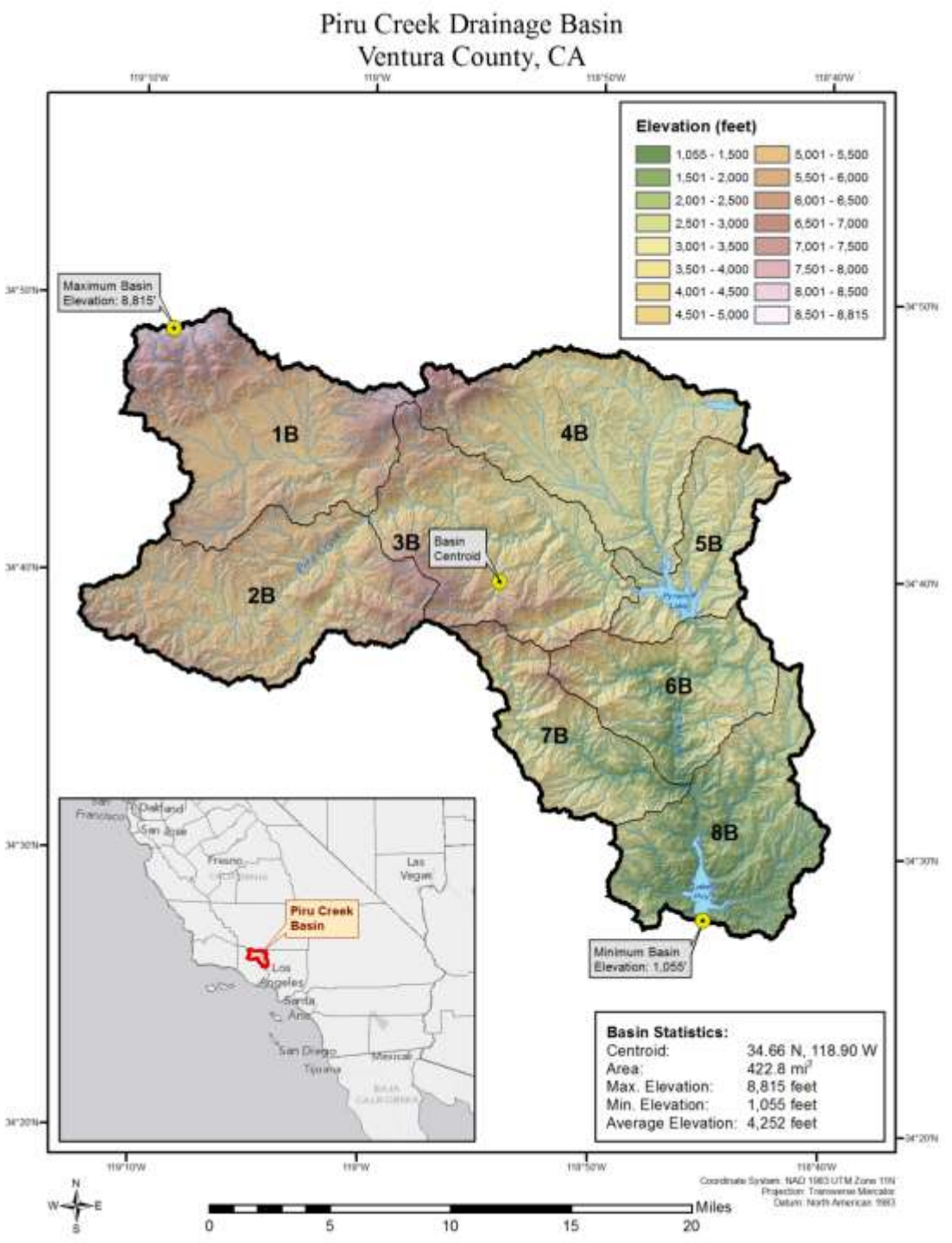
Calculating Probable Maximum Precipitation (PMP) in Complex Terrain - Updating HMR 59 for a Southern California Basin

Bill Kappel, President/Senior Meteorologist
Ed Tomlinson, PhD, Chief Meteorologist
Applied Weather Associates, Monument, CO
www.appliedweatherassociates.com

USSD 2014 Annual Meeting & Conference
April 7-11, 2014 San Francisco, CA

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

Applied Weather Associates

Background

- HMR 59-Published in 1999-newest yet still 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  - Based on outdated methods and techniques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
- Major issues with HMR 59
  - Highly subjective and not reproducible
  - Several inconsistencies and calculation errors
  - Not clear how storm data used to develop the PMP values
  - Covers a widely varying region
    - Climatologically
    - Topographically

