Regional Precipitation-Frequency Analysis And Extreme Storms Including PMP Current State of Understanding/Practice

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What's the Status of Regional Precipitation-Frequency Analysis for Use with Extreme Storms ?

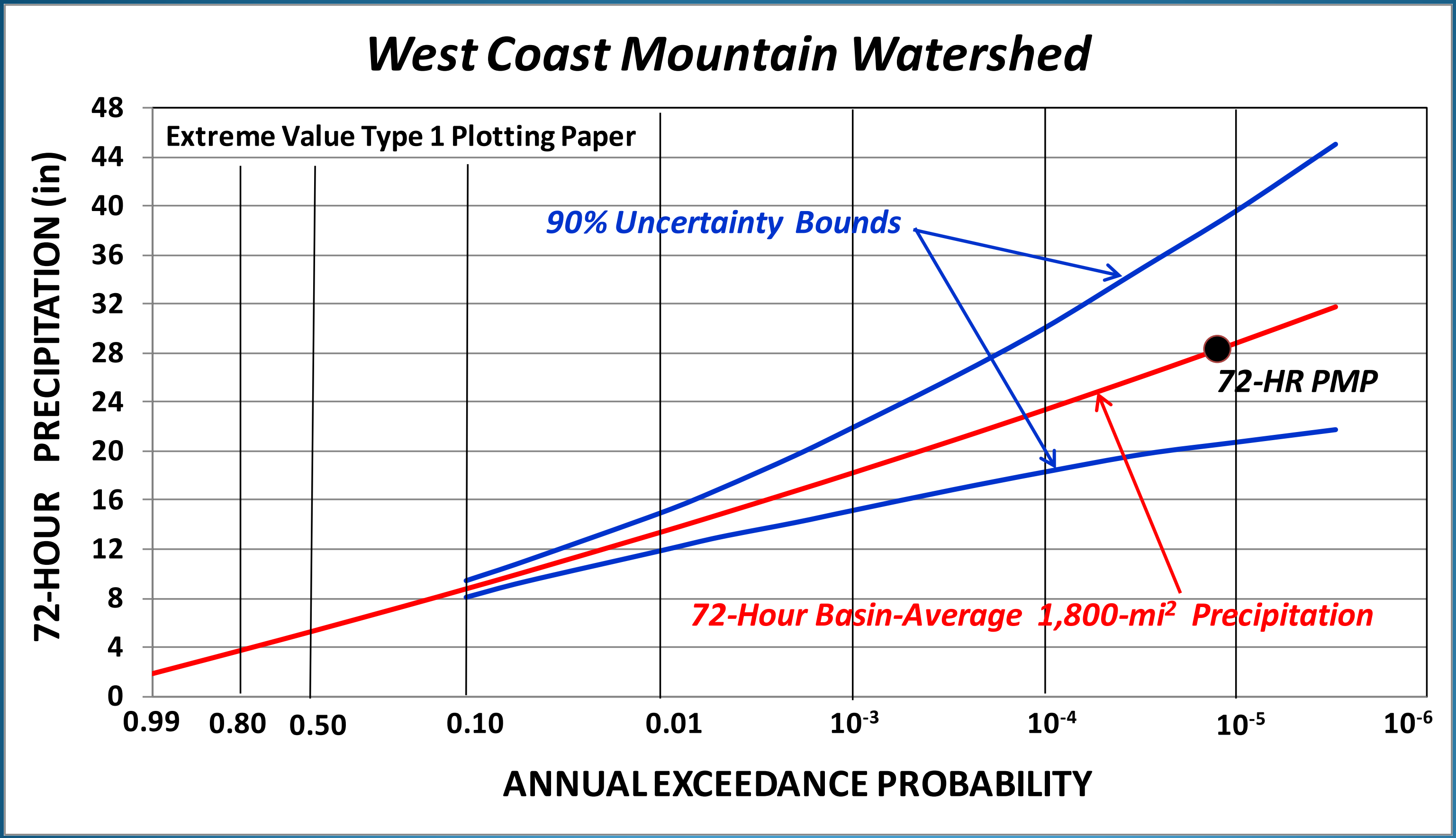
Precipitation-Frequency Relationships Needed for Watersheds for Rainfall-Runoff Modeling of Extreme Storms and Floods

Precipitation-Frequency Relationships Have Been Developed for Watersheds using Regional Analysis Methods since 1998

Hydrologic Risk Assessments - 20 Dam Projects

USBR BChydro USCOE Hydropower Utilities

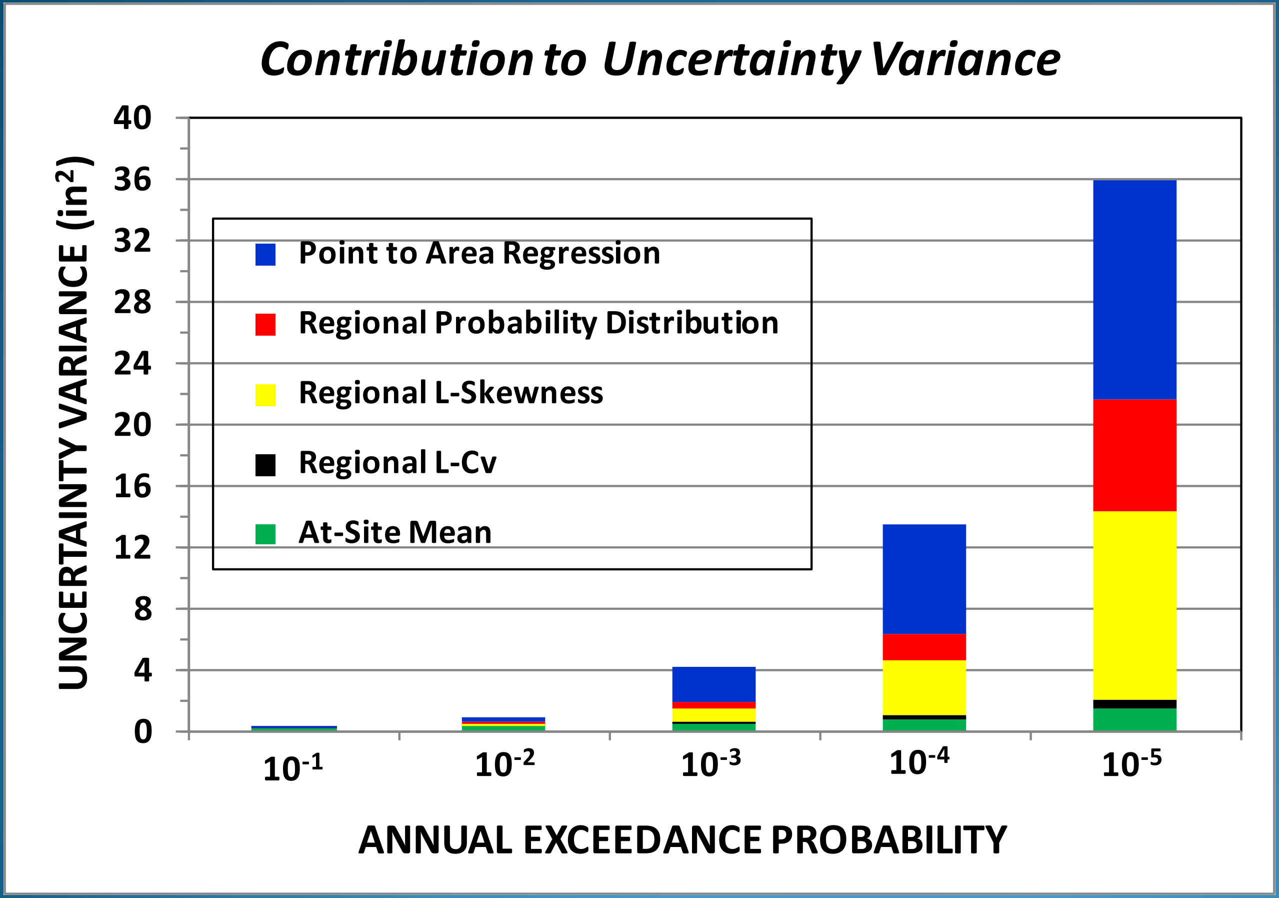
Precipitation-Frequency for Watersheds
What Does End-Product Look Like ?



