

Calculating Probable Maximum Precipitation (PMP) in Complex Terrain - Updating HMR 59 for Piru Basin in Southern California

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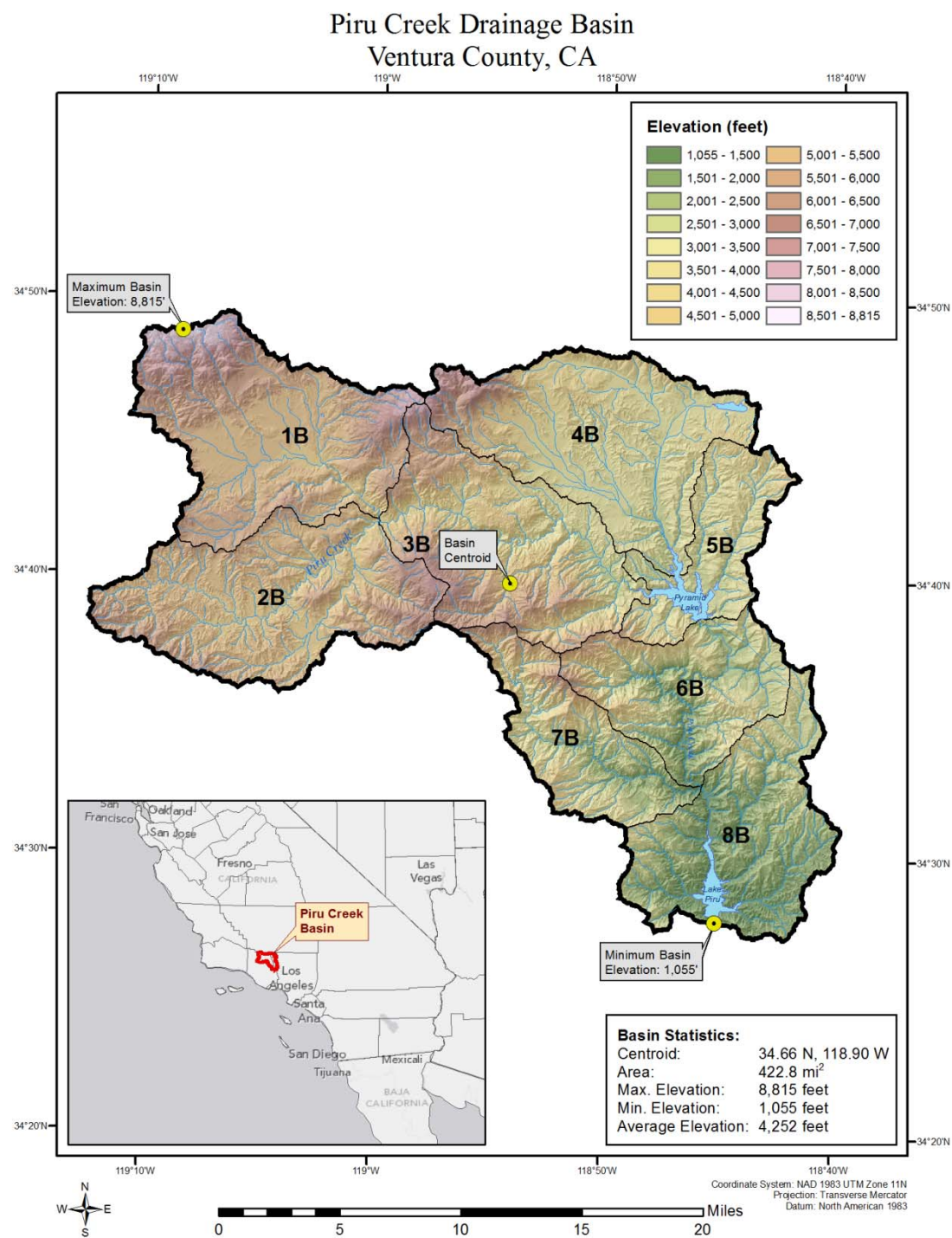
Reasons For Study

Deficient Spillway

Correct HMR 59 PMP Errors

Update Storm Database

State-of-practice data and understanding



Cooperative Efforts

- Funding/Cooperating Partners
 - CA DWR
 - United Water
- Working together both partners benefit
 - CA DWR-Pyramid Dam
 - United Water-Santa Felicia Dam



Background

- HMR 59-Published in 1999
 - Newest HMR - at least 15years old
 - Based on outdated methods and techniques
 - Better understanding of meteorology
 - Updated storm datasets
 - Improved spatial analysis
 - Methods and techniques updated to quantify topographic effects
 - Updated NOAA Precipitation Atlas
 - NOAA Atlas 2 used
 - NOAA Atlas 14 now available



Background

- Major issues with HMR 59
 - Highly subjective and not reproducible
 - Several inconsistencies and calculation errors
 - Not clear how storm data were used to develop the PMP values
 - Covers a widely varying region
 - Climatologically
 - Topographically



HMR 59 Domain and Location of Piru Creek Basin



How Did AWA Compute PMP?