Applied Weather Associates

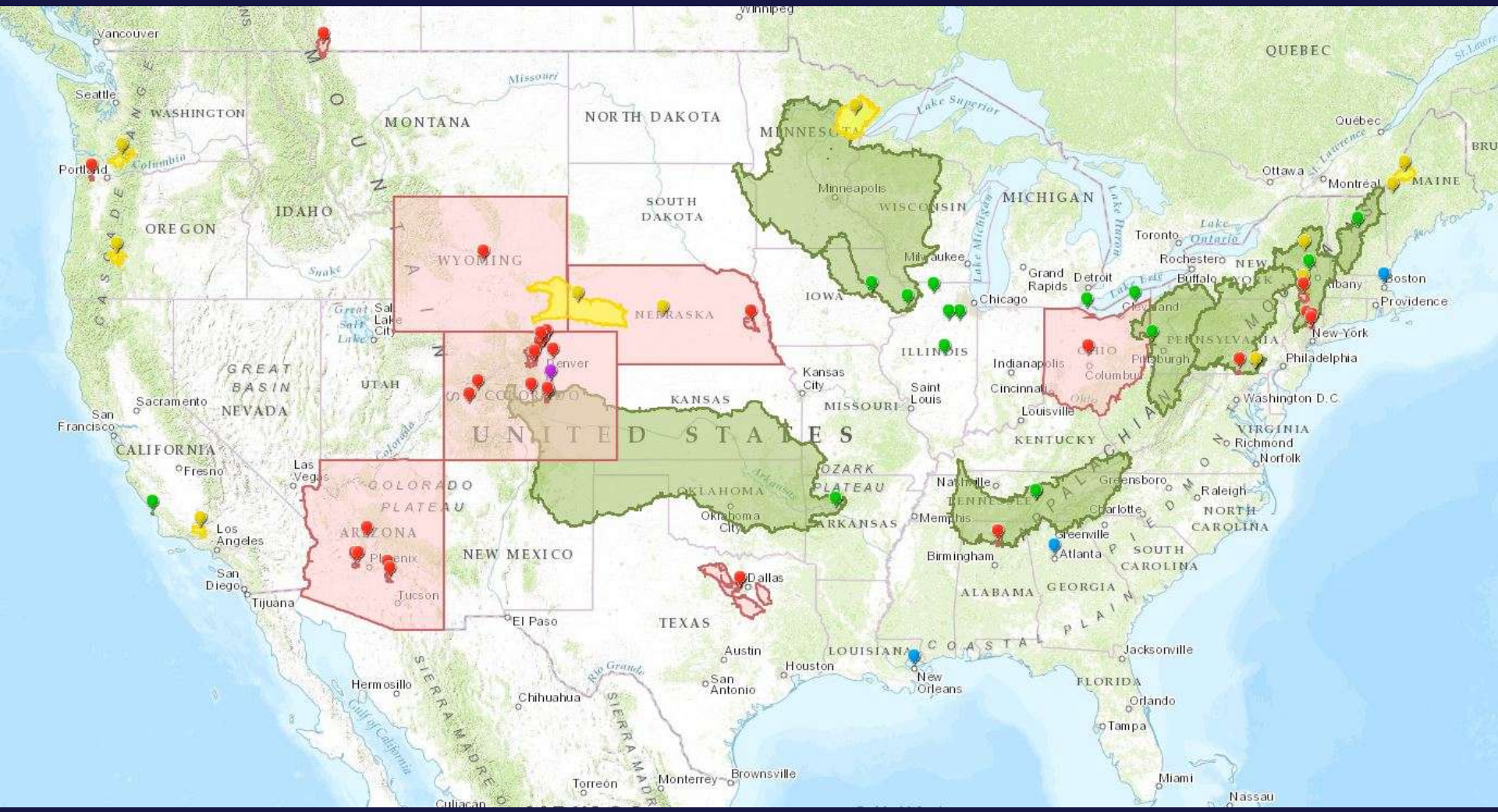
HMR 59 Domain and Location of Piru Creek Basin

How Did We Compute PMP?