PMP is just another point on the curve

Methodologies Have Been Developed for Computation of Mean Frequency Curve and Uncertainty Bounds

Precipitation-Frequency for Watersheds



Regional Analysis Dramatically Reduces Uncertainties for More Common Events

Largest Contributions to Total Uncertainty are Typically:

Uncertainties in Regional L-Skewness

and Relationship for Point to Areal Precipitation

What Has Made Development of Precipitation-Frequency Relationships for Watersheds Possible ?

Regional Analysis Methodology

grouping of datasets of like phenomenon to reduce uncertainties, improve identification of parent probability distribution

Jim Wallis – IBM Research

L-Moment Statistics

major advancement in statistical measures for small datasets exhibiting marked skewness

Jon Hosking – IBM Research

PRISM Model

spatial mapping of precipitation and L-moment statistics

Chris Daly – Oregon State University

Why This is Possible Now

Isopercental Analysis

spatial interpolation methods for spatial mapping of precipitation (storm events) in mountainous areas

Improvements in NWS Techniques

SPAS Software

use of radar data and ground-based precipitation for spatial mapping of precipitation (storm events)

Applied Weather Associates and MetStat Software

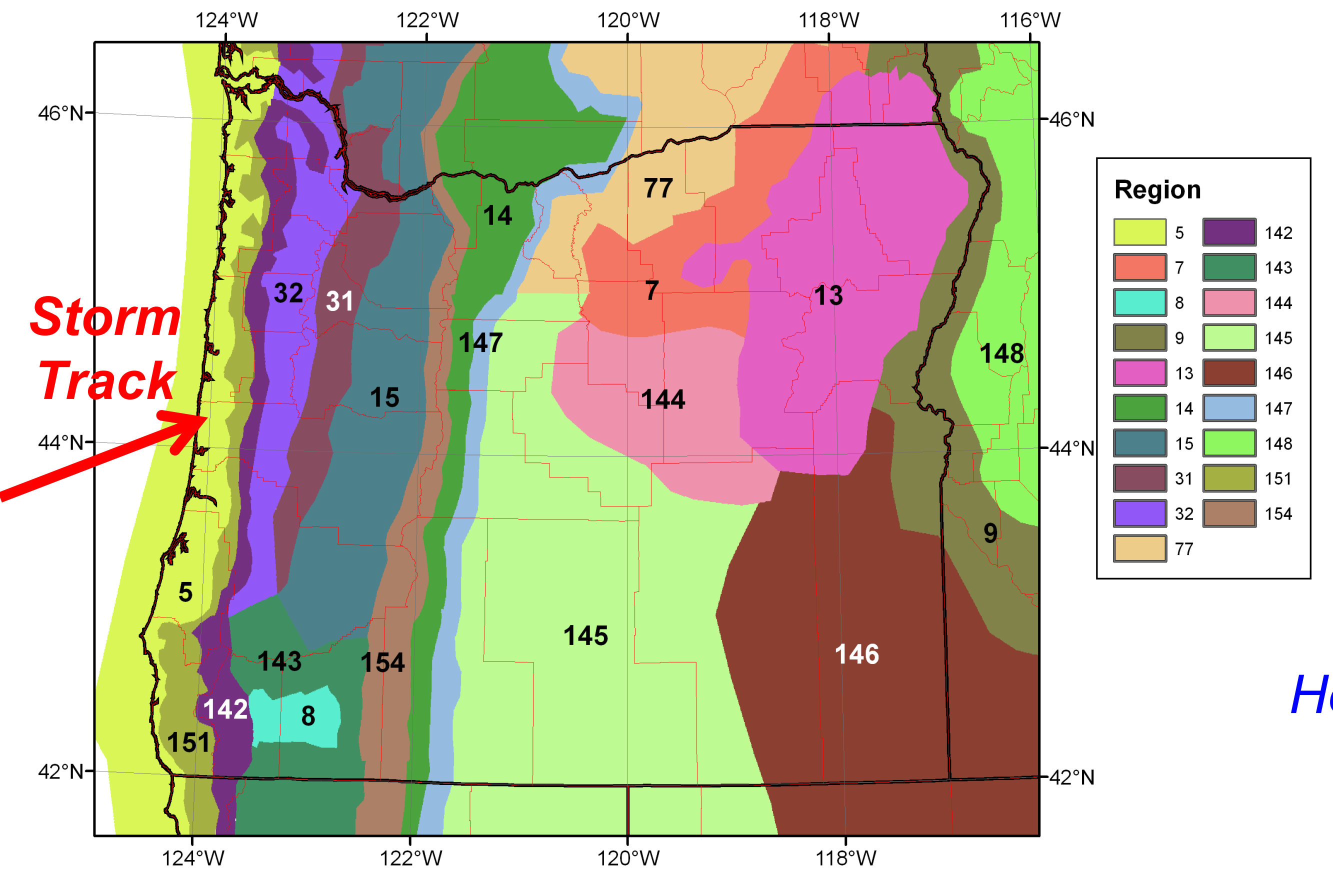
Building Foundation of Experience

experienced gained from analyses in variety of climatic settings has lead to better understanding and improvements in methodologies

Regions - Concepts

Datasets for stations (sites) within a <u>Homogeneous Region</u> are grouped for analysis