- Storm Based Approach-Deterministic
 - Similar to HMR/WMO procedures
 - Reproducible
 - Assumptions/subjectivities explicitly stated

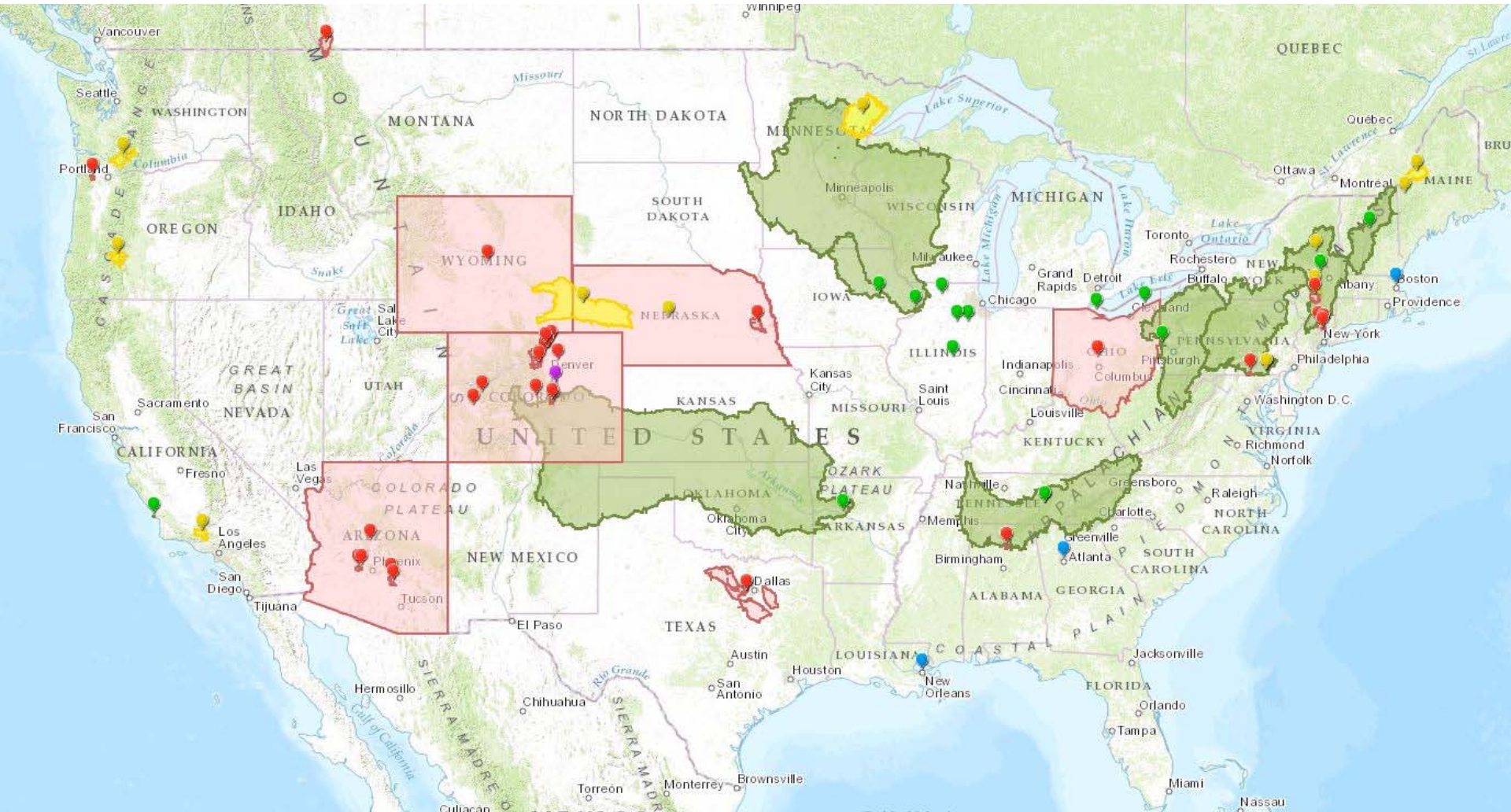


How Did AWA Compute PMP?

- Consistency with AWA PMP studies
 - Improvements in understanding of meteorology
 - Expanded storm data base
 - Use of computer technologies (HYSPLIT/GIS)
 - Use of NEXRAD weather radar
 - Better understanding of meteorology