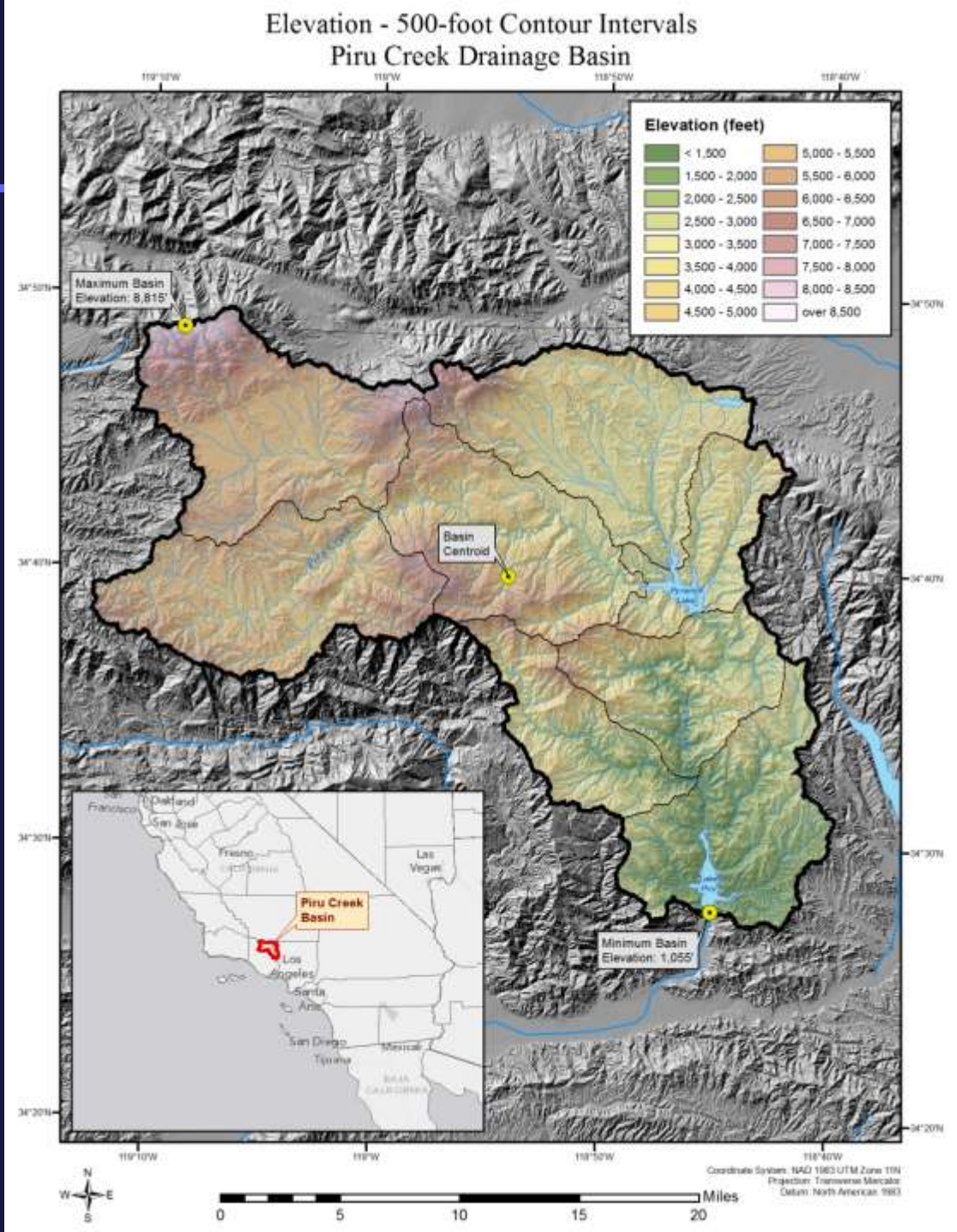
- Storm Based Approach-Deterministic
  - Similar to HMR/WMO procedures
  - Reproducible
  - Assumption/subjectivities explicitly stated
- Consistency with AWA PMP studies
  - Improvements in understanding of meteorology
  - Expanded storm data base
  - Use of computer technologies (HYSPLIT/GIS)
  - Use of NEXRAD weather radar
  - Better understanding of meteorology

