#249

Extreme Rainfall in Florida: Local Climatologies Revisited

(Using Climate Data to Identify Risk: Preliminary Results)

Preston Leftwich and James J. O'Brien
Center for Ocean-Atmospheric Prediction Studies
Florida State University, Tallahassee, Florida

I. Introduction

Extreme meteorological events are a normal behavior of the Earth's climate. One of these events, extreme rainfall, has its primary impact in regional and local areas. Climatology of rainfall (runoff) can help identify areas of higher risk of floods, flash floods and crop damage. This study focuses on local climatology to identify risk associated with 24h and 48h periods. Examples of applications of results are demonstrated.

II. Data

- NCDC Daily Surface Data
- WBAN and Cooperative Network stations
- Florida Climate Center archive
- Period: 1948 – 2008
- Daily precipitation totals
- Focus on 24h and 48h rainfall in Florida
- Consider annual maximum values, partial duration values, and frequency spectra of one-day and two-day rainfall.

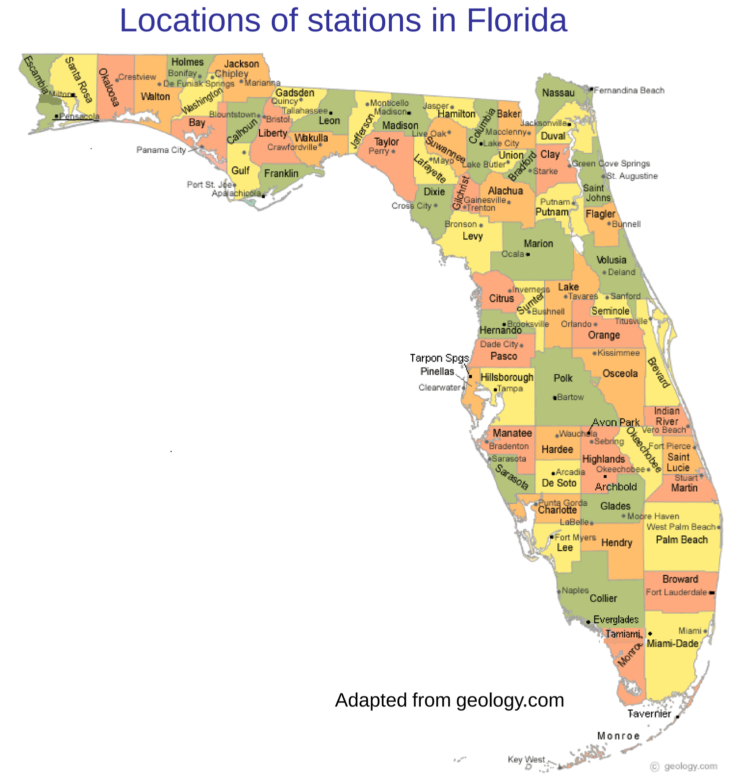
III. Procedures

1. Rainfall frequency spectra (Stephens et al. 2003)

Upper Quantiles of Observed Rainfall (in)

		1-Day			2-Day	
Station	**75%**	**95%**	**Max**	**75%**	**95%**	**Max**
Apalachicola	.72	2.10	10.67	.93	2.66	13.87
Arcadia	.70	1.90	7.38	.96	2.29	9.03
Archbold Bio Stat	.60	1.76	6.07	.85	2.26	6.05
Avon Park	.61	1.73	9.04	.86	2.22	9.35
Bartow	.64	1.80	6.75	.87	2.28	8.05
Brooksville	.65	1.90	10.22	.90	2.36	18.42
Everglades	.61	1.80	10.09	.86	2.30	13.62
Fernandina Beach	.59	1.77	22.02	.80	2.24	22.35
Fort Lauderdale	.60	1.88	14.59	.86	2.55	15.79
Fort Myers	.65	1.85	7.78	.91	2.37	10.94
Jacksonville	.58	1.72	10.13	.80	2.24	12.45
Lake City	.59	1.74	7.90	.82	2.21	10.30
Madison	.63	1.78	8.93	.85	2.24	10.34
Milton	.75	2.01	12.08	.99	2.60	16.98
Ocala	.58	1.67	11.72	.82	2.11	11.76
Pensacola	.73	2.12	11.68	.98	2.72	15.45
Tallahassee	.71	2.02	8.86	.95	2.55	13.09
Tampa	.58	1.68	11.45	.79	2.09	13.96
Tarpon Springs	.62	1.84	11.09	.83	2.36	13.70
Tavernier	.59	1.87	13.79	.78	2.40	14.81