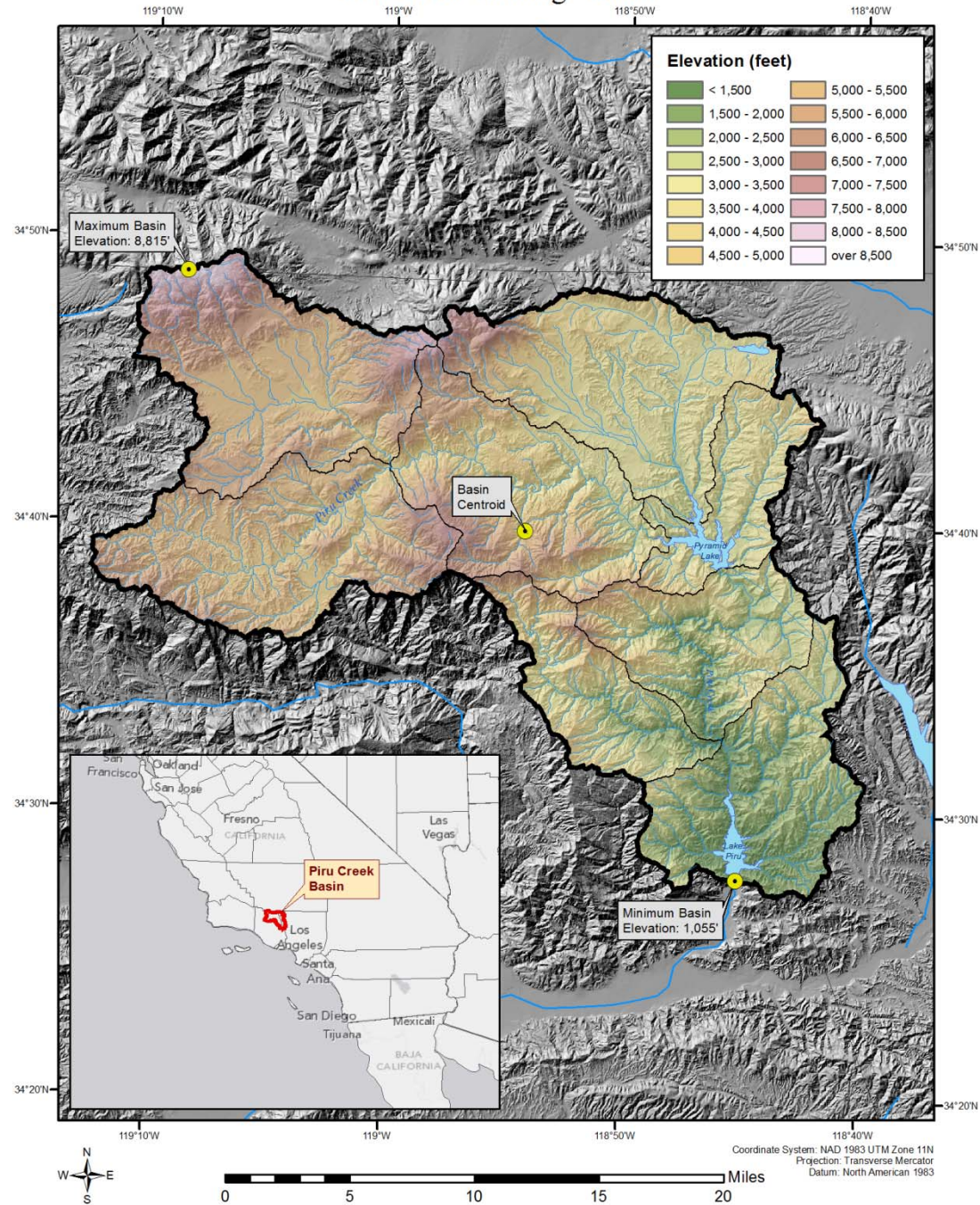


Not Our First PMP Study



Elevation - 500-foot Contour Intervals Piru Creek Drainage Basin

Elevations Across the Basin, 500 Foot Intervals

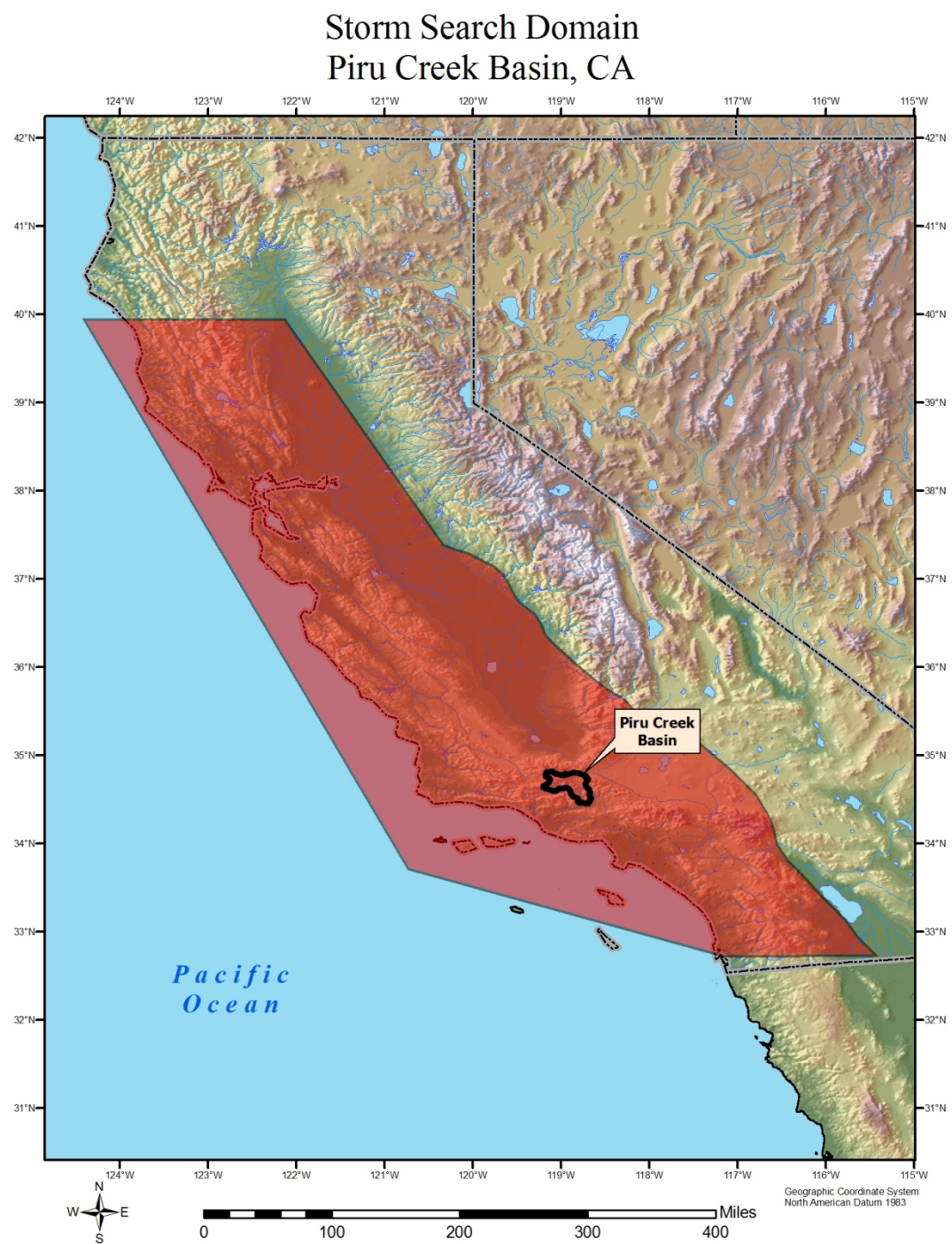


Updating PMP for the Piru Basin

- **Storm Search**
 - Update the storm database
 - Identify the most extreme rainfall events
 - Throughout the state
 - Surrounding regions
 - Identify Storm Types
 - Local Convective-not important for PMP at this site
 - Remnant Tropical
 - General Frontal