Oregon Precipitation Regions



Heterogeneous Super-Regions for Oregon

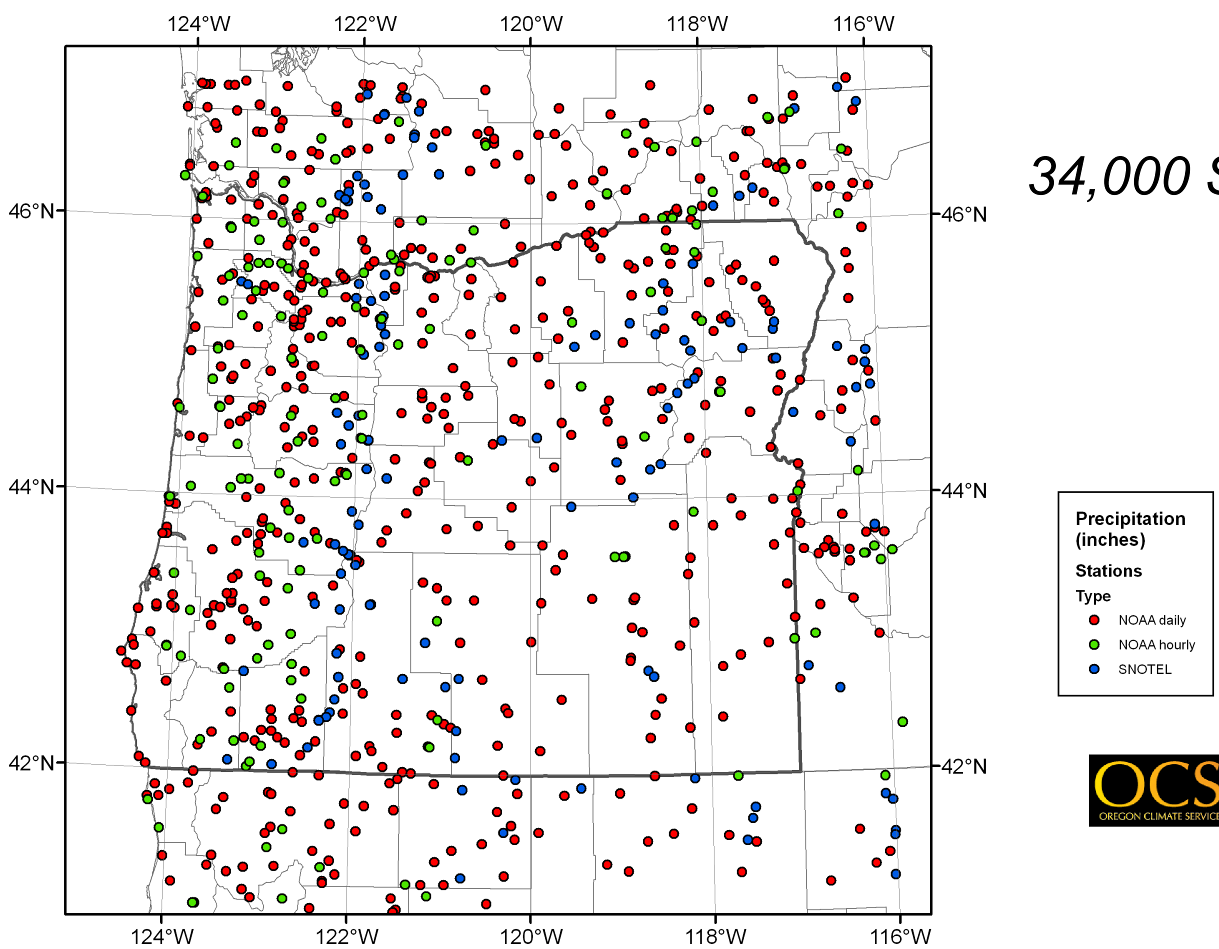
Similar Climatic and Topographic Setting

Homogeneous Regions are Subsets of Heterogeneous Super-Regions

Large Regional Datasets

Numerous stations (datasets) available for conducting Regional Precipitation-Frequency Analysis

Precipitation Measurement Station Locations



Oregon State
700 Stations
34,000 Station-Years of Record

The Need for Regionalization

At-Site Analysis

Subject to High Sampling Variability

Regional Analysis

Reduces Sampling Variability

Groups datasets of same phenomenon from a homogeneous region for analysis

Greatly improves reliability of identification of regional probability distribution and estimation of regional magnitude-frequency relationship

Excel Workbook Simulations

Benefits of Regional Analysis (Trading Space for Time Sampling)

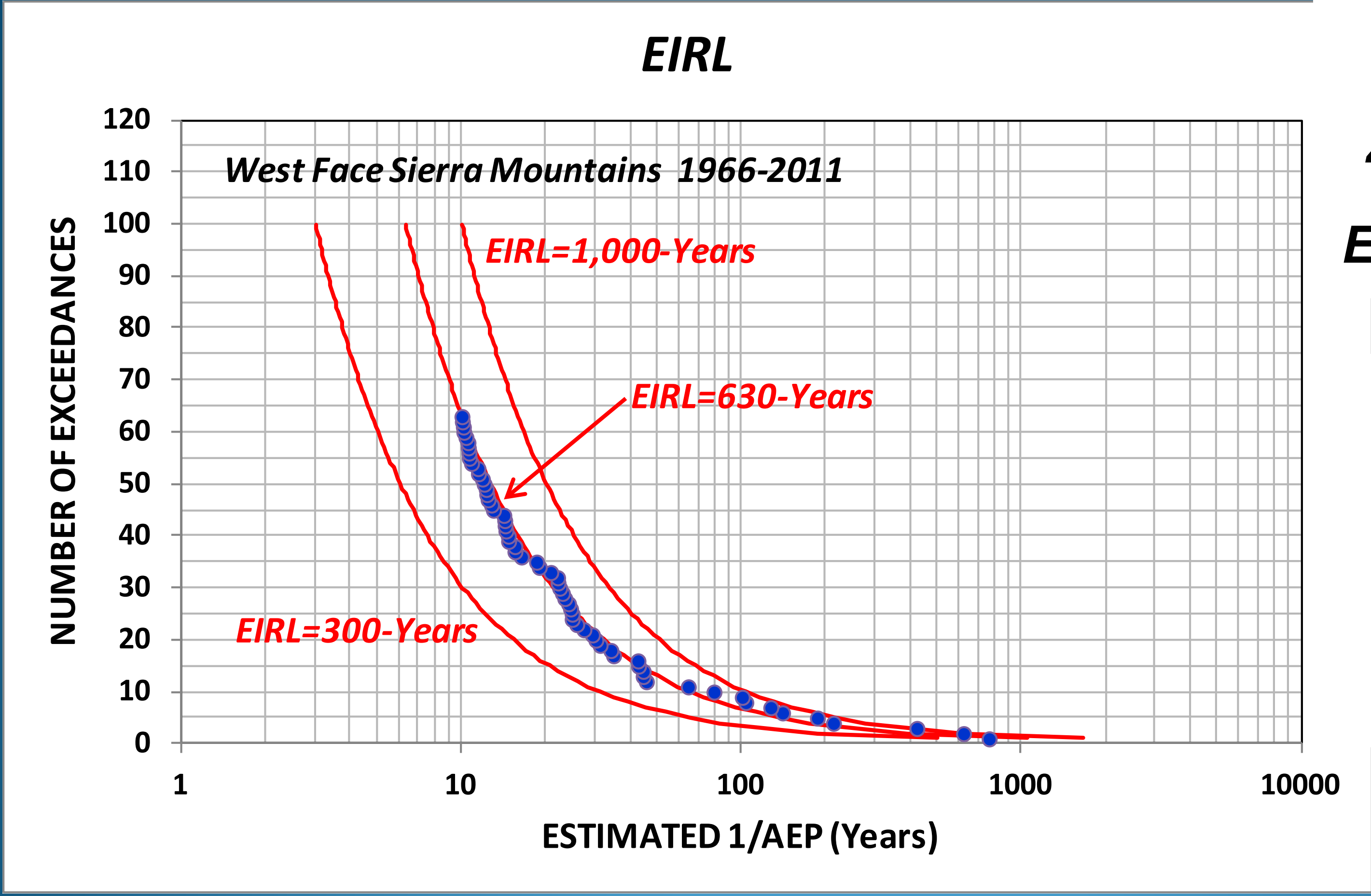
Large Geographic Regions relative to Storm Areal Coverage Results in Independence or Low Correlation of Datasets at Distant Stations

Equivalent Independent Record Length (EIRL) is a measure of the statistical information in the regional dataset

<u>EIRL is a function of:</u>

- *Size of region relative to typical areal coverage of storms*
- *Number of storms per storm season*
- *Density of precipitation measurement stations*
- *Chronological length of dataset (1966-2011)*

Equivalent Independent Record Length (EIRL)



130 stations

4,599 station-yrs

EIRL=14% stn-yrs

63 storms
(distinct dates)
exceeding
1:10 AEP

Greater EIRL results in greater reliability (smaller uncertainty bounds) for estimates of extreme precipitation

