EVALUATION OF THE 1-DAY, 1%AEP RAINFALL DEPTHS IN OKLAHOMA

Presented by :

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About the Presenter

- **B.S.C.E (2008) Oklahoma State University**

- **Licensed TBPE (2013)**

- **StateTech Engineering (2013)**

- **M.S.C.E. (2015) Texas Tech University (TTU)**

- **Doctorial Student (TTU); anticipated graduation May 2017**

- **Dissertation Topic : Rainfall Statistics/Risk Modeling**

Outline

- **Review 7 Rainfall Studies between (1917-2013) in Oklahoma :**

  "brief synopsis of statistical methods and results"

- **1-Day, 100-yr DDF ; Isopluvial Maps (Precipitation Contours Maps)**

- **Compare 1-Day, 100-yr DDF at County Centroids**

Outline   (Studies)

1. **Miami Conservancy District (1917), T.R. Part V "Storm Rainfall of Eastern United States", (MCD 1917)**

2. **Floods, "Continuation of (MCD 1917)" (Switzer 1929)**

3. **Rainfall Intensity-frequency Data (USDA 1935)**

4. **TP-40 (USWB 1963)**

5. **Southern Region Climate Center, SRCC (1997)**

6. **DDF Precipitation for Oklahoma, (USGS 1999)**

7. **NOAA Atlas 14 Vol 8 Ver 2.0 , (NOAA 2013)**

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Miami Conservancy District, "Storm Rainfall of Eastern United States", Technical Report V (MCD 1917) :

- **First Extreme Rainfall study performed in the U.S.**

- **USWB Daily Rainfall Data (1850-1914) ; ~4,500 locations**

- **Excess Rainfall >=1 in/ Day (PDS)**

- **Aggregated records within 2 –(deg) grids to one record**

- **Calculated probabilities base on % Ranking (eg. 100-yr Freq = 5th largest value in 500 samples)**

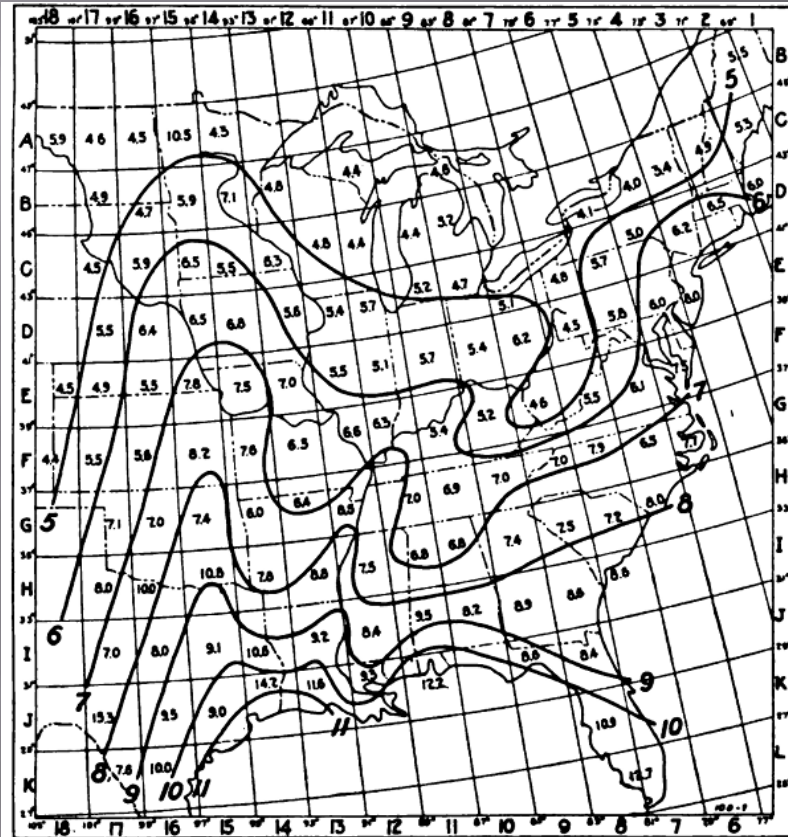TEXAS TECH UNIVERSITY

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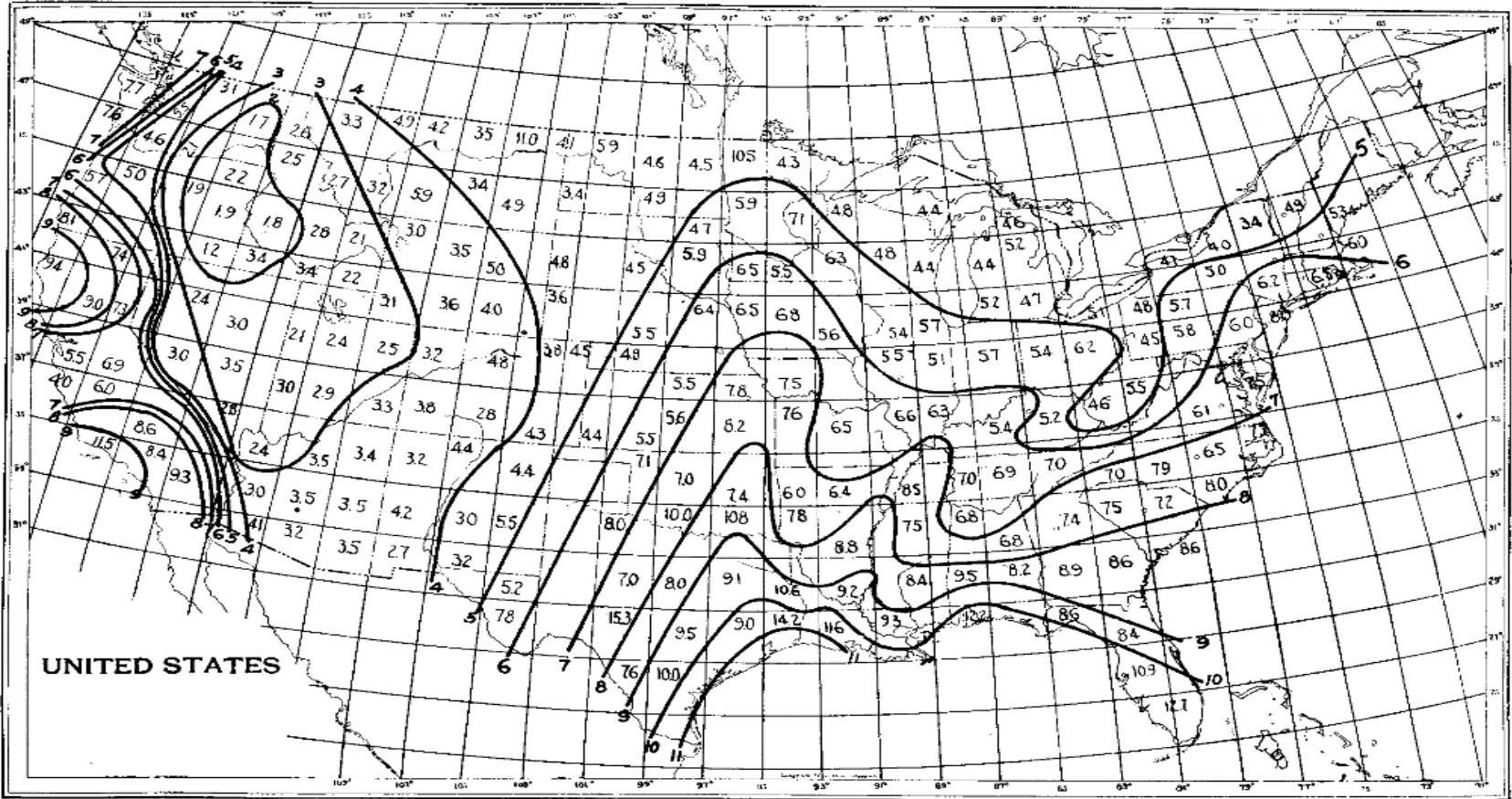FIG. 31.—ISOPLUVIAL CHART FOR 100-YEAR PERIOD AND 1-DAY RAINFALL.