Piru Creek Storm Search Domain



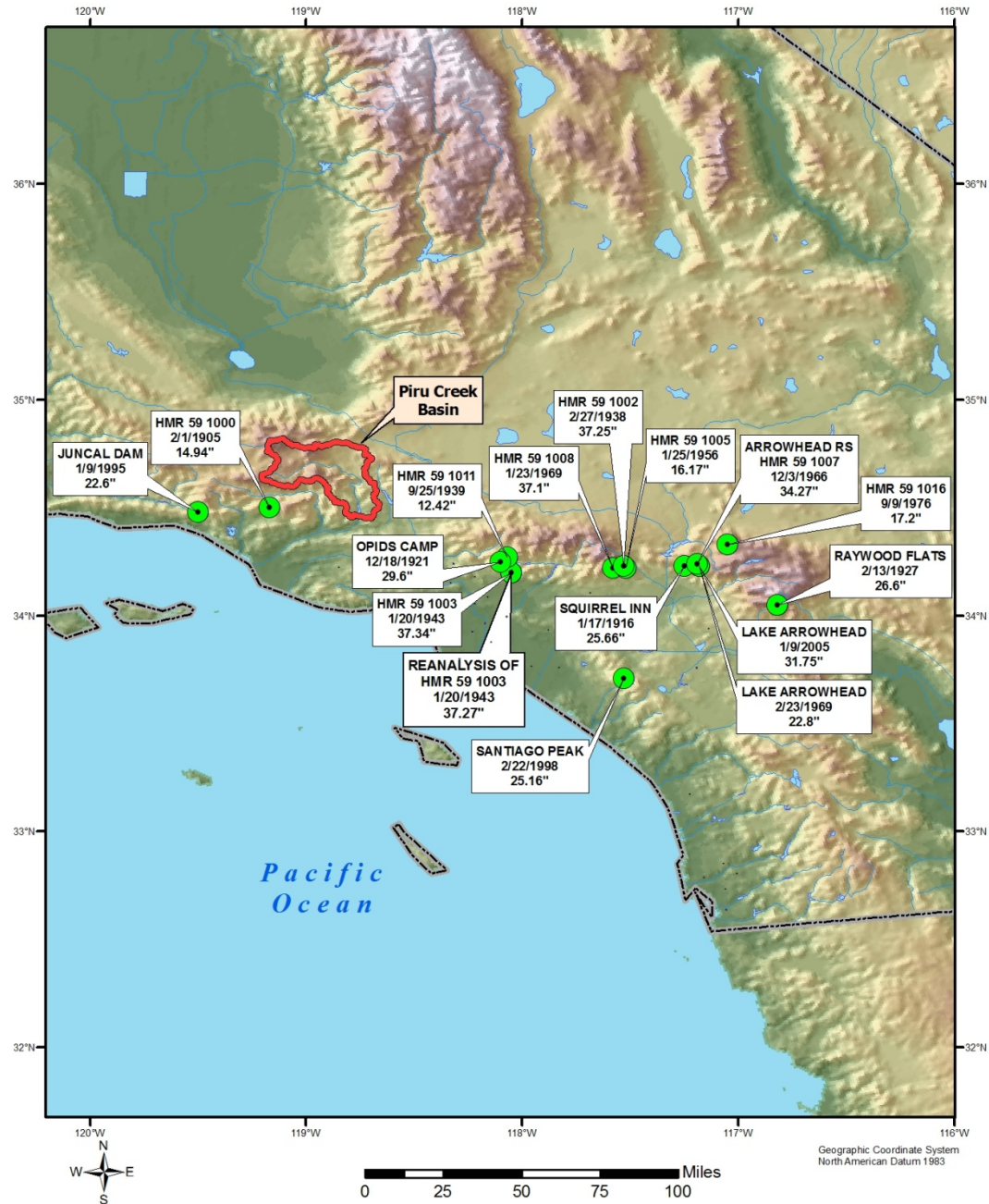
Updating PMP-Storm Search

- 1000's of storms initially captured
- Grouped by storm type
 - Local Convective, Tropical, Frontal
 - Location
 - Duration
- Storms used in HMRs included
- Ensure no potential PMP type storms missed
- Storms must be transpositionable
 - Similar meteorological & topographical characteristics



Short Storm List Locations Piru Creek Basin, CA

Short List Storm Locations Used for PMP Development

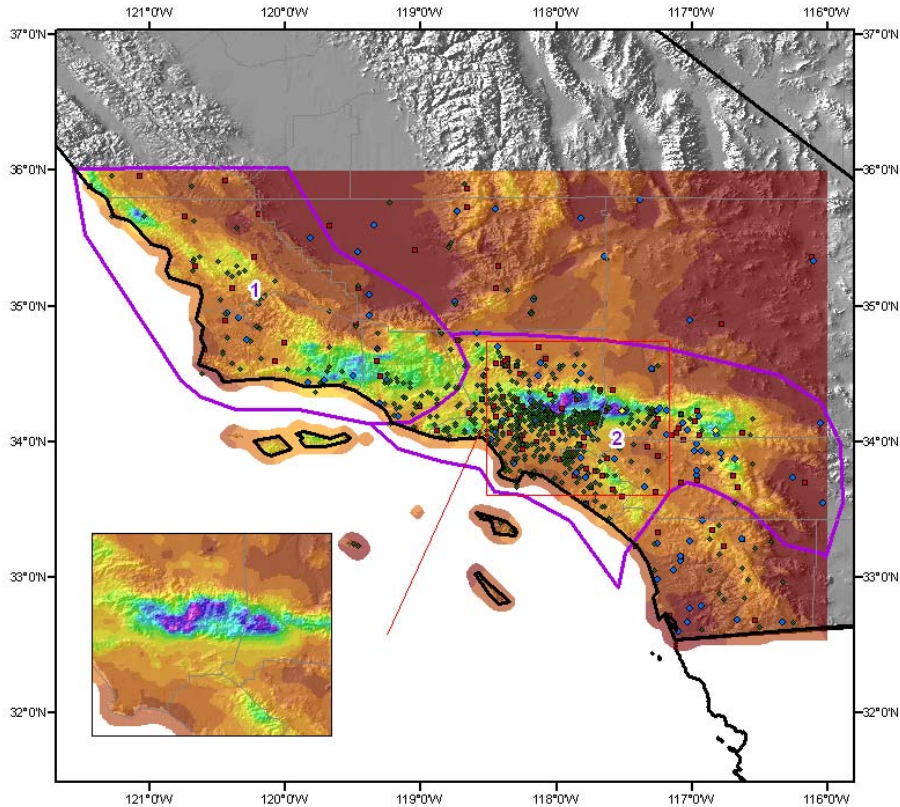


Updating PMP-Storm Analysis

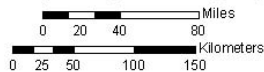
- Storm Precipitation Analysis System (SPAS)
 - Depth-Area-Duration Table
 - Mass Curves
 - Total Storm and Hourly Isohyetal Patterns
 - Hourly (5-minute rainfall) at 1/3rd square mile
 - Dynamically adjusted radar and/or basemap for spatial interpolation