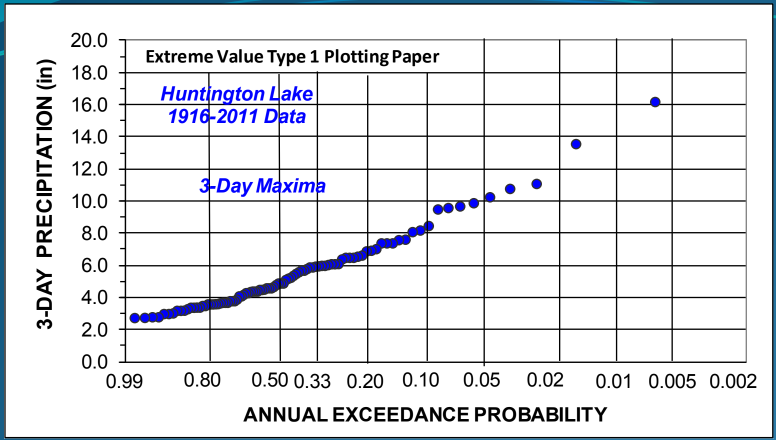
Graphical Example of Regional Analysis

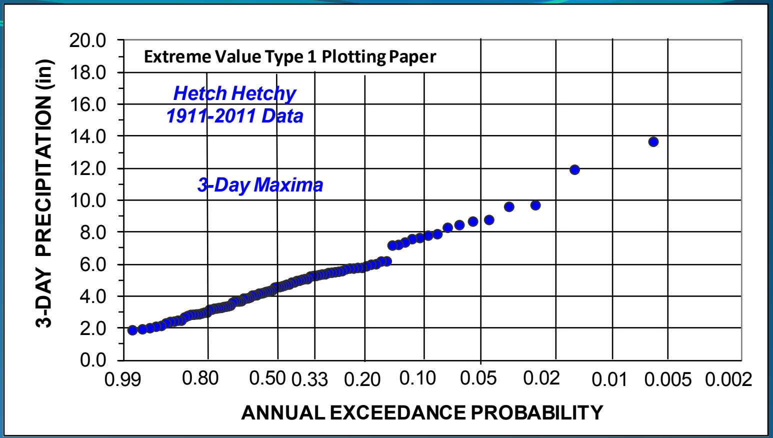
Comparing Slope and Shape
of Dimensionless Probability-Plots
for Sites on West Face of Sierra Mountains

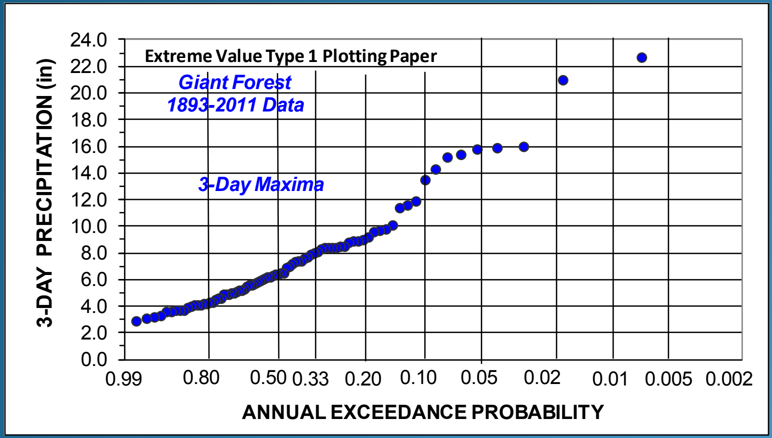
Physical Interpretation

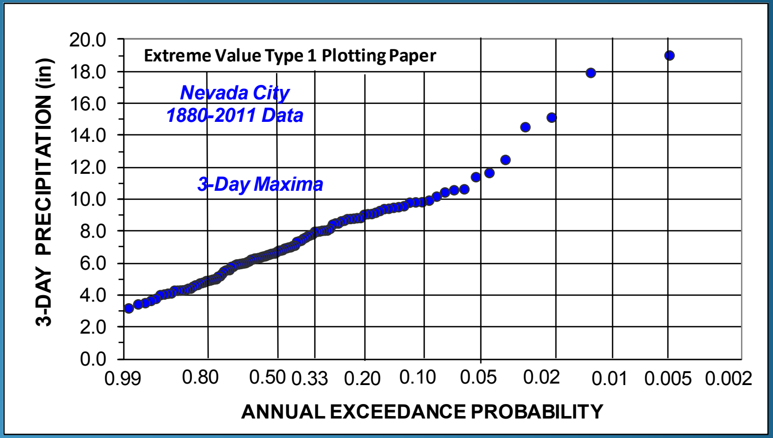
Dimensionless Probability-Plots
Reflect Frequency Characteristics
of Storms Generated by Pacific Ocean
Measured on Upwind Mountain Faces

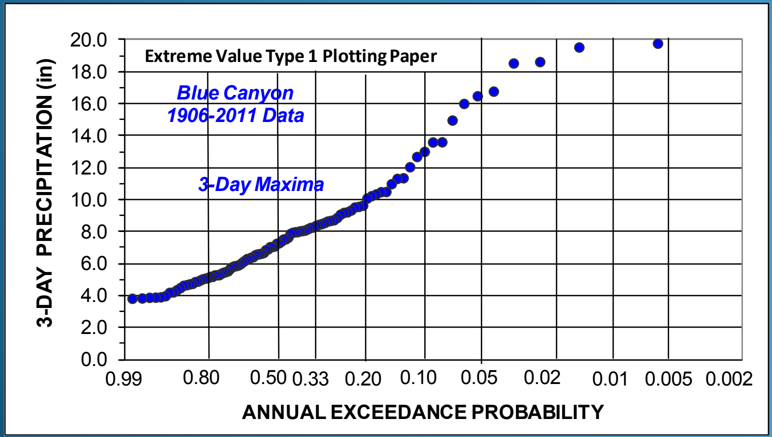
72-Hr Precipitation West Face Sierra Mountains