FIG 7 - ISOPLUVIAL CHART - 100 YEAR PERIOD ONE DAY RAINFALL
EAST OF 103° MERIDIAN DATA FROM MIAMI CONSERVANCY DISTRICT

Unites States Department of Agriculture-Misc Publication 24 "Rainfall-Intensity-Frequency Data (USDA 1935) :

- **USWB 5-Min records (1893-1933) , 211 locations**

- **Evaluated Storm Depths ~(28,000 storms)**

- **DDF for (5min-24 hours) , (5-100 year Frequencies)**

- **Extreme Rainfall (PDS) <u>NOT DESCRIBED IN REPORT</u>**

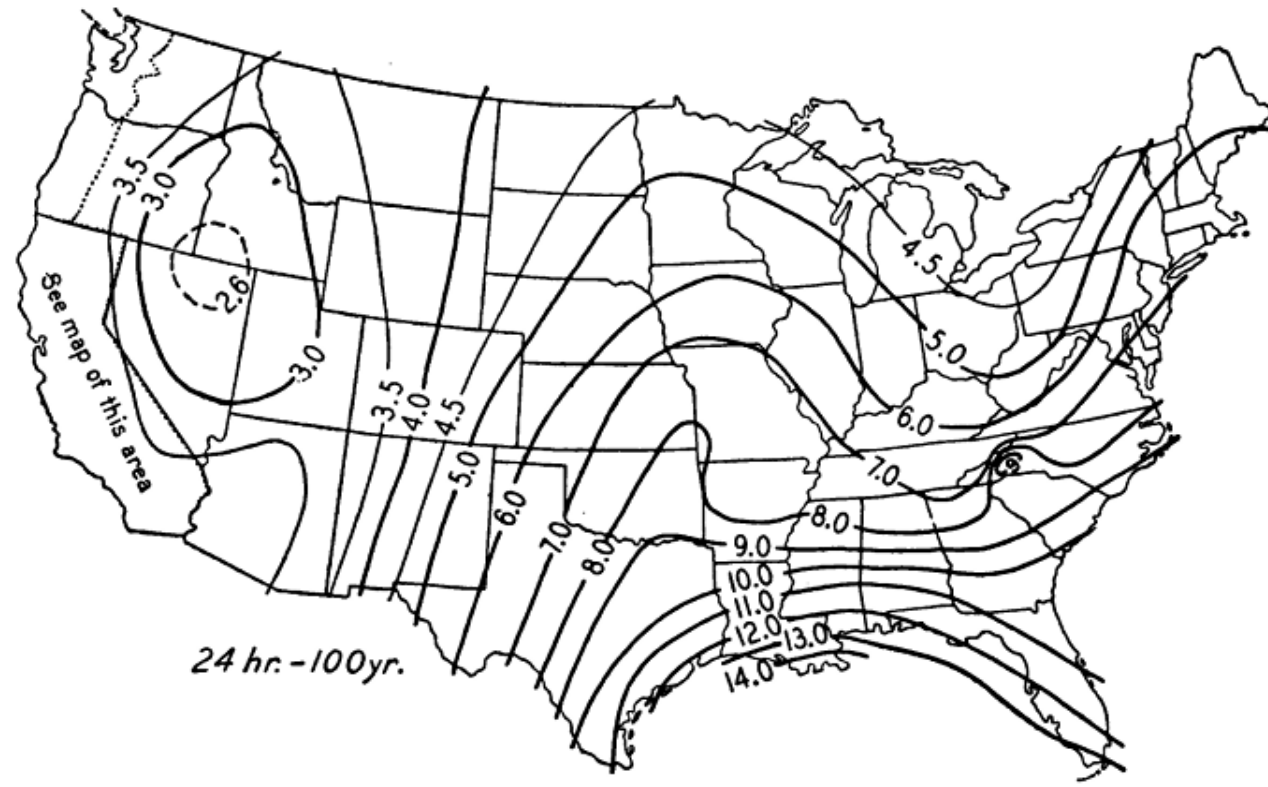- **Used semi-log (Curve fitting) for frequency predictions**

FIGURE 59.—Twenty-four-hour rainfall, in inches, to be expected once in 100 years. (Data for Pacific Coast area are given in fig. 62.)

NOAA –Technical Paper 40-"Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years", (TP40 1963):