Locations of stations in Florida



Adapted from geology.com

2. Extremes

- **Variability of rainfall greatest in observed maxima; focus on risk from extremes.**
- **For extreme quantile calculations, convert observed one-day and two-day rainfall to x-hr values: One-day to 24h: 1.13; Two-day to 48h: 1.05 (per Huff and Angel 1992).**
- **Fit Generalized Extreme Value (GEV) Distributions whose moments are derived via L-moments:**

GEV pdf: $$f(x) = \frac{1}{\sigma_X}\left[1+E\left(\frac{x-\mu_X}{\sigma_X}\right)\right]^{-\left(1+\frac{1}{E}\right)} \exp\left\{-\left[1+E\left(\frac{x-\mu_X}{\sigma_X}\right)\right]^{-\frac{1}{E}}\right\}$$

L-moments (Hosking 1990) defined in terms of linear combinations of order statistics.

μ_X is the location parameter; σ_X is a scale parameter; E is a shape parameter {E = 0 (Gumbel); E > 0 (Frechet); E < 0 (Weibull)}

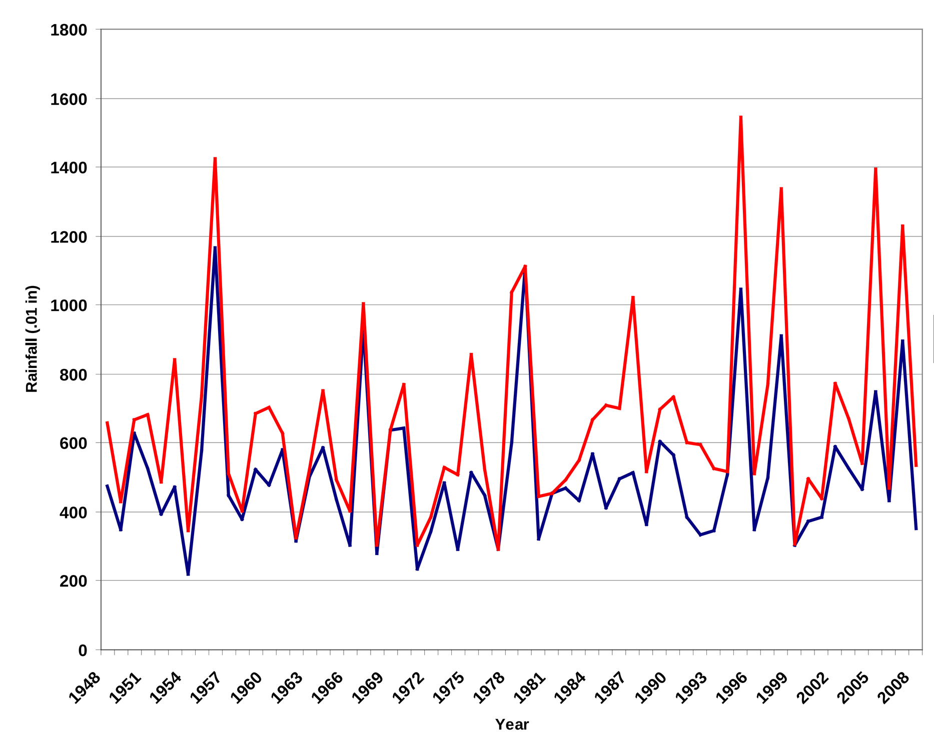
Return Period is the inverse of the annual probability of occurrence:
F(xT) = 1 – 1 / T ; T = period

GEV Quantile function:

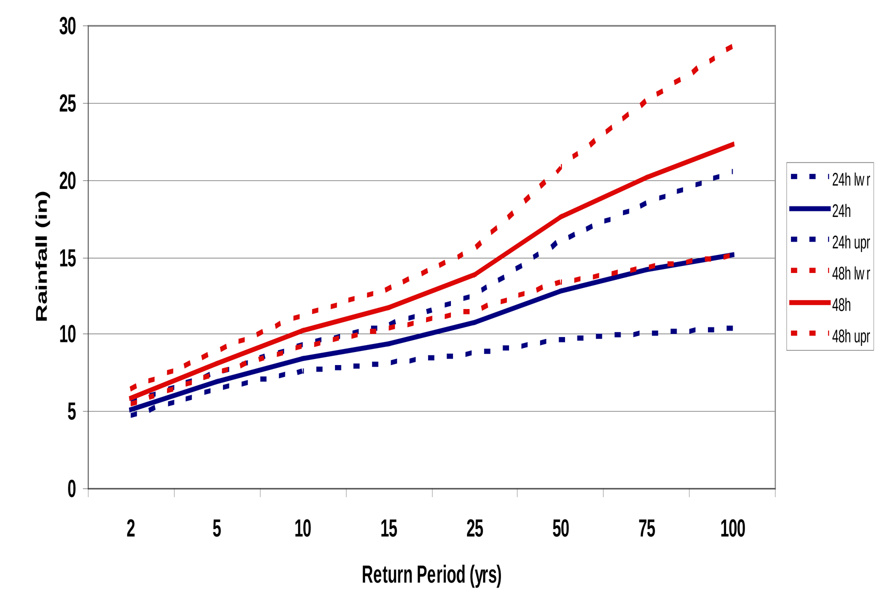
$$xT = \mu_X - \frac{\sigma_X}{E}\left[1-\left\{-\log\left(1-\frac{1}{T}\right)\right\}^{-E}\right]$$

IV. Risk of Extreme Rainfall at Local Sites

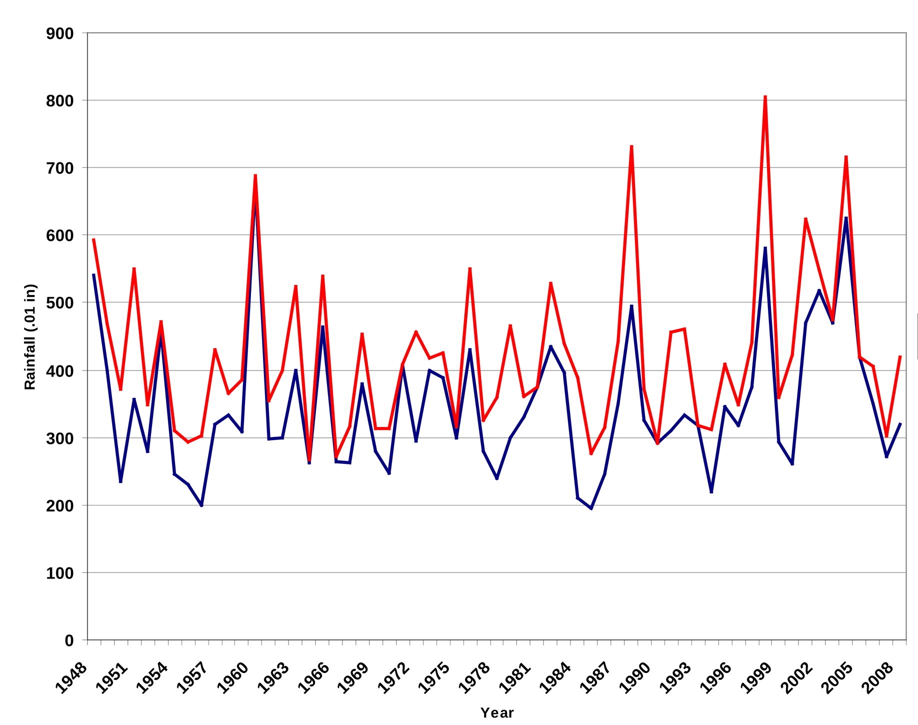
1. Compute quantiles, Q_i , for various return periods from GEV distributions fitted to original samples. Convert one- and two-day rainfall to 24h and 48h amounts.