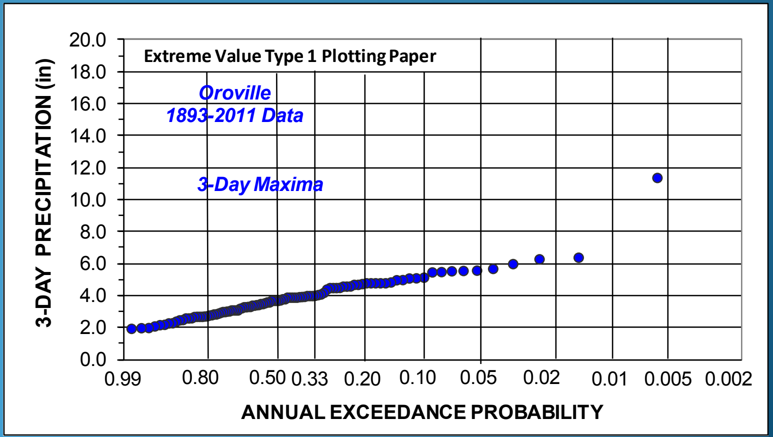






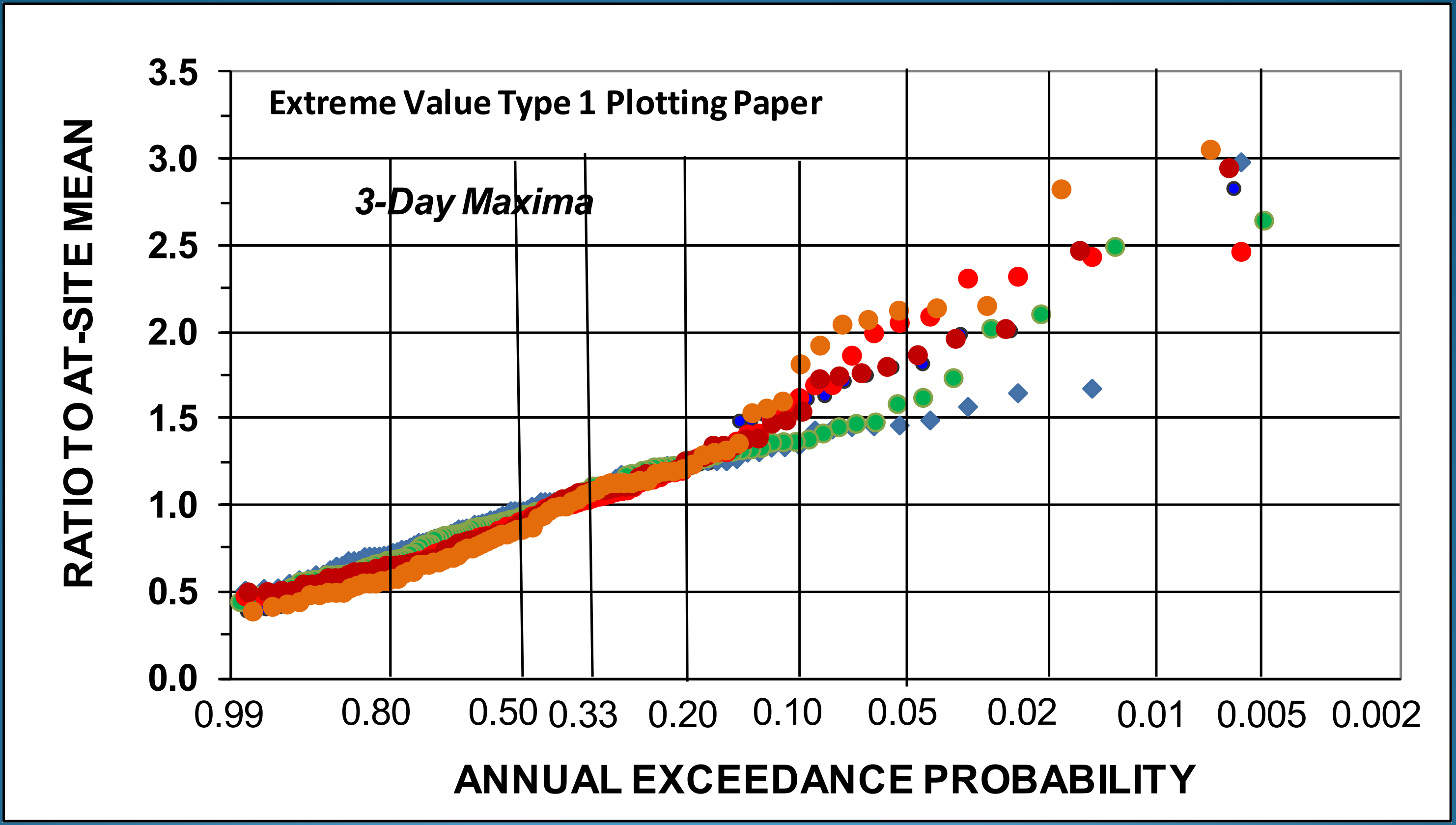






Graphical Example of Regional Analysis

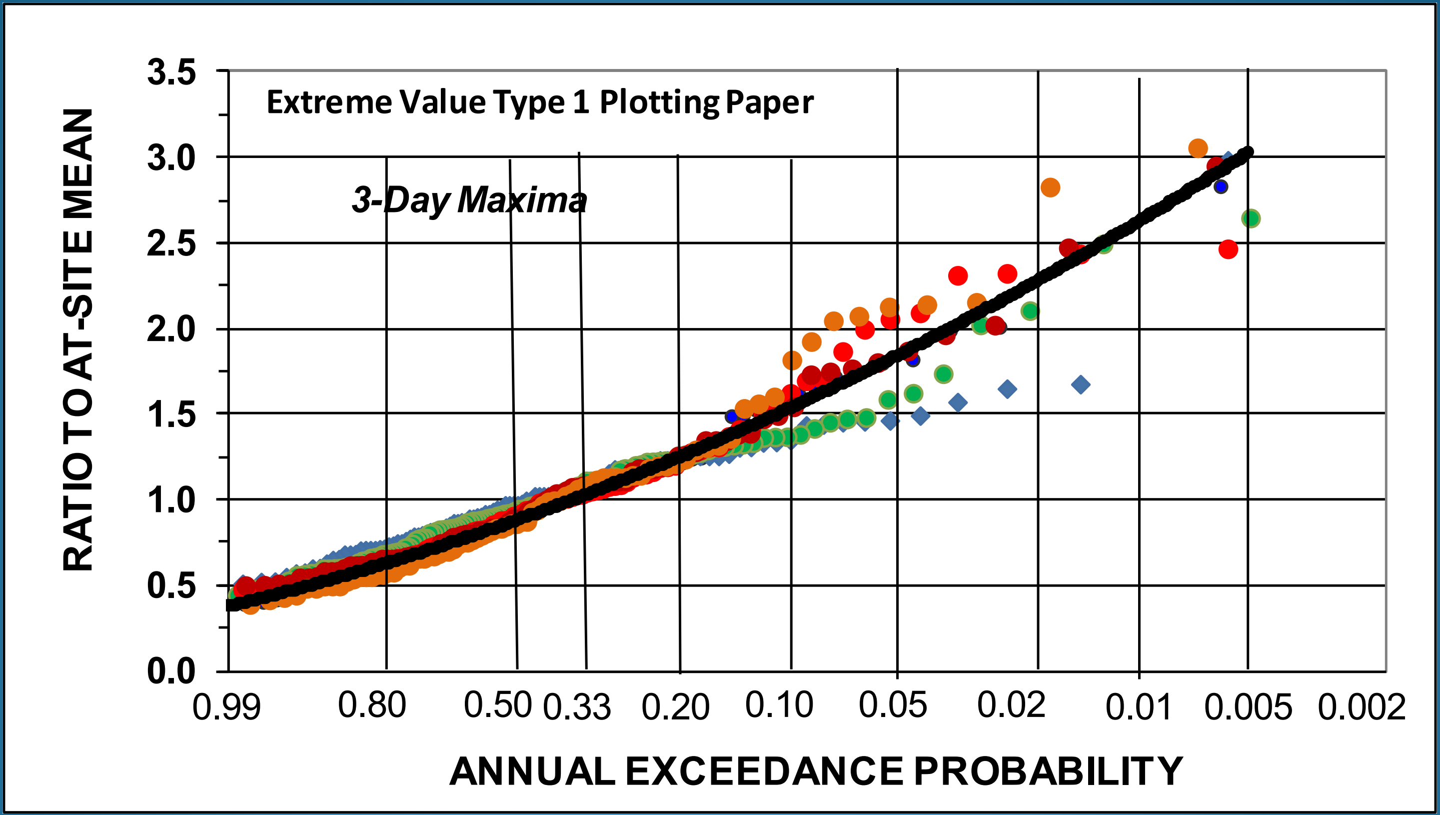
Rescaled by Station Mean (At-Site Mean)



Similarity of Shapes of 6 Dimensionless Probability-Plots

Graphical Example of Regional Analysis

Region Growth Curve
Dimensionless Regional Frequency Curve



Differences in probability-plots attributed primarily to sampling variability

Numerical Solution of Regional Growth Curve

Regional L-Cv (dimensionless scale)