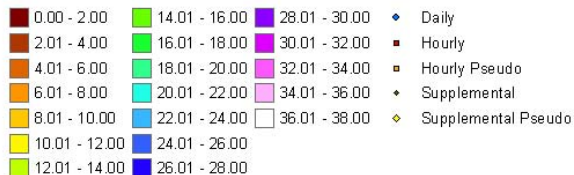
SPAS Storm Analysis Results



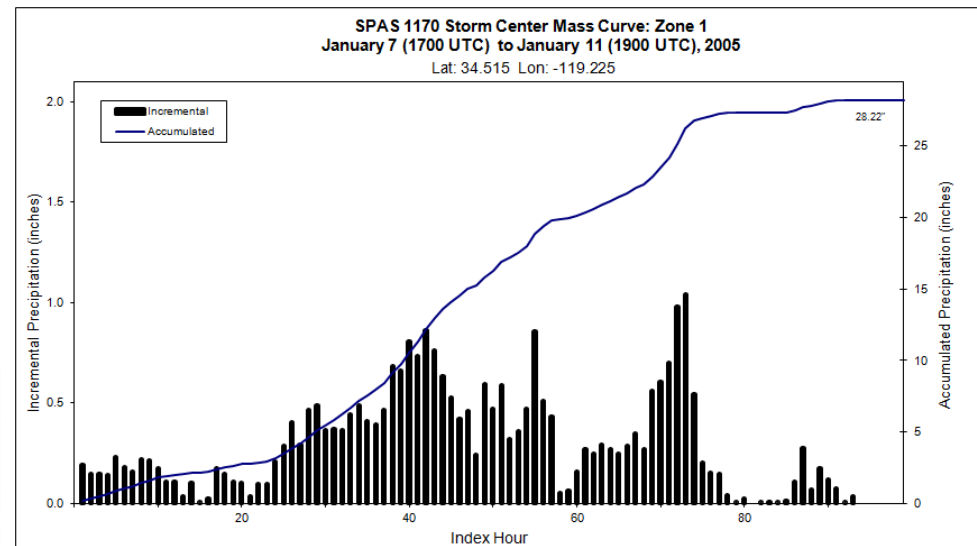
Total Precipitation (120-hours)
 SPAS storm number: 1168
 January 20, 1943 (0900 Z) to January 25, 1943 (0800 Z)



Precipitation (inches)



Storm 1170 - January 7 - 11, 2005												
MAXIMUM AVERAGE DEPTH OF PRECIPITATION (INCHES)												
Area (mi ²)	Duration (hours)											
	1	3	6	12	24	36	48	60	72	96	99	total
0.40	1.80	3.53	5.00	7.43	13.19	17.79	22.89	24.92	26.49	28.22	28.22	28.22
1	1.78	3.48	4.98	7.36	13.11	17.76	22.81	24.82	26.24	28.11	28.11	28.11
10	1.62	3.33	4.73	6.74	12.35	16.70	21.22	22.93	25.02	26.58	26.79	26.79
25	1.47	3.11	4.52	6.29	11.96	16.13	20.49	22.30	24.27	25.69	25.84	25.84
50	1.35	2.90	4.31	5.95	11.48	15.54	19.72	21.42	23.18	24.65	24.85	24.85
100	1.17	2.65	4.02	5.47	10.76	14.68	18.47	20.23	21.88	23.27	23.49	23.49
150	1.05	2.44	3.80	5.35	10.27	13.79	17.34	19.29	20.69	22.38	22.50	22.50
200	0.97	2.33	3.62	5.12	9.93	13.45	16.75	18.21	20.22	21.68	21.69	21.69
300	0.79	2.14	3.36	4.87	9.23	12.71	16.18	17.66	18.84	20.49	20.58	20.58
400	0.77	2.02	3.16	4.76	9.16	12.02	15.21	16.75	17.91	19.55	19.79	19.79
500	0.72	1.92	3.00	4.65	8.63	11.74	15.05	16.38	17.56	19.07	19.16	19.16
1,000	0.60	1.58	2.39	4.26	7.93	10.49	13.42	14.61	15.68	17.01	17.05	17.05
2,000	0.43	1.10	2.03	3.71	6.51	8.82	11.04	12.03	13.00	14.25	14.32	14.32
5,000	0.27	0.68	1.32	2.38	4.09	5.68	7.07	7.49	8.77	9.66	9.88	9.88
10,000	0.18	0.45	0.85	1.46	2.84	3.82	4.35	4.88	5.75	6.40	6.56	6.56
12,239	0.15	0.39	0.73	1.28	2.44	3.32	3.89	4.44	4.94	5.61	5.64	4.95