- **5,000 stations across the U.S. (min 5 years of record)**

- **Converted (AMS) to (PDS) with ratios**

- **Adjusted Daily Records by 1.13 factor (sample bias)**

- **Gumbel Extreme Value Distribution**

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100-YEAR 24-HOUR RAINFALL (INCHES)
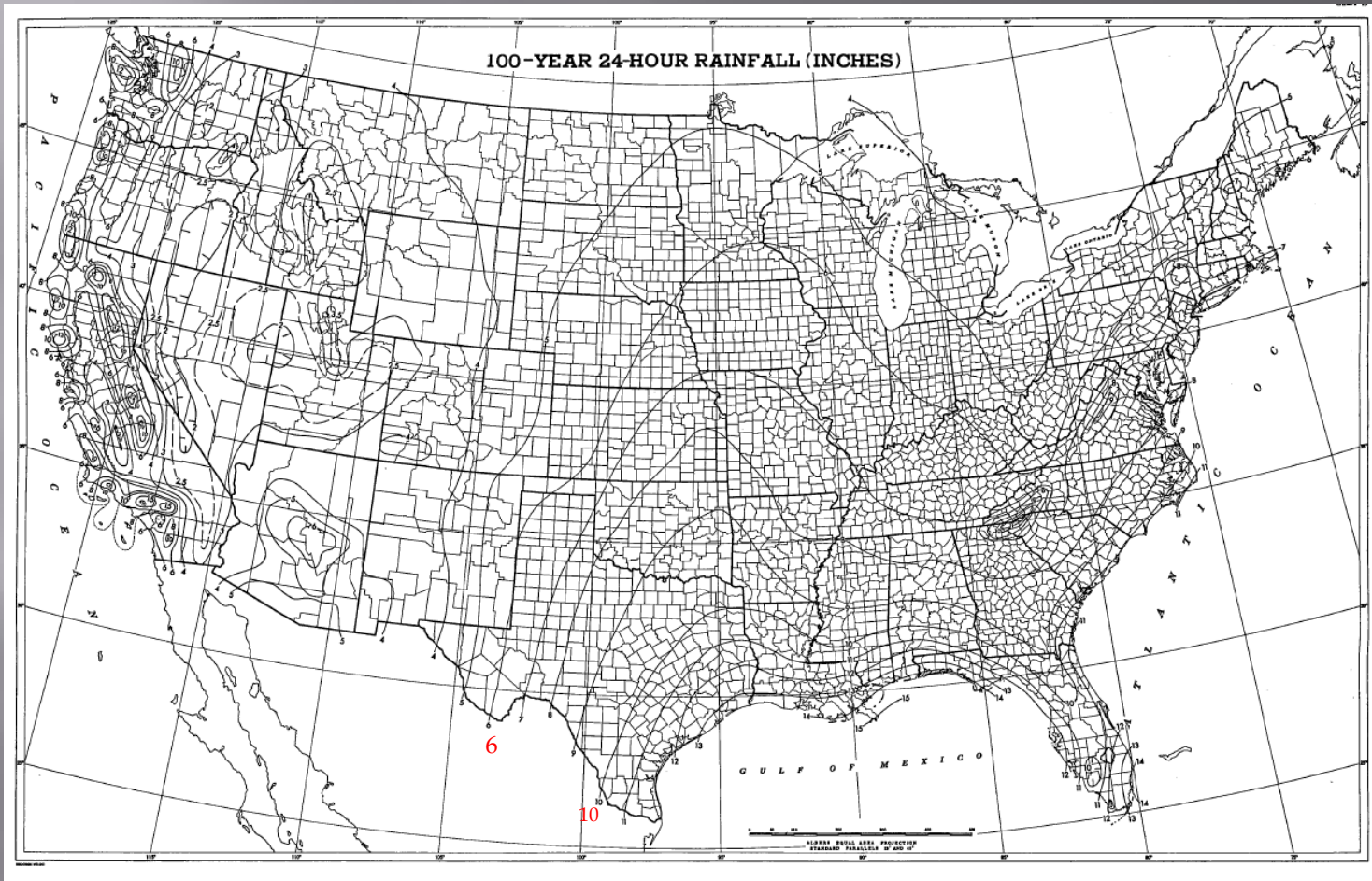
Rainfall Frequency/Magnitude Atlas for the South-Central United States