Applied Weather Associates

Not Our First PMP Study



Elevations Across the Basin, 500 Foot Intervals

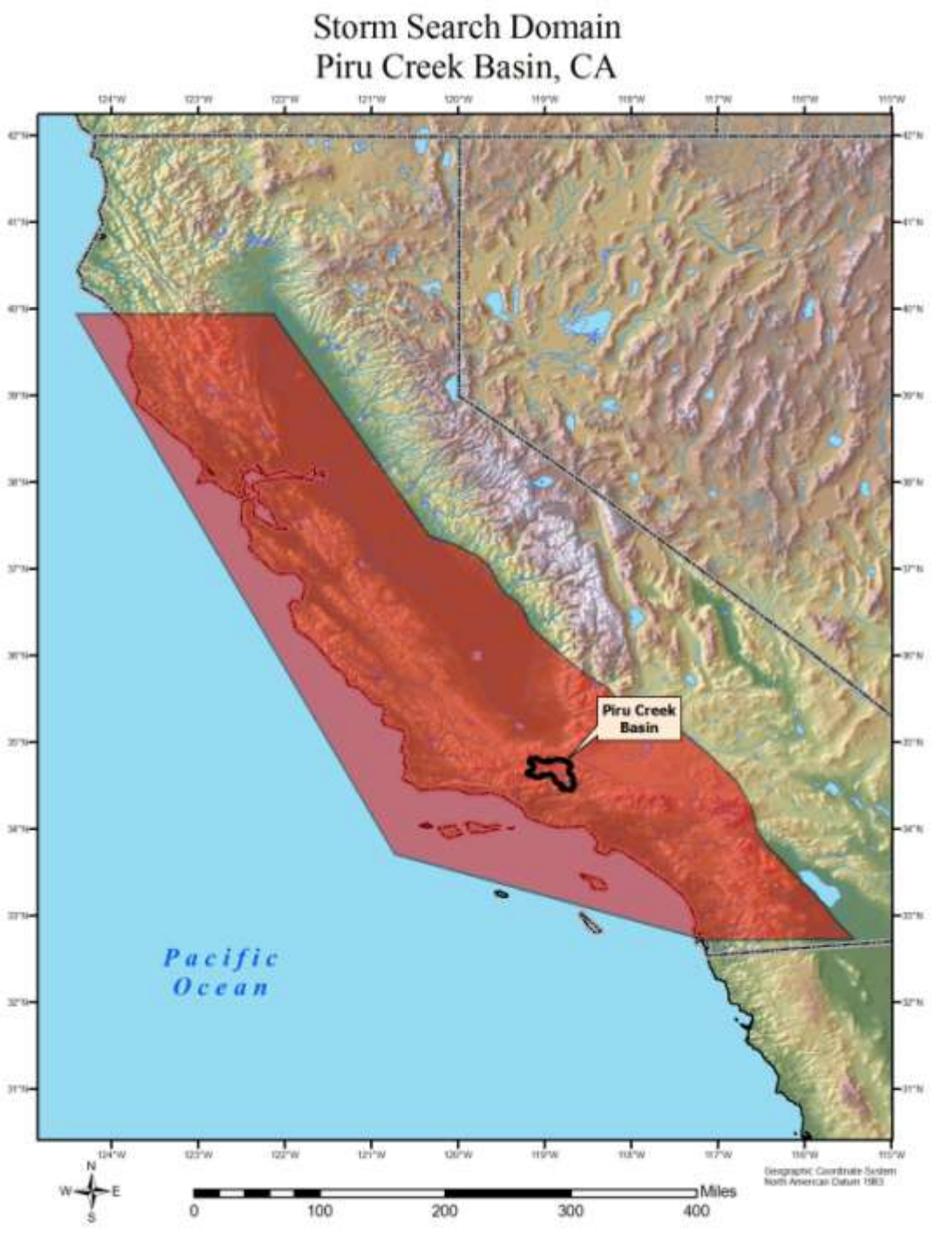


Updating PMP-What Did We Do

- 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

Applied Weather Associates

Piru Creek Storm Search Domain