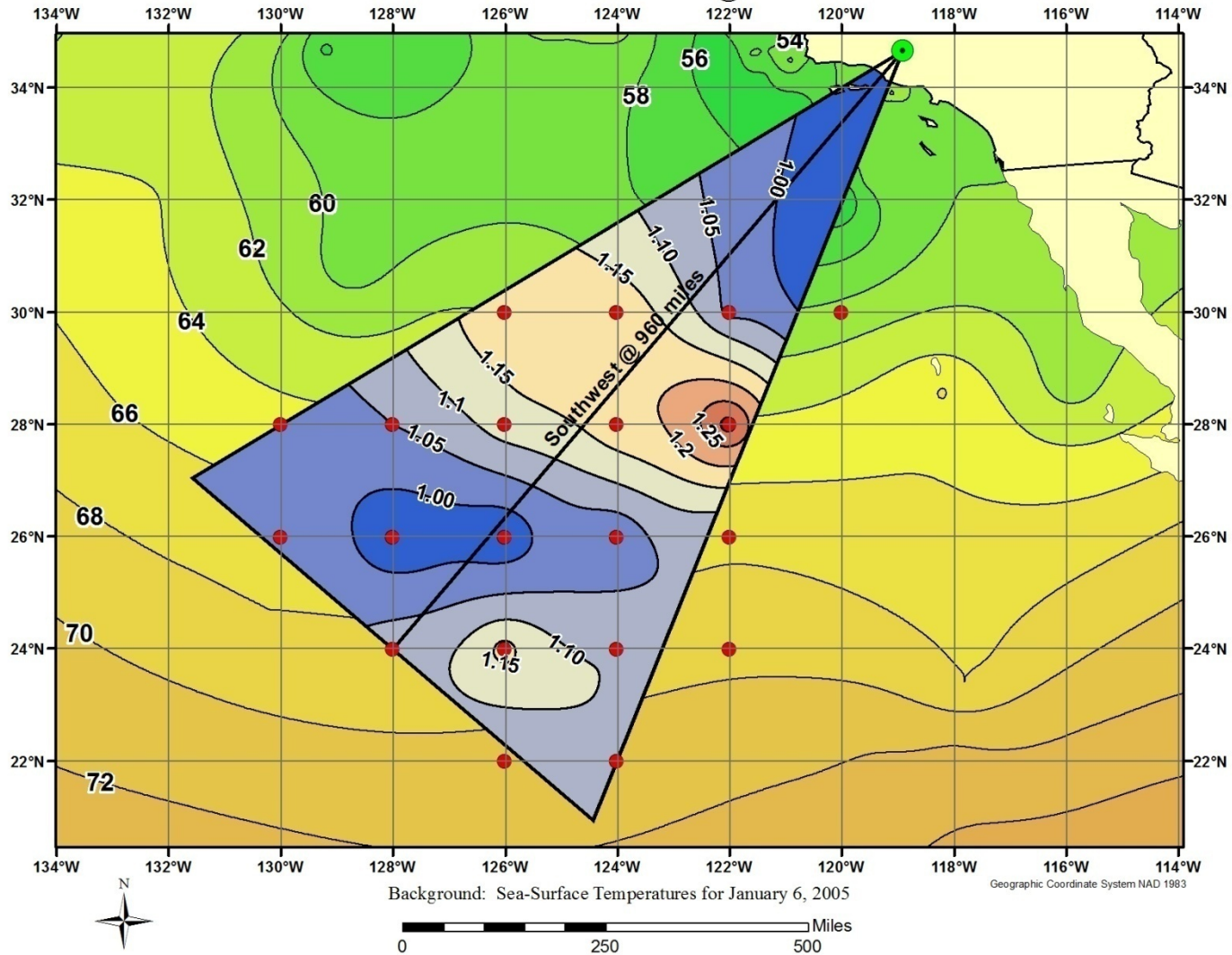
How Did We Compute PMP?

- Each storm maximized
 - Make it as big as physically possible
 - Storm rainfall = dynamics + moisture
 - Can't quantify dynamics, can quantify moisture
 - Assume most efficient storm dynamics
 - Only moisture varies
 - Use Sea Surface Temperatures (SSTs) instead of land based dew points for maximization
- Determine moisture which fed the storm = fuel
- Ratio: climatological maximum moisture to actual storm moisture = in-place maximization factor



+2-sigma SST Maximization Sensitivity

Maximization Factors for Storm 1170: January, 2005
Inflow Vector: Southwest @ 960 miles



How Did We Compute PMP?

- PMP on a $\sim 2.5\text{mi}^2$ grid
 - Move maximized storms to each grid
 - Account for differences in moisture and elevation
- Calculate Orographic Transposition Factor (OTF)
 - Uses Precip Frequency-NOAA Atlas 14
 - Difference between source (in-place storm) and target (Piru drainage basin) locations
- OTF-Quantifiable/Reproducible
 - Replaces HMR Storm Separation Method (SSM)
 - Highly subjective
 - Not reproducible
- Results in total adjustment factor
- Apply to the DAD values