- **1st order stations , minimum of 35 years; typical range was 1949-1991**

- **Adjusted Daily Records by 1.13 factor (sample bias)**

- **DDF (3hr-24 hr) and (2-100 year) frequencies (PDS)**

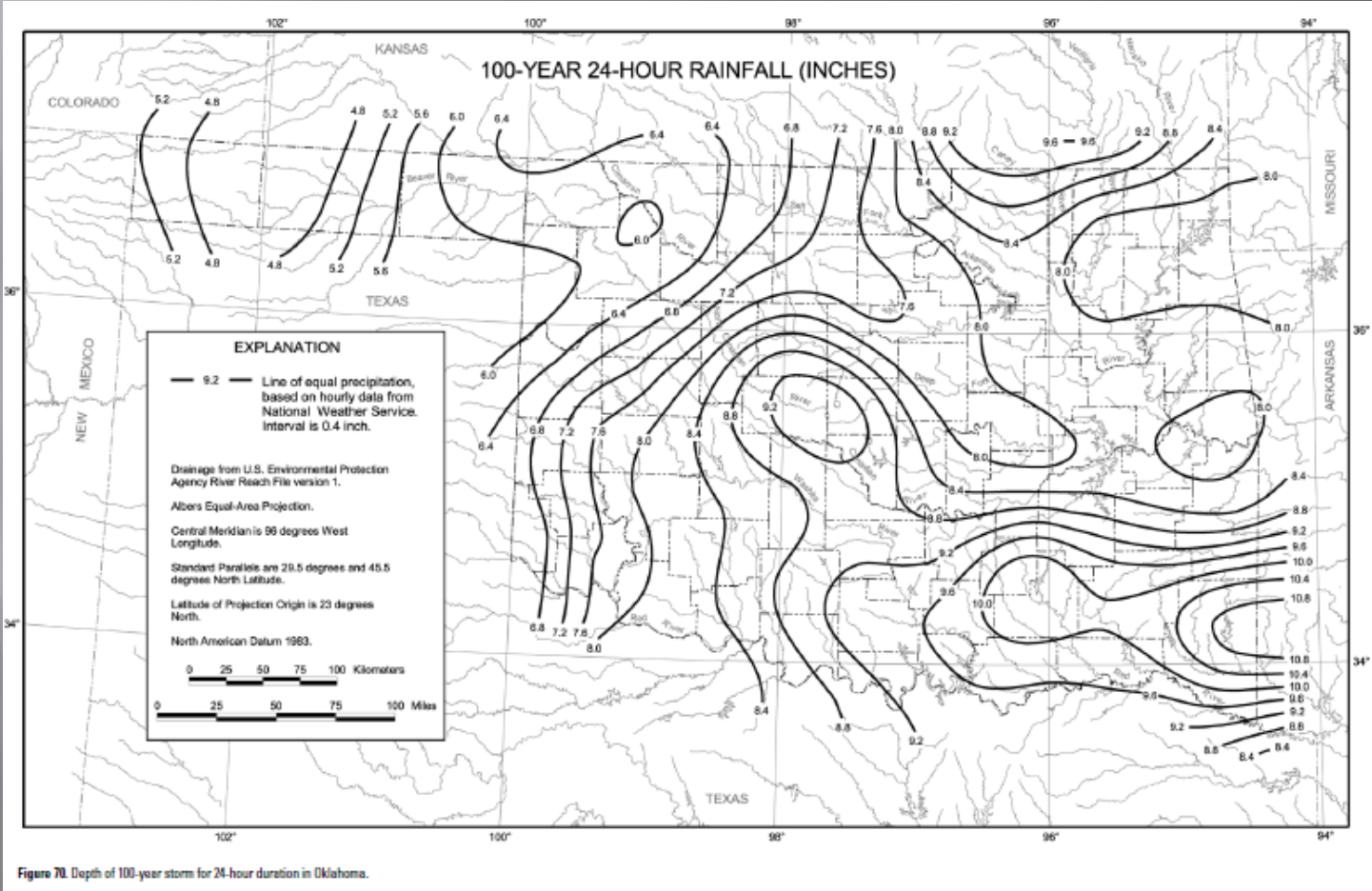- **semi-log regression**

- **Manually drawn isohytes**

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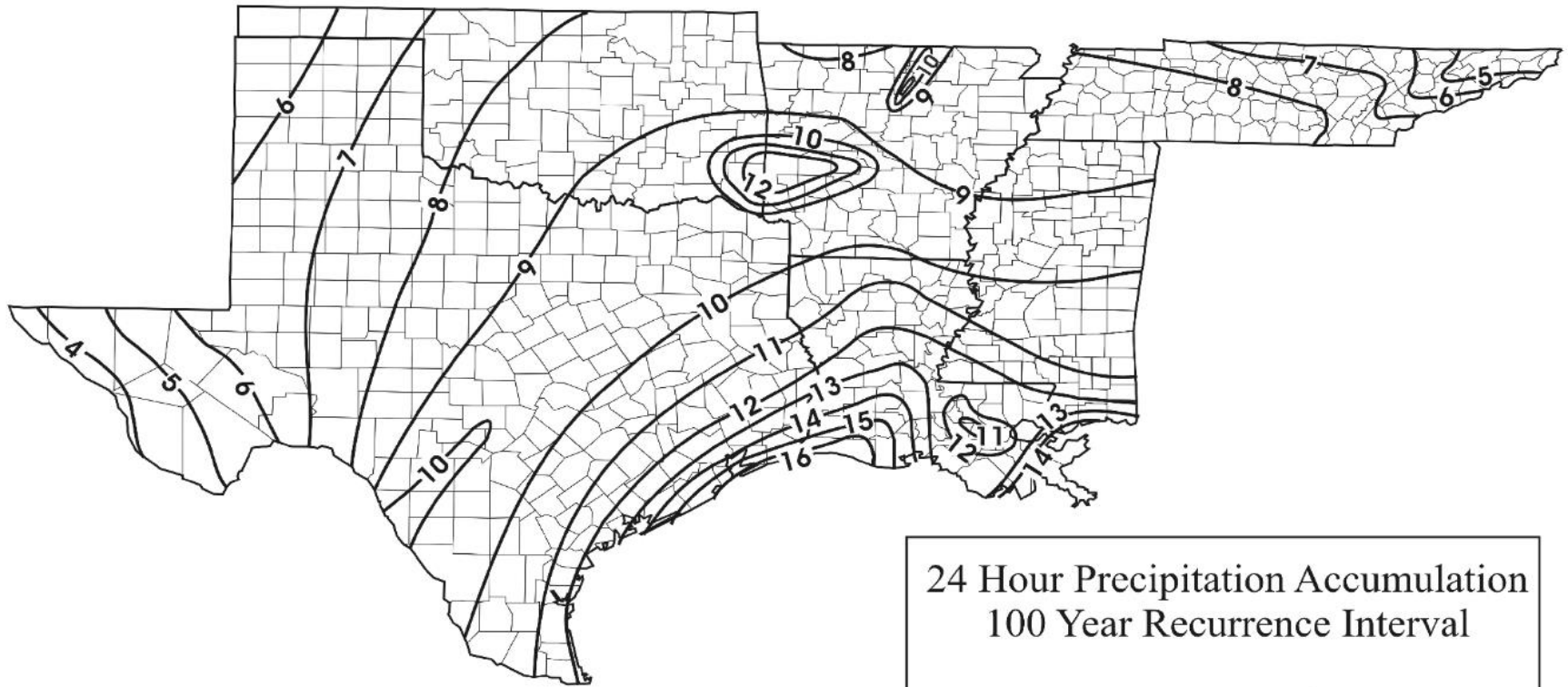
24 Hour Precipitation Accumulation
100 Year Recurrence Interval

contours in inches

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USGS –DEPTH-DURATION FREQUENCY OF PRECIPITATION FOR OKLAHOMA (USGS OK 1999)

- **413 Daily stations (minimum 10 years of record); ~19,200 years of record**

- **Adjusted Daily Records by 1.13 factor (sample bias)**

- **DDF (15min-7Days) and (2-500 year) frequencies (AMS)**

- **L-moment statistics , Generalized Extreme Value (GEV) function**

- **Geospatial statistics (Kriging) 2 km grid size ;~45,000 cells**

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Figure 70. Depth of 100-year storm for 24-hour duration in Oklahoma.

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NOAA Atlas 14 Vol 8 Ver 2.0 for Oklahoma