Regional L-Skewness (dimensionless shape)

used to obtain solution of Regional Growth Curve

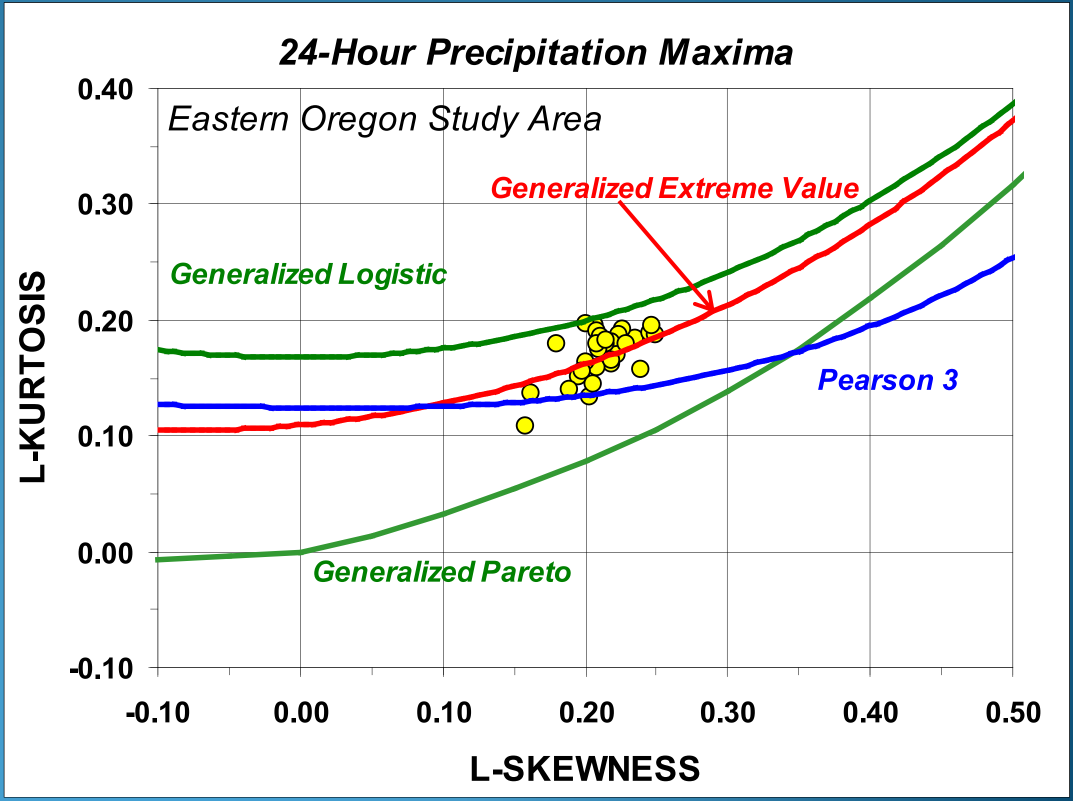
for Identified Regional Probability Distribution

Regional Probability Distribution

Studies in Western United States and British Columbia have shown 1-Day to 7-Day Precipitation Annual Maxima to be Described by a Probability Distribution Near the Generalized Extreme Value (GEV) Distribution

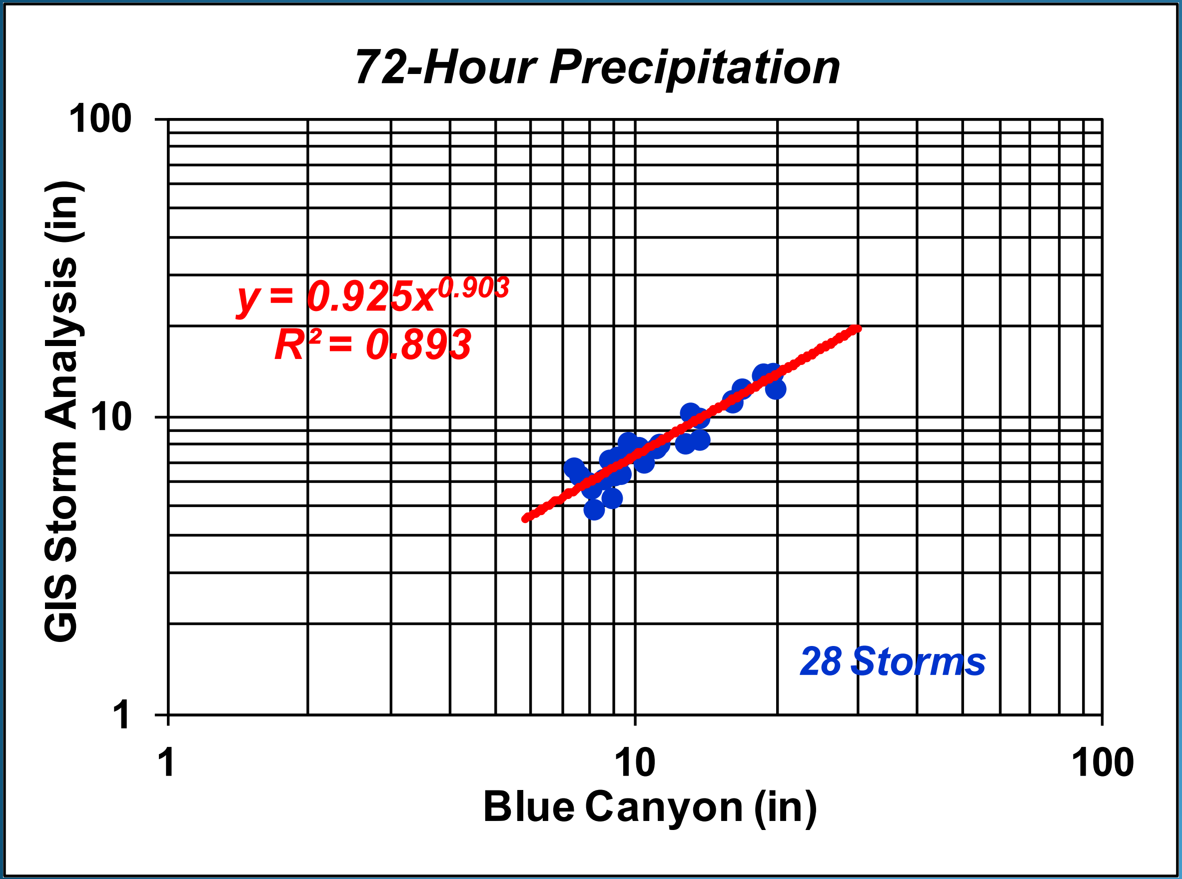
Results from Regions in Oregon for 24-Hour Precipitation Annual Maxima

4-Parameter Kappa Distribution Used for Watersheds



Development of Precipitation-Frequency Relationships for Watersheds

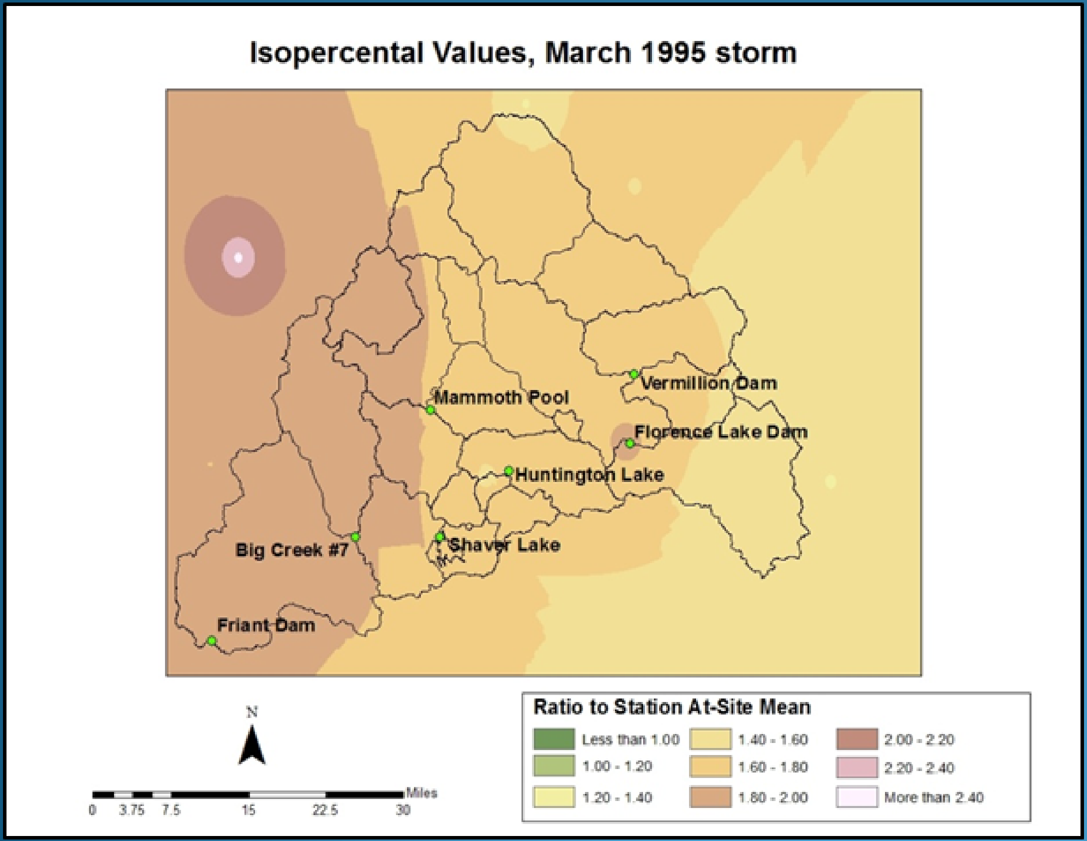
Need Relationship between Point Precipitation and Areal Precipitation for Major Storms