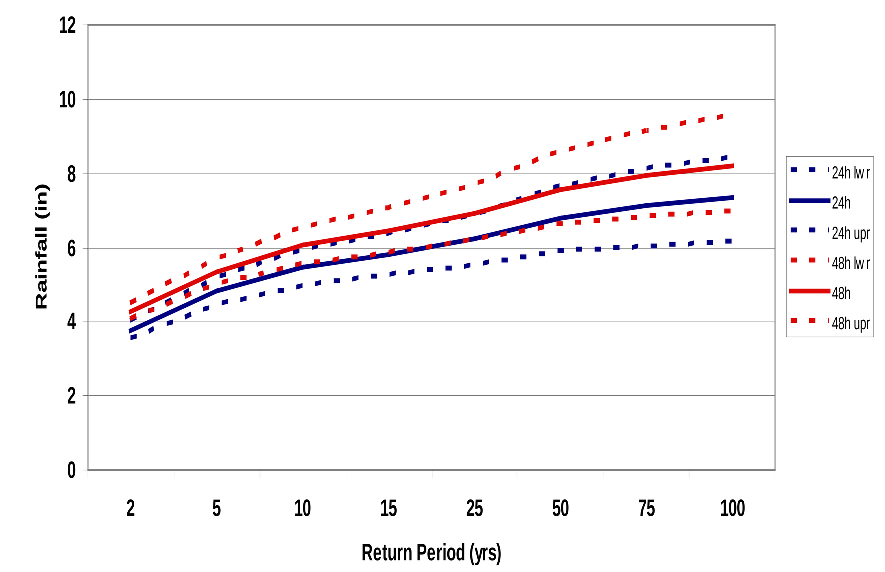
Annual Maximum One- and Two-Day Precipitation at Pensacola.



Confidence Intervals (95%) for Annual Maximum 24h and 48h Rainfall at Pensacola



Annual Maximum One- and Two-Day Precipitation at Bartow



Confidence Intervals (95%) for Annual Maximum 24h and 48h Rainfall at Bartow

2.Use balanced resampling procedure to calculate 95% confidence intervals for extreme rainfall quantiles (Burn 2003). For this study, distributions of various quantiles were calculated via permutation of 500 random samples.

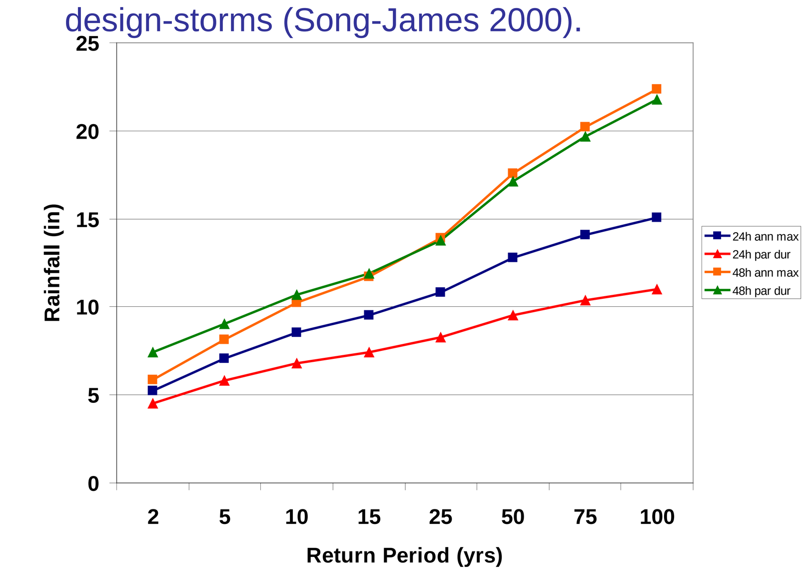
3. Calculate a risk index (after Hogue et al. 1997). Use 100-yr (i = 100) quantiles, Q_{48i} and Q_{24i}, and upper confidence limits, L_{48Ui} and L_{24Ui} . The goal is to reflect degree of hazard addressed by including 48h amounts in assessments. Risk Index, $RI_i = HF_i \times VF_i$, where HF_i is a hazard factor and VF_i is vulnerability factor, given by:

$$HF_i = Q_{48i} - Q_{24i} \qquad VF_i = L_{48U_i} - L_{24U_i}$$

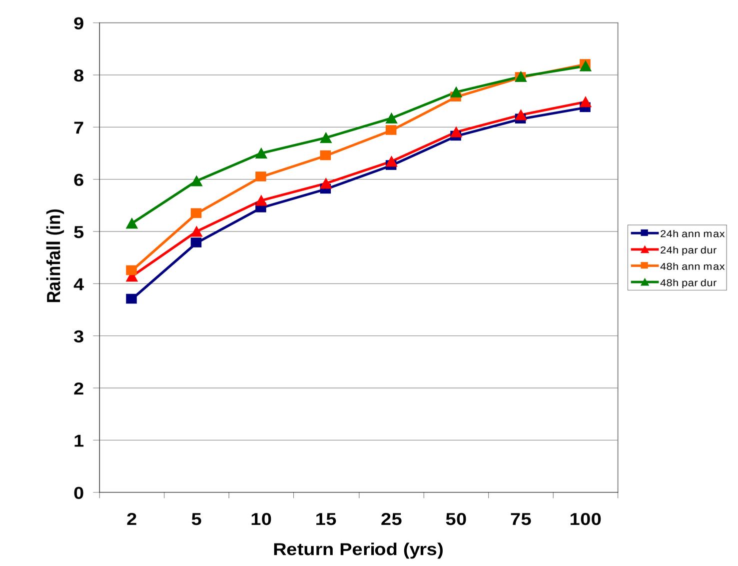
Station	RI	Station	RI	Station	RI	Station	RI
Apalachicola	0.3	Brooksville	43.6	Jacksonville	27.3	Pensacola	58.1
Arcadia	2.5	Everglades	45.4	Lake City	10.0	Tallahassee	4.3
Archbold BioStat	0.4	Fernandina Bch	10.9	Madison	2.9	Tampa	6.6
Avon Park	0.1	Fort Lauderdale	1.9	Milton	31.8	Tarpon Springs	17.5
Bartow	1.0	Fort Myers	8.8	Ocala	1.1	Tavernier	0.3

V. Revisted Applications

1. Consider combined results from annual maximum and partial duration data; as used in design-storms (Song-James 2000).

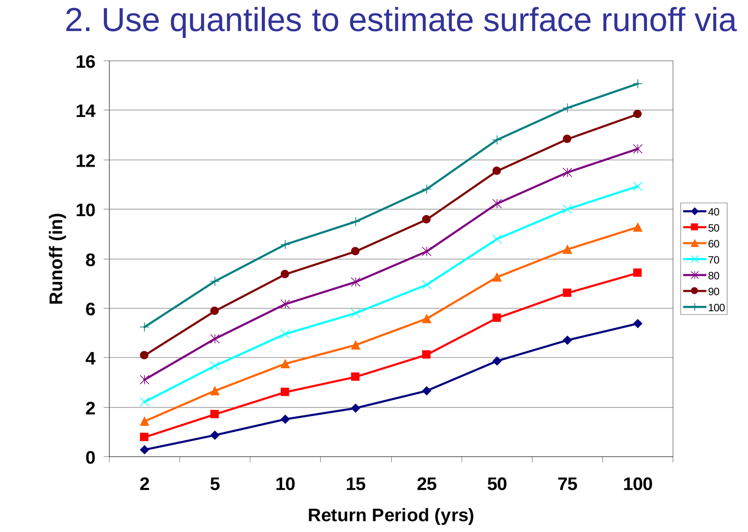


Quantiles of extreme rainfall at Pensacola.

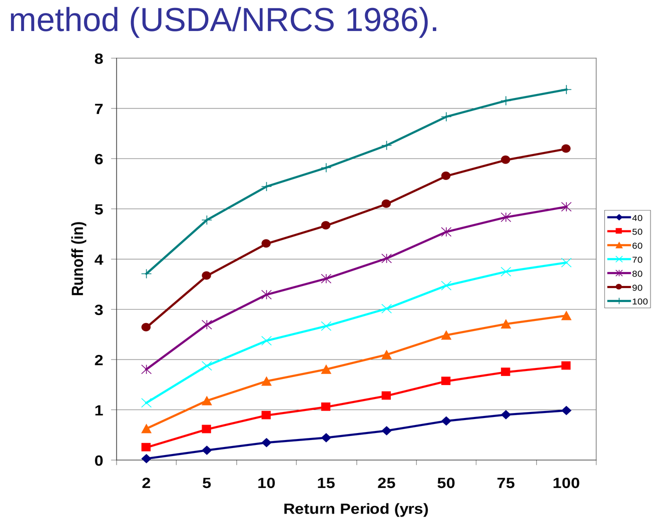


Quantiles of extreme rainfall at Bartow.