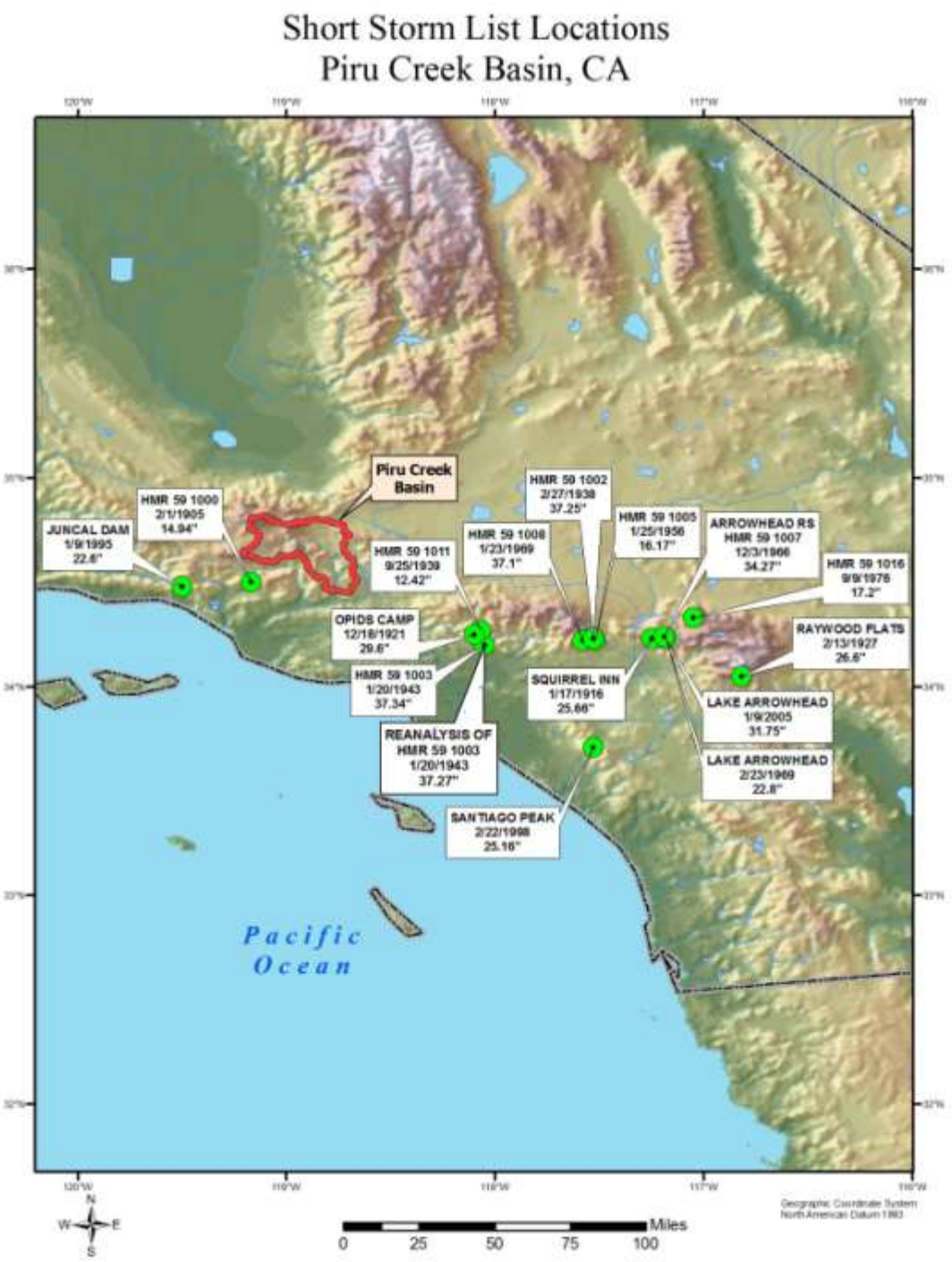


Updating PMP-Storm Search

- 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

Applied Weather Associates

Short List Storm Locations Used for PMP Development

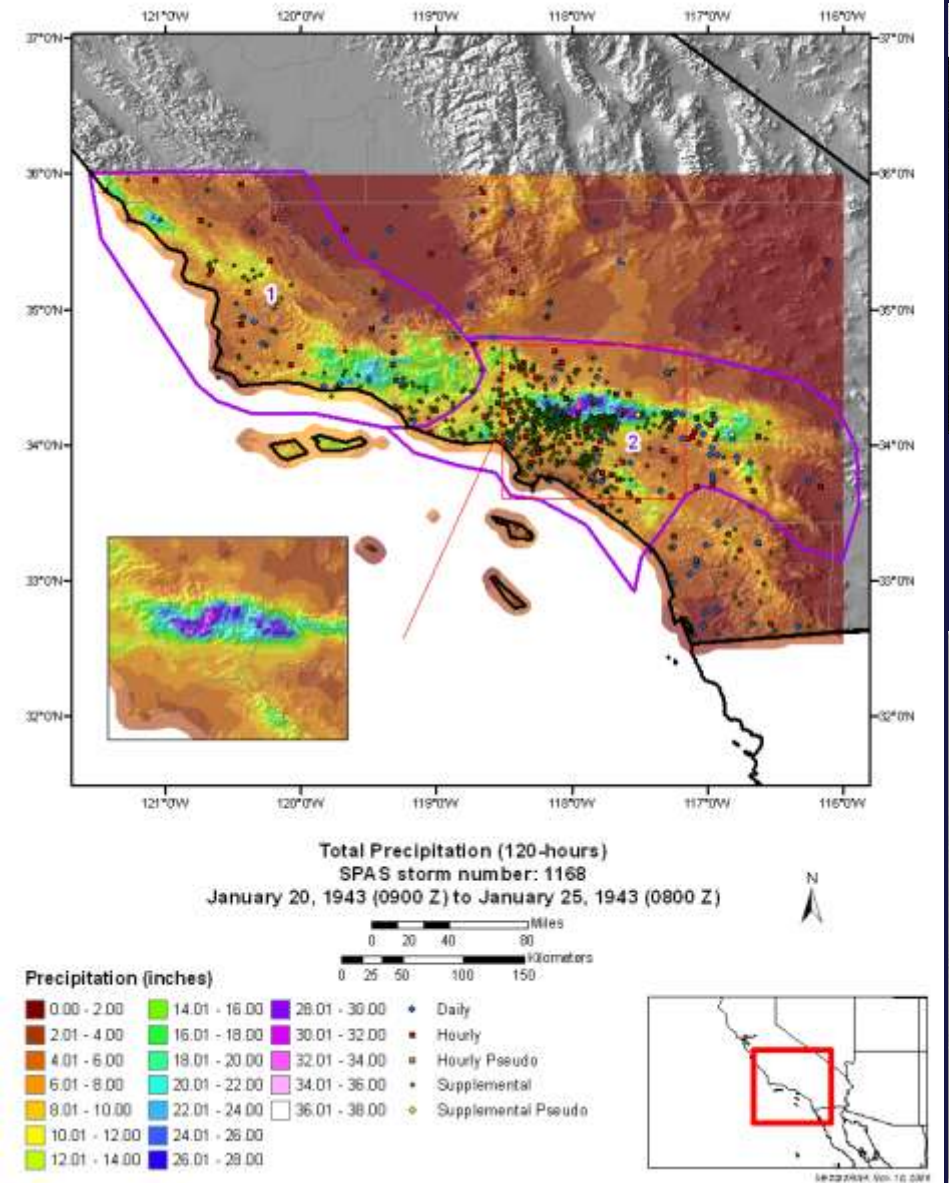


Updating PMP-Storm Analysis

- 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