- **http://hdsc.nws.noaa.gov/hdsc/pfds/**

- **Data up to 2012**

- **DDF(5-min to 60 Day) , (1-1,000) Year) , 90% Confidence intervals**

- **Adjusted Daily Records by 1.13 factor (sample bias)**

- **L-moment statistics, GEV distribution**

- **Geospatial statistics using PRISM (MAR) correlation to 30-(arcsec) grids (~0.25 sqm) or (0.5 X 0.5) miles ; ~250,000 cells**
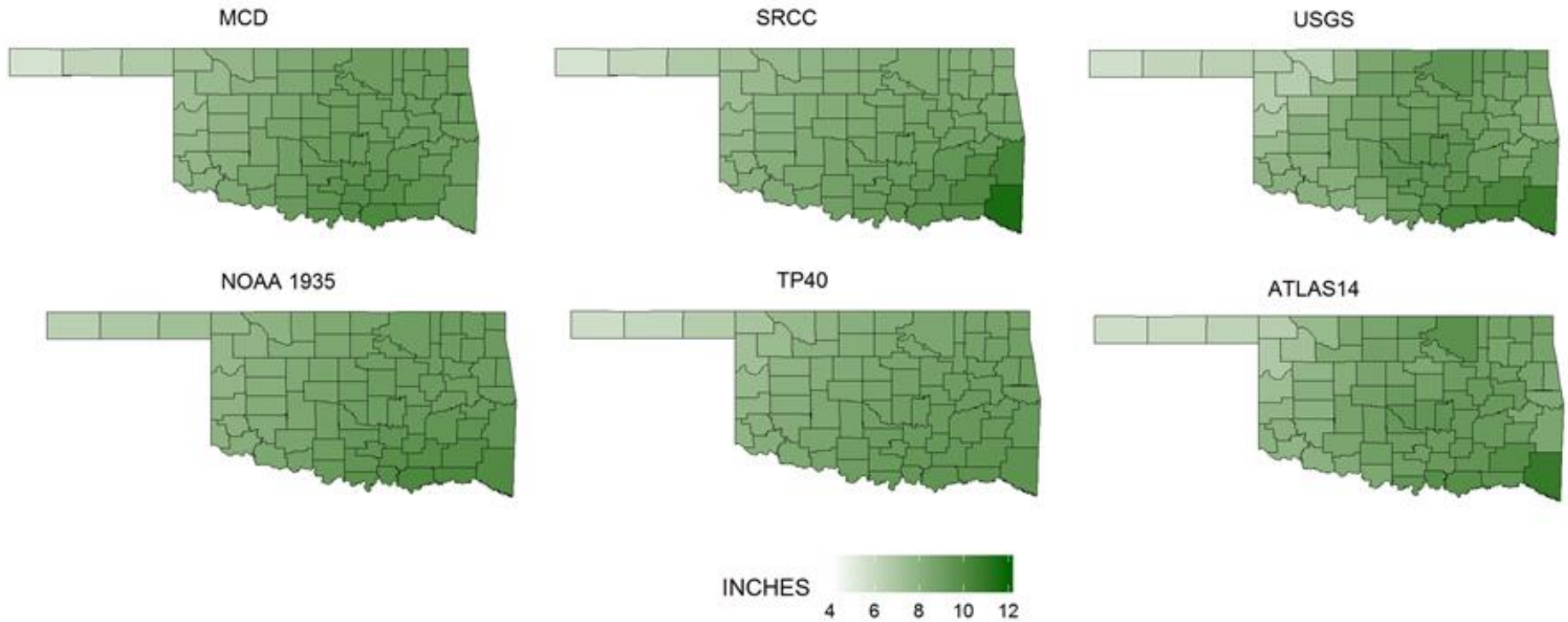
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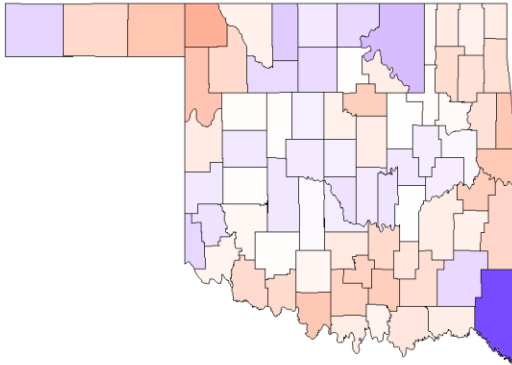ENGINEERING, LLC
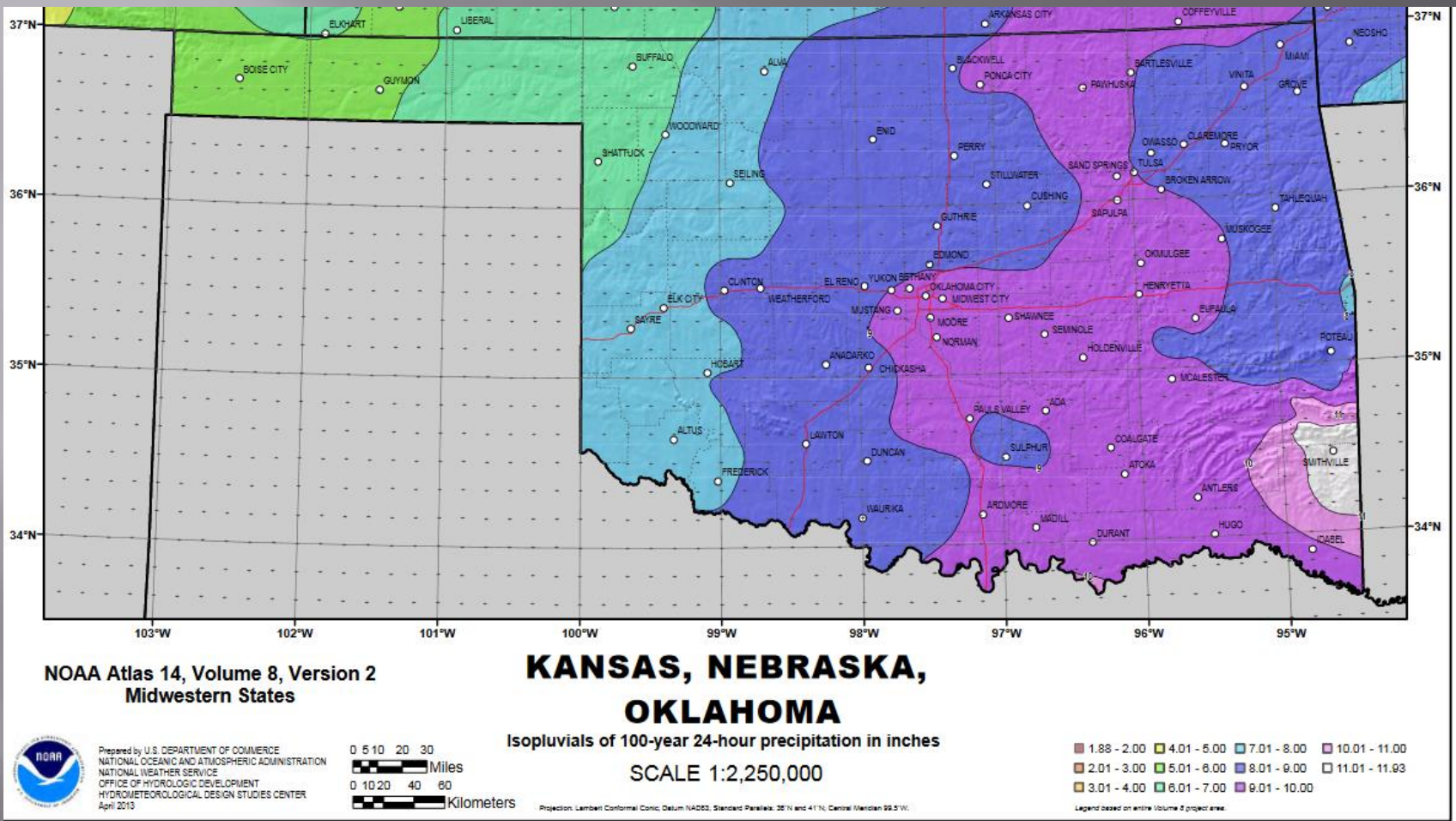
Atlas 14 Comparison