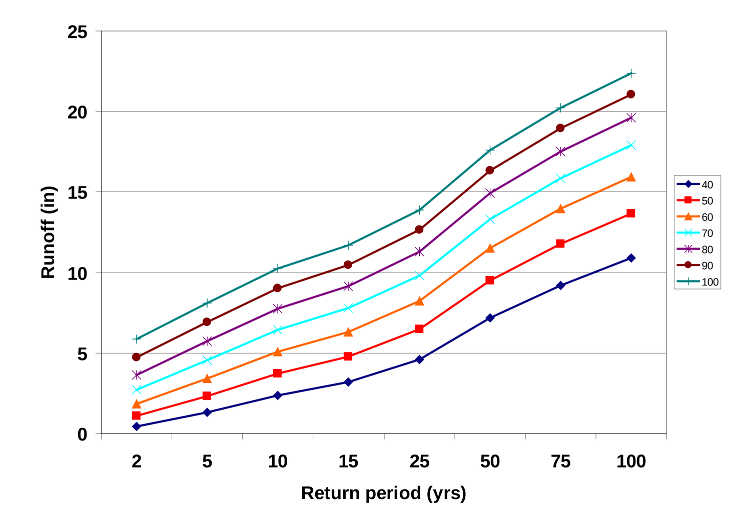
2. Use quantiles to estimate surface runoff via NRCS method (USDA/NRCS 1986).



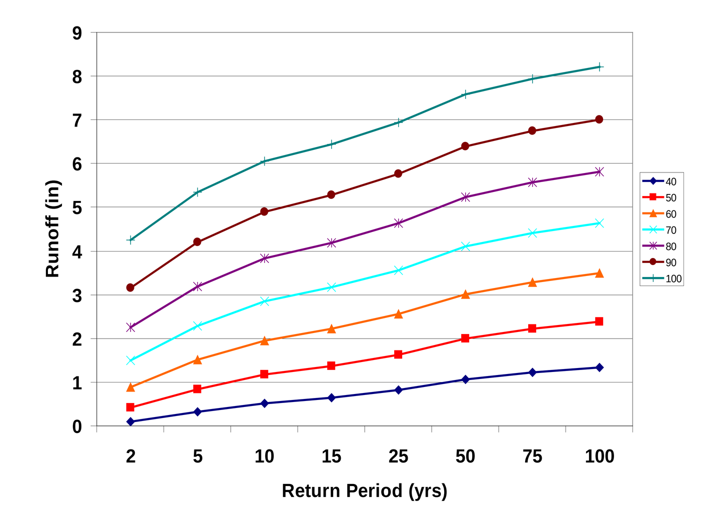
Quantiles of 24h surface runoff at Pensacola.



Quantiles of 24h surface runoff at Bartow.



Quantiles of 48h surface runoff at Pensacola.



Quantiles of 48h surface runoff at Bartow.

VI. Summary

1. Rainfall frequency spectra indicate greatest variability in local one-day and two-day maxima. This supports local focus on extremes. Other quantiles are more suitable for regional application.
2. Differences between annual maximum one-day and two-day rainfall vary yearly and among Florida stations, suggesting variability of risk in 48h versus 24h. A Risk Index quantifies such variability in risk of extreme rainfall.
3. Higher values of the Risk Index suggest consideration of potential for 48h, as well as 24h, extreme rainfall in runoff risk assessment. The impact of tropical cyclones is evident at several coastal stations, but not all. This further supports consideration of local climatologies.
4. Combined use of annual maximum and partial duration rainfall may produce more representative design-storm criteria and surface runoff risk estimates.

VII. References

1. Burn, D. H., 2003: The use of resampling for estimating confidence intervals for single site and pooled frequency analysis.
2. Hogue, M. M. et al., 1997: Storm surge flooding in Chittagong city and associated risks.
3. Hosking, J.R.M, 1990: L-moments: Analysis and estimation of distributions…
4. Huff, F.A. and J.R. Angel, 1992: **Rainfall Frequency Atlas for the Midwest**.
5. Song-James, Z., 2000: Use of Design Storm Criteria in Florida.
5. USWB: **Technical Reports 40** (1961) and **49** (1964).
7. Stephens, K.A., et al., 2003: Re-inventing urban hydrology in British Columbia: Runoff volume management for watershed protection.
8. USDA/NRCS, 1986: **Urban Hydrology for Small Watersheds**. TR-55.
(Complete reference list available upon request)