GIS Storm Analysis (Spatial Analysis) using Isopercental Method or SPAS Radar Analysis

Spatial Mapping of Precipitation with Isopercental Method

Convert from Precipitation Domain to Frequency Domain, Divide 72-hr Station Precipitation by At-Site Mean



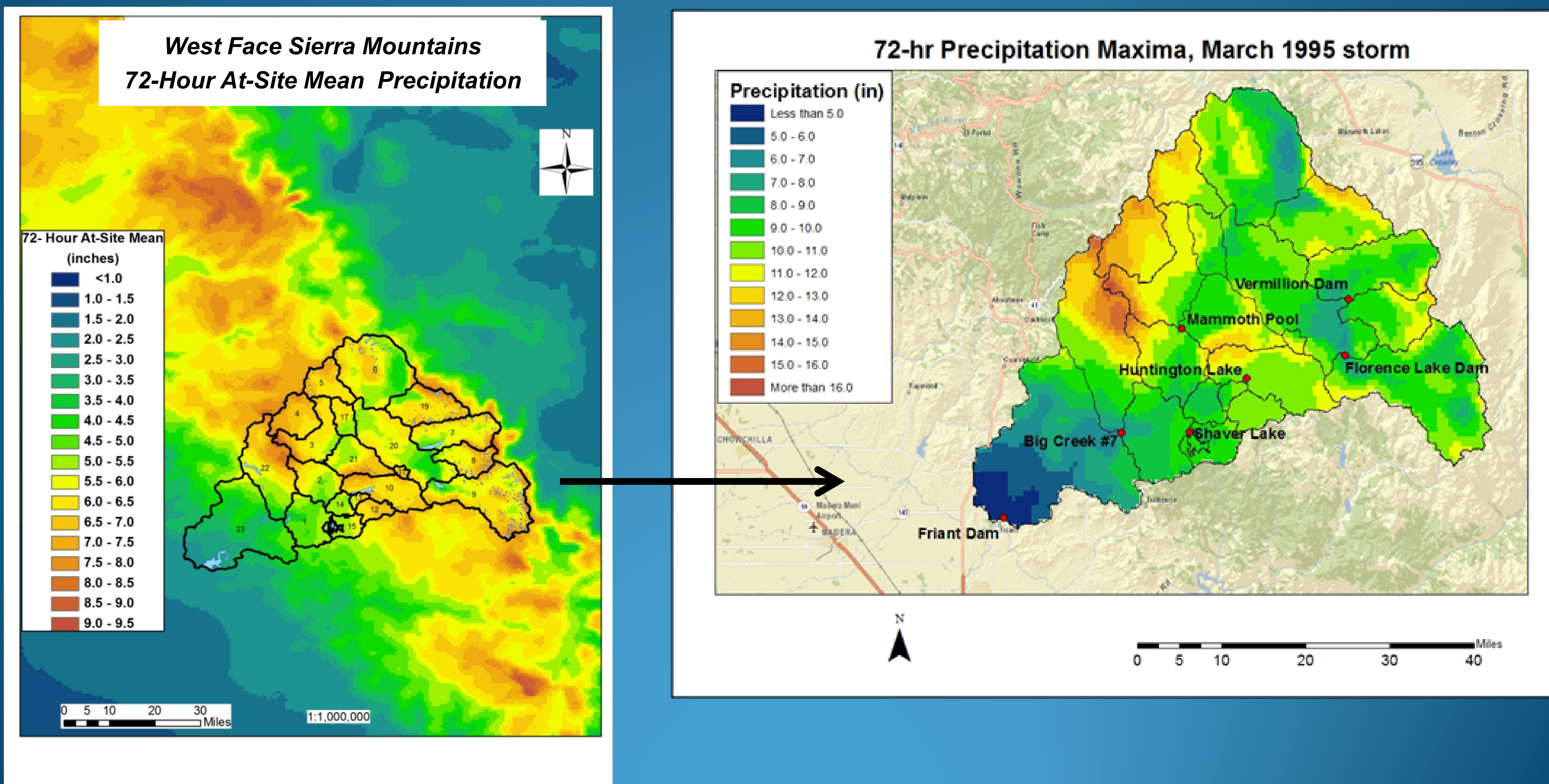
Over 100 Major Storms Analyzed

Well-Behaved Mild Isopercental Gradients in Frequency Domain

Inverse Distance Weighting (IDW) in Frequency Domain

Spatial Mapping of Precipitation with Isopercental Method

Transform from Frequency Domain (Isopercental) to Precipitation Using Spatial Map of At-Site Means



Characterize Uncertainties for Use in Developing Precipitation-Frequency Curve for Watershed