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-Orthorectified/Digitized Data
-Extracted from County Centroid
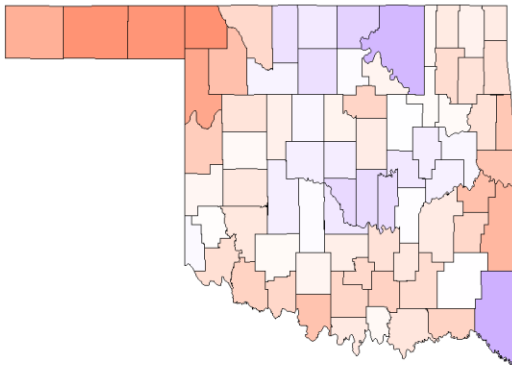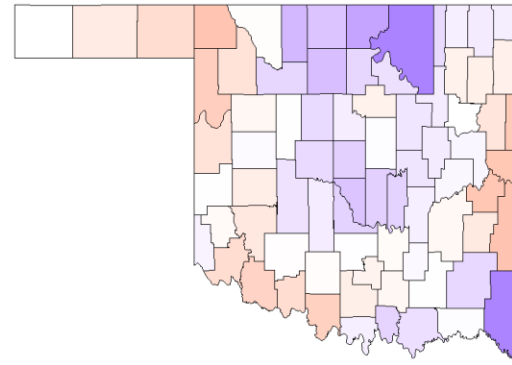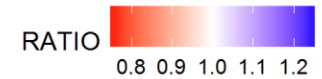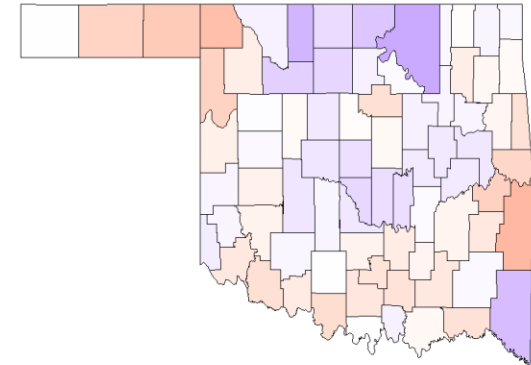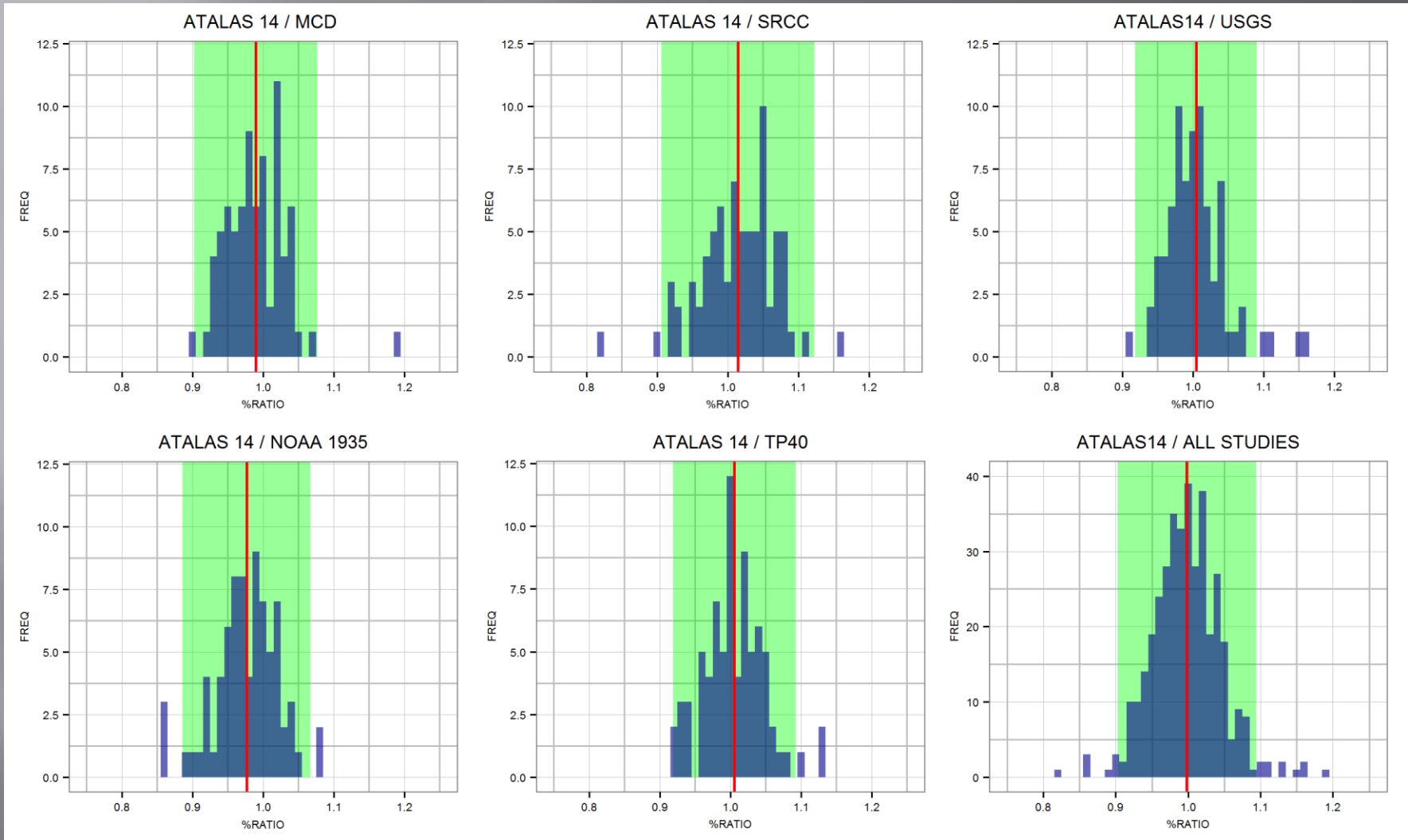
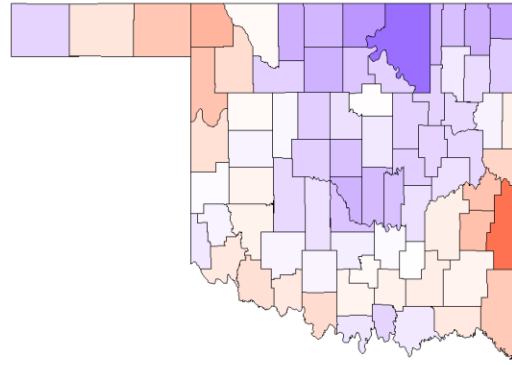## Chisq Test "Goodness of Fit"
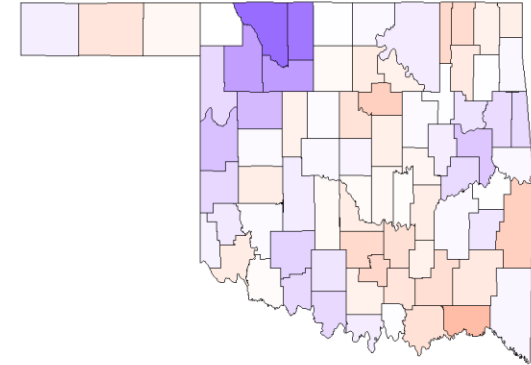
Test	Dist	null	alt	accept	df
chisq test	chisq	Y ind X	Y ! Ind X	< 0.05	76

y	x	Chi-Sqaure		
		Chisq (p-value .05)	value	rank
ATLAS14	all studies	339.6	7.4	-
ATLAS14	MCD	56.9	1.3	3
ATLAS14	NOAA1935	56.9	1.8	4
ATLAS14	TP40	56.9	1.2	2
ATLAS14	SRCC	56.9	2.1	5
ATLAS14	USGS	56.9	1.1	1

Pearson Correlation "linearity"

Test	Dist	null	alt	accept	df
Pearson	T-dist	corr = 0	Cor !=0	< 0.05	75

y	x	Pearson Correlation					
		Cor	95% L	95%U	p-value	T-value	rank
ATLAS14	all studies	0.89	0.87	0.91	~0	-	-
ATLAS14	MCD	0.91	0.86	0.94	~0	18.6	4
ATLAS14	NOAA1935	0.91	0.86	0.94	~0	19.2	2
ATLAS14	TP40	0.91	0.86	0.94	~0	18.9	3
ATLAS14	SRCC	0.86	0.78	0.91	~0	14.4	5
ATLAS14	USGS	0.94	0.92	0.97	~0	25.7	1

Student Test "Population Mean"

Test	Dist	null	alt	accept	df
μy-μx	T-dist	diff is = 0	diff !=0	> 0.05	76

y	x	Paired T-Test					
		delta μ	95% Delta L	95% delta U	p-value	T-value	rank
ATLAS14	all studies	-0.02	-0.06	0.02	0.32	-	-
ATLAS14	MCD	-0.09	-0.18	-0.01	0.04	-2.13	3
ATLAS14	NOAA1935	-0.19	-0.28	-0.11	~0	-4.52	5
ATLAS14	TP40	0.05	-0.03	0.14	0.21	1.27	2
ATLAS14	SRCC	0.12	0.01	0.22	0.03	2.16	4
ATLAS14	USGS	0.01	-0.06	0.09	0.73	0.35	1

