHWA Pooled Fund Program open solicitation for the Northwestern States (www.pooledfund.org/Details/Solicitation/1362)
1. BACKGROUND. USGS Atlas

1998. Asquith. DEPTH-DURATION FREQUENCY OF PRECIPITATION FOR TEXAS.
USGS Water-Resources Investigations Report 98–4044.
• "Defines the depth-duration frequency (DDF) of rainfall annual maxima in Texas by providing an atlas of the parameters of probability distributions."
• "Many TxDOT Design engineers have had greater-than-expected difficulty implementing the procedures...." (From TxDOT Implementation Status, Project Summary Report 5-1301-01-0).
• Data goes up to 1994.

2004. Asquith and Roussel. ATLAS OF DEPTH-DURATION FREQUENCY OF PRECIPITATION ANNUAL MAXIMA FOR TEXAS.
• "Provides a directly interpretable atlas of DDF in Texas on the basis of research results of Asquith (1998)."
• The report contains 96 maps of the depth of rainfall for 12 storm durations and 8 annual nonexceedance probabilities (recurrence intervals)."
• Improved ease of use; resolved inconsistencies in estimates
• Data not updated for this project.

2. AVAILABLE PRODUCTS
USGS ATLAS. Cartographic maps
Maps were created as visual aids and are not recommended for interpolating estimates.

2. AVAILABLE PRODUCTS
NA14 Cartographic maps

Digitized cartographic maps vs. gridded data

Example: 100-year 1-hour estimates for Colorado (contours every 0.5 in)

NA 14. Underlying data

- PFDS operates from a set of ASCII grids (30-arc sec resolution)

<table>
<thead>
<tr>
<th>Duration</th>
<th>Average recurrence interval (ARI)</th>
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<td>60-week</td>
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</table>

USGS Atlas coverage
NA14 Precipitation frequency estimates in GIS format

- PDS: 570 grids (190 quantile; 190 upper CL; 190 lower CL)
- AMS: 513 grids (171 quantile; 171 upper CL; 171 lower CL)

NA14. PF estimates for a single location

NA14. Zooming in...
NA14. ...retrieving PF estimate with confidence limits

2.97 (2.76-3.18)

NA 14. DDF curves, confidence intervals plots

NA 14. Additional products

- Confidence intervals on estimates
- Temporal distributions
- Seasonality analysis
- Rainfall (liquid precipitation) frequency estimates
- Annual maximum series data for a range of durations
- Related documentation
- Link to relevant NCDC climate data and EPA watershed information, etc.

COMING SOON: Areal-Reduction-Factors
- location, duration and ARI specific ARF curves
- areal estimates calculated for areas delineated on PFDS
3. UNDERLYING DATA

Data collection

For NA14 dta collected from various agencies for improved spatial coverage (46 agencies for MWSE; 24 agencies for NE)

- NOAA, National Climatic Data Center (NCDC)
- Earth Networks
- Environment Canada
- Brno: State Water Survey: National Atmospheric Deposition Program (NADP)
- Mid-Atlantic River Forecast Center: Integrated Flood Observing and Warning System (FLOW) data
- Midwestern Region Climate Center (MRCC): 19th Century Forts and Voluntary Observers Database
- Automated Surface Observing Systems (ASOS)
- Colorado Climate Center: (CoCoRaHS)
- Mount Washington Observatory
- NCDC: U.S. Climate Reference Network (USCRN)
- U.S. Forest Service: Remote Automated Weather Stations (RAWS) dataset
- NCDC: U.S. Climate Reference Network (USCRN)
- National Resources Conservation Service (NRCS): Soil Climate Analysis Network (SCAN)
- New Mexico Department of Transportation
- Office of the New Jersey State Climatologist at Rutgers University: NJ Mesonet
- U.S. Department of Agriculture: Agricultural Research Service (ARS)
- U.S. Army Corps of Engineers local offices
- New York City Department of Environmental Protection (NYCDEP)
- ...
Importance of incorporating recent large events

<table>
<thead>
<tr>
<th>ARI [years]</th>
<th>PF estimate [in]</th>
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<tr>
<td>1000</td>
<td>10.0</td>
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<tr>
<td>1000</td>
<td>12.4</td>
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<tr>
<td>1000</td>
<td>14.3</td>
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<td>16.4</td>
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</table>

Example: Corpus Christi, TX

3. FREQUENCY ANALYSIS METHODS

USGS and NA14: AMS-based regional frequency analysis approach based on L-moment statistics.

NA14 also provides PDS-based estimates.
NA14 AMS quality control

- QC done for all durations; high and low outliers investigated

HIGH OUTLIER EXAMPLE

Example: Royalton SW (21-7157), 1-day (NCDC station)

AMS QC - Low outlier (LO) example

Youngstown, NY (30-9690); 2-day

<table>
<thead>
<tr>
<th>ARI [years]</th>
<th>PF estimate [Hz]</th>
<th>With LO</th>
<th>Without LO</th>
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Testing main assumptions

- Spatial independence

- Stationarity
  - At-station analysis
    - Test for trends in mean: parametric t-test, non-parametric Mann-Kendal test
    - Levene's test for variance homogeneity
    - Investigate spatial patterns
  - Regional analysis:
    - Normalize all AMS in a region
    - Regress against time.
    - Test H0: no serial correlation

6/9/2014
Distribution selection affects estimates significantly

USGS: GLO for 15min – 24hr; GEV for 1day – 7 day (1998)
GLO for 15min – 12hr; GEV for other durations (2004)

NA14: GEV for all durations

In this example, all distributions passed tests!

Distribution selection affects estimates significantly

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NA14: GEV for all durations

In this example, all distributions passed tests!

Summary
NA14 improvement

PRODUCTS
- 3D-arc sec grids (vs cartographic maps)
- interactive Google map for IDF/DDF at any selected location
- confidence intervals
- supplementary information (temporal distribution, ARF, etc.)

UNDERLYING DATA
- additional data sources
- additional 24 years of data
- incorporated recent large events
- improved quality control techniques

FREQUENCY ANALYSIS TECHNIQUES

NOAA Atlas 14. Cost/schedule for TX

- Takes about 3 years to complete
  work can begin when funding is in place
  
- Receipt of funds can be scheduled over 3 years
  TX: $1,057,000 over 3 years ($352,300 per year)

- Project Manager:
  Sanja Perica, lead author for NA14 Vols. 4-10
Thank you!

Extra slides

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Derivation of regional L-moments

**Duration**

- **MAM**
- **MAM/MAM**

**Duration**

- **N.**
- **Q.**

**Derivation**

- **λ**
- **τ**

**MAM/MAM**

- **N.**
- **Q.**
At-station DDF curves – consistency check

USGS: consistency checked in 2004 study

NA14: constrained optimization used to adjust inconsistencies

Confidence limits

USGS: not provided

NA14: 90% confidence intervals (i.e., 5% and 95% confidence limits) algorithm was adjusted to account for inter-station correlation

Interpolation

Starts with derivation of Mean Annual Maxima (MAM) grids at 30 arc-seconds resolution

- Used Oregon State University’s PRISM hybrid statistical-geographic approach for mapping climate data

- Ratios of 2-year PF and MAM and consecutive PFs interpolated and used to estimate PF grids