Develop Probability Distributions for Uncertainties

Point Precipitation At-Site Mean

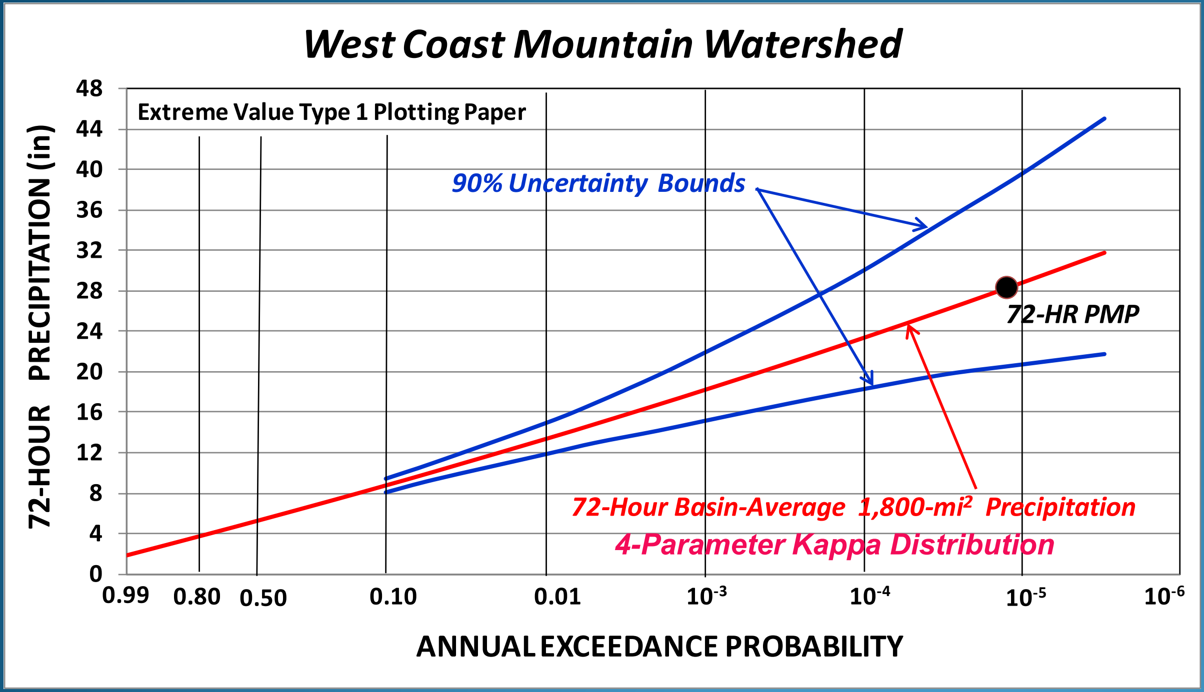
Regional L-Cv

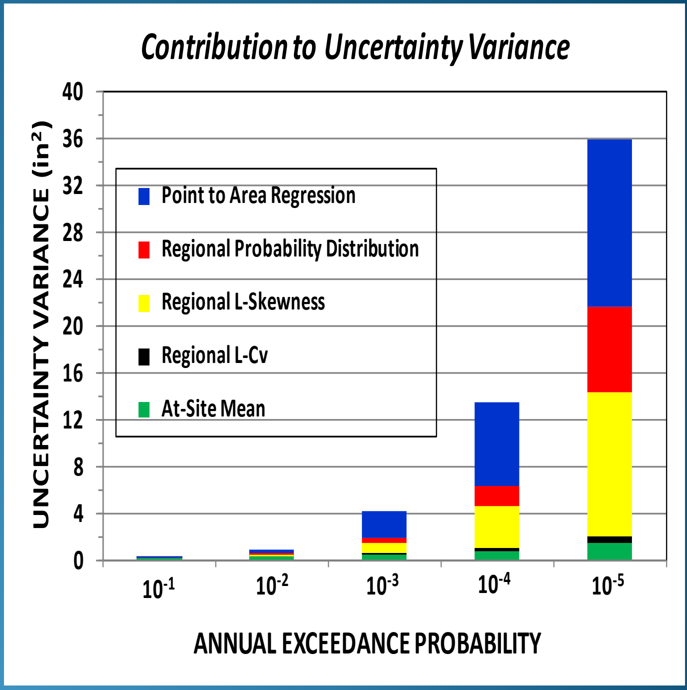
Regional L-Skewness

Regional Probability Distribution

Relationship of Point to Areal Precipitation

Monte Carlo Simulation Used to Develop Mean Precipitation-Frequency Curve and Uncertainty Bounds





Precipitation-Frequency Relationship for the Watershed is Often the Dominant Contributor to Behavior of Flood-Frequency Relationships

Summary: Precipitation-Frequency

Key Components for Developing Precipitation-Frequency Relationships for Watershed-Specific Applications

Regional Analysis Methods

Large Regional Datasets

L-Moment Statistics

GIS Spatial Mapping Tools, PRISM model

Spatial Analysis of Storms (Isopercental, SPAS)

Annual Exceedance Probabilities (AEPs) of Published PMP Estimates

AEPs for PMP based on Regional Precipitation-Frequency and Analyses of Historical Extreme Storms (%PMP)

AEPs of PMP vary from about 10^{-4} to perhaps 10^{-10}

AEP varies - nearness to sources of atmospheric moisture
(Coastal versus Inland Areas)

AEP varies - number of storms in storm season
(Arid versus Humid Climates)

AEP varies with storm characteristics of interest
(Short-duration intensities, Long-duration volume)

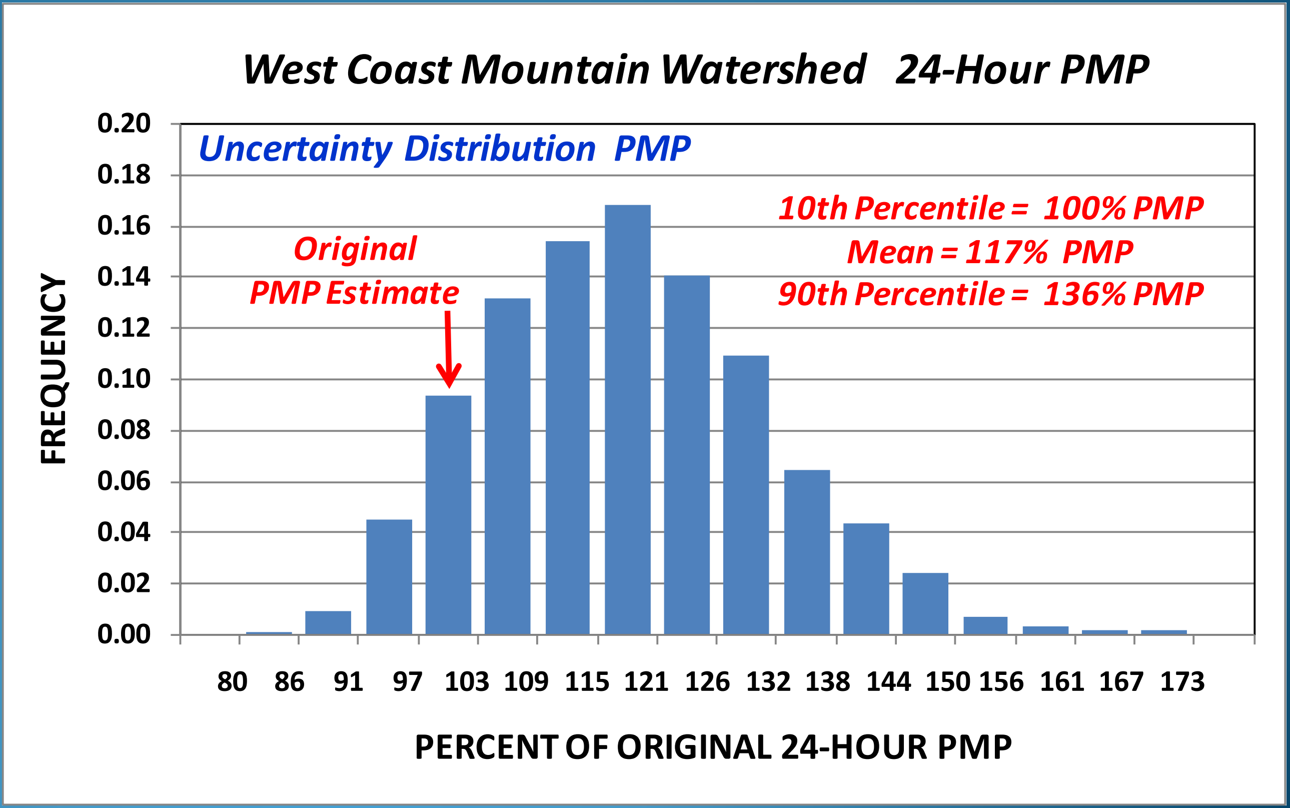
Uncertainties in PMP Estimates

- *Inflow moisture flux for moisture maximization*
- *Sampling limitations of storm database (storm efficiency)*
- *Simplifying assumptions, policy versus science decisions*
- *Effect of analyst's judgment*

Uncertainty Analysis for PMP

First of its kind

Jan 2013



Summary - PMP

AEPs for PMP Have Much Wider Range
Than "Assumed" in Engineering Community

Results of Uncertainty Analysis (PMP bias)
and Magnitude of Uncertainties in PMP Estimation
Will Likely Surprise Many in Engineering Community

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