Var Test "Ratio of Variances"

Test	Dist	null	alt	accept	df
vy = vx	F-dist	var r= 1	var r !=1	> 0.05	76

y	x	Var-Test					
		v ratio	95% L	95%U	p-value	F-value	rank
ATLAS14	all studies	1.07	0.88	1.31	0.50	-	-
ATLAS14	MCD	1.12	0.71	1.76	0.63	1.12	2
ATLAS14	NOAA1935	1.51	0.96	2.38	0.07	1.51	5
ATLAS14	TP40	1.38	0.88	2.17	0.16	1.38	4
ATLAS14	SRCC	1.05	0.67	1.64	0.84	1.05	1
ATLAS14	USGS	0.74	0.47	1.16	0.19	0.74	3

"Overall Score" summation of Rank

Study	chi-sq test	t-test	var-test	pearson	total	rank
MCD	3	3	2	4	12	3
NOAA1935	4	5	5	2	16	5
TP40	2	2	4	3	11	2
SRCC	5	4	1	5	15	4
USGS	1	1	3	1	6	1

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Atlas 14 Study Comparison
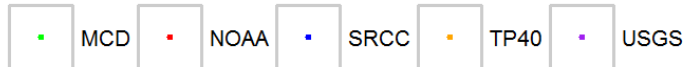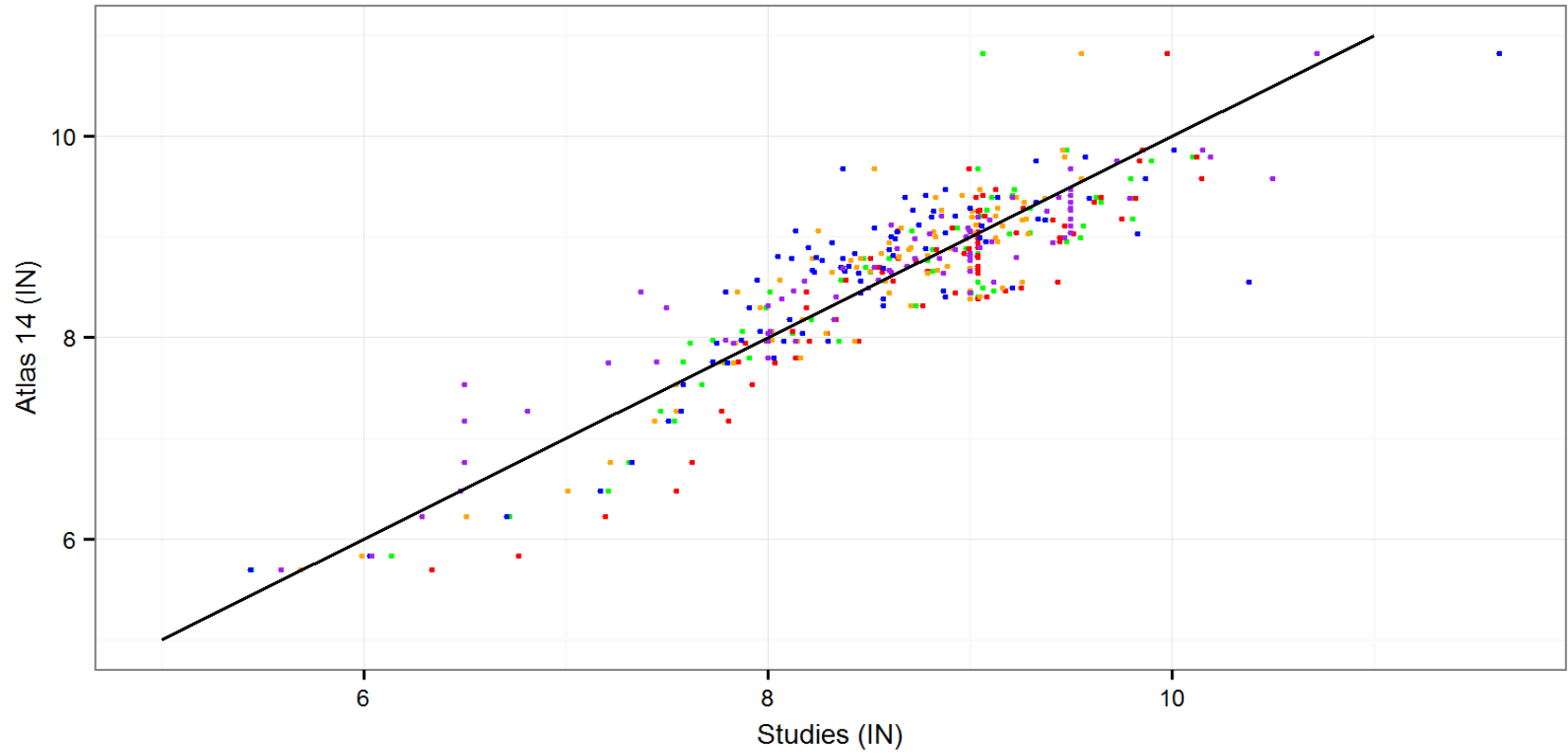
Overall Model

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.63597    0.20674   3.076  0.00225 **
DEPTH        0.92396    0.02383  38.766  < 2e-16 ***
```

Overall Model "0 Intercept"

```
Coefficients:
      Estimate Std. Error t value Pr(>|t|)
DEPTH 0.996919   0.002375   419.8  <2e-16 ***
```

Study Specific "0 Intercept"

```
Coefficients:
          Estimate Std. Error t value Pr(>|t|)
STUDYMCD  0.989716   0.005248   188.6  <2e-16 ***
STUDYNOAA 0.976696   0.005248   186.1  <2e-16 ***
STUDYSRCC 1.014611   0.005248   193.3  <2e-16 ***
STUDYTP40 1.005712   0.005248   191.6  <2e-16 ***
STUDYUSGS 1.004470   0.005248   191.4  <2e-16 ***
---
```

Study Specific "same slope"

```
Coefficients:
          Estimate Std. Error t value Pr(>|t|)
DEPTH     0.93955    0.02335  40.242  < 2e-16 ***
STUDYMCD  0.43459    0.20796   2.090  0.03730 *
STUDYNOAA 0.33794    0.21031   1.607  0.10891
STUDYSRCC 0.62952    0.20323   3.098  0.00210 **
STUDYTP40 0.57144    0.20464   2.792  0.00550 **
STUDYUSGS 0.53337    0.20556   2.595  0.00983 **
```

Study Specific "with Intercept"