Example PMP

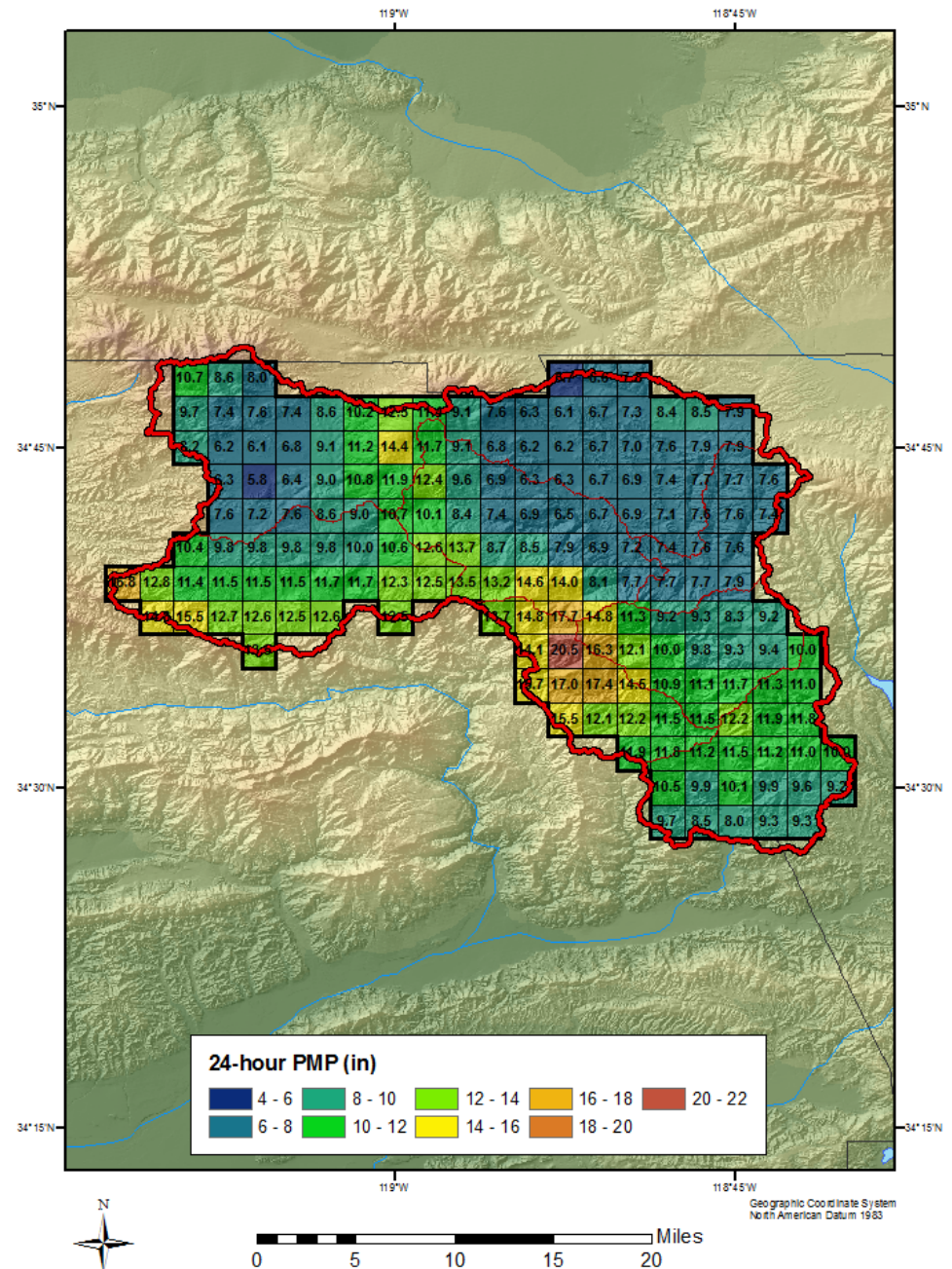
Results

72-hour PMP values

Provide basin average,
sub-basin averages,
or grid values

Spatially/Temporally
Distributed Using
Actual Storm Pattern
or Climatology

24-hour PMP at each Grid Point for All Storms (Inches)
Piru Creek Basin



Summary

- Storm based and reproducible
 - Ability to consider site-specific characteristics
- PMP study produces updated/reliable values
 - Developed using the most current methods and data available
 - Higher confidence in results/data
- Not accepted by FERC SFO office
 - Process accepted at all other study locations by FERC/State Dam Safety
 - Complicated political/technical issues
 - Did demonstrate HMR 59 problems
 - Resulted in significant changes in DSOD guidelines for using HMR 59



Summary

- FERC SFO office PMP Response
 - FERC-The Basin is poorly instrumented, need additional precipitation and flow data for large events to judge performance of PMP
 - AWA-AWA had more data than NWS in preparing HMR 59, so if data are insufficient for reliable results, HMR 59 cannot be used nor previous publications-no PMP values would then be available
 - FERC-Study focused on long-duration storms, short duration events (thunderstorms) not considered
 - AWA-Directed by BOC to focus on long-duration storms as short duration storms would in not produce the PMF
 - FERC-NEXRAD radar not acceptable to determine areal distribution, poor radar coverage over the basin
 - AWA-This is why NEXRAD data was calibrated to rain gage data (ground truth). This showed a misunderstanding of the process as this had no affect on PMP development.
 - FERC-Use of HYSPLIT to derive SST not acceptable
 - AWA-Provided an objective, reproducible process to determine SST, as opposed to HMR 59, which was subjective and not reproducible.

QUESTIONS

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