```
Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
STUDYMCD          0.27096    0.44991   0.602  0.54736
STUDYNOAA        -1.25998    0.52931  -2.380  0.01779 *
STUDYSRCC         1.15895    0.42589   2.721  0.00681 **
STUDYTP40        -0.52111    0.49120  -1.061  0.28942
STUDYUSGS         1.61187    0.36231   4.449 1.14e-05 ***
DEPTH:STUDYMCD    0.95835    0.05146  18.624  < 2e-16 ***
DEPTH:STUDYNOAA   1.12101    0.05991  18.712  < 2e-16 ***
DEPTH:STUDYSRCC   0.87723    0.04987  17.589  < 2e-16 ***
DEPTH:STUDYTP40   1.06722    0.05718  18.665  < 2e-16 ***
DEPTH:STUDYUSGS   0.81411    0.04184  19.458  < 2e-16 ***
```

Study Specific "same Intercept"

```
Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.51776    0.20293   2.551  0.0111 *
DEPTH:STUDYMCD    0.93026    0.02365  39.327  <2e-16 ***
DEPTH:STUDYNOAA   0.92047    0.02344  39.274  <2e-16 ***
DEPTH:STUDYSRCC   0.95193    0.02421  39.325  <2e-16 ***
DEPTH:STUDYTP40   0.94676    0.02409  39.297  <2e-16 ***
DEPTH:STUDYUSGS   0.93957    0.02383  39.434  <2e-16 ***
```
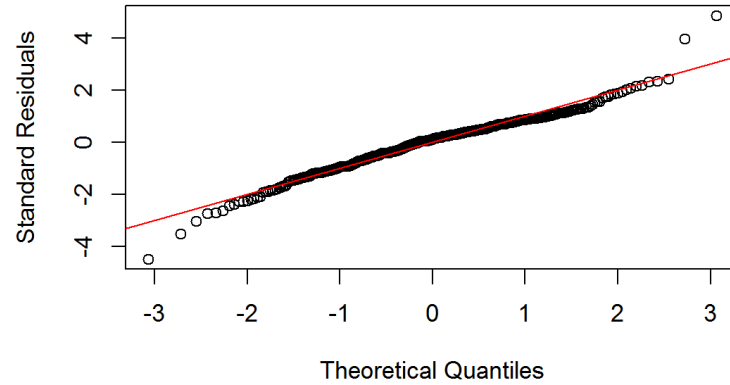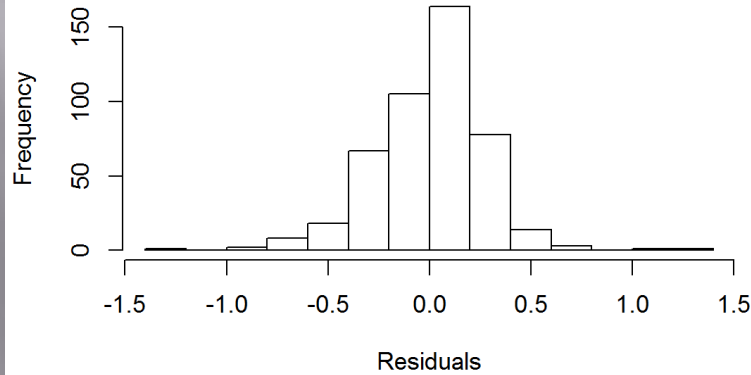
*   P value < 0.05
**   P value < 0.01
*** P value < 0.001

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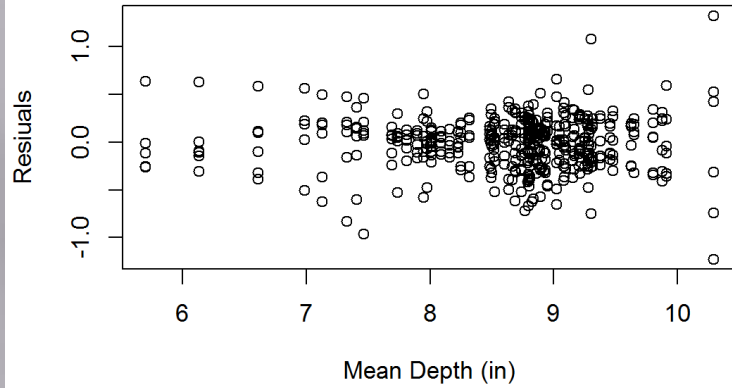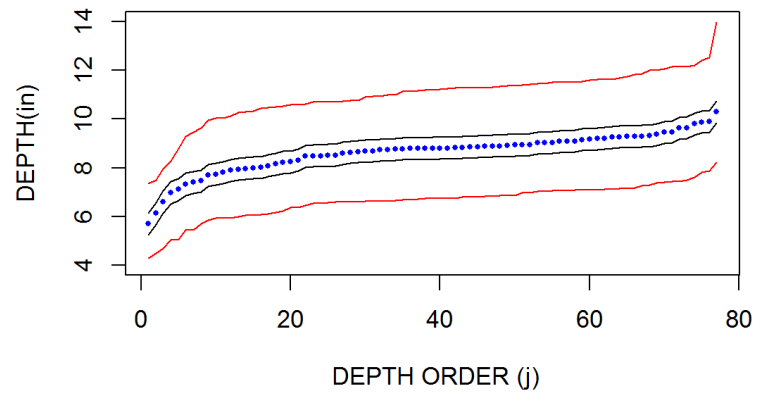
- **Studies compared to Atlas 14: USGS, TP40, MCD, SRCC, NOAA1935 (slide 18)**

- **All (5) studies are <2% different on average to Atlas 14 (slide 17, 19 ,20)**

- **All (5) studies are within +/- 10 % difference at 2x sd ~95% (slide 17)**

- **90% Confidence interval of the mean for all studies is << 90% CI Atlas 14 (slide 21)**

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1) Asquith, W. (1998); "Depth-Duration Frequency of Texas"; U.S. GEOLOGICAL SURVEY.

2) Asquith, W., & Roussel, M. (2004); "Atlas of Depth-Duration Frequency of Texas Annual Maxima"; U.S. Geological Survey.

3) Hershfield, D. M. (1963);"Rainfall Frequency Atlas of the United States for Durations from 30 Minutes   to 24 Hours and return Periods from 1 to 100 Years"; United States Weather Bureau.

4) Kite, G. (1977); "Frequency and Risk Analyses in Hydrology"; Water Resources Publications.

5) Lowry, R. (1934); "Excessive Rainfall in Texas Bulletin No. 25"; State Reclamation District.

6) Morgan, A. (1917); "Storm Rainfall of Eastern United States, Technical Report Part ";The State of Ohio Miami Conservancy District.

7) Perica, S. ; et al. (2013); "Precipitation-Frequency Atlas , NOAA Atlas 14"; NOAA.

8) Switzer, F. (1929); "Floods"; Sibley Journal of Engineering, 362-366.

9) Tortorelli, R., Rea, A., & Asquith, W. (1999); "Depth-Duration Frequency of Precipitation for Oklahoma"; U.S. GEOLOGICAL SURVEY.

10) Williams, B. (1929); "A Study of Rainfall in Texas Bulletin No. 1"; State Reclamation District.

11) Yarnell, D. (1935); "Rainfall Intensity Frequency Data". United States Department of Agriculture

12) Faiers, G.E.; Keim, B.D.; Muller, R.A.; "Rainfall Frequency/Magnitude Atlas for the South-Central United States", SRCC Technical Paper;(1997)

Questions?

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