Applied Weather Associates

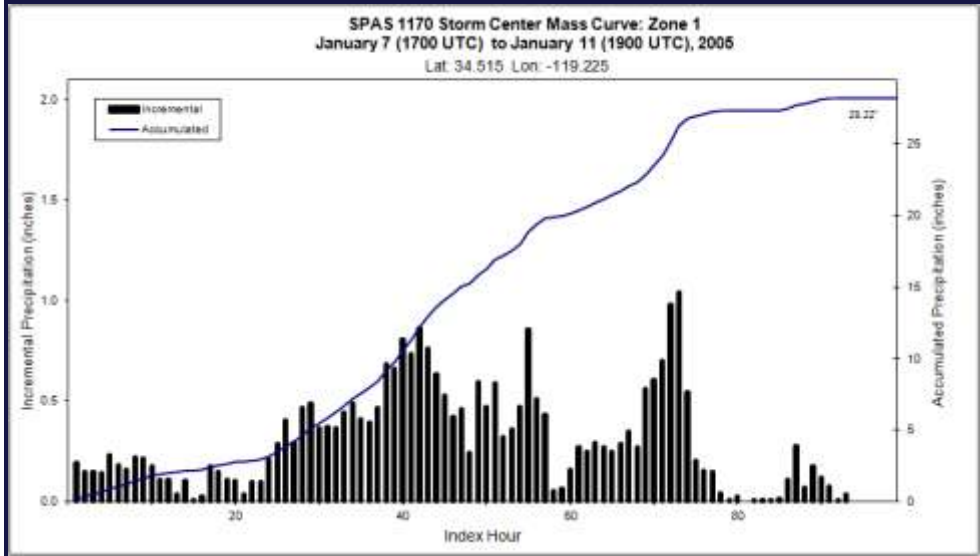
SPAS Storm Analysis Results



Storm 1170 - January 7 - 11, 2005

MAXIMUM AVERAGE DEPTH OF PRECIPITATION (INCHES)

	Duration (hours)											
Area (mi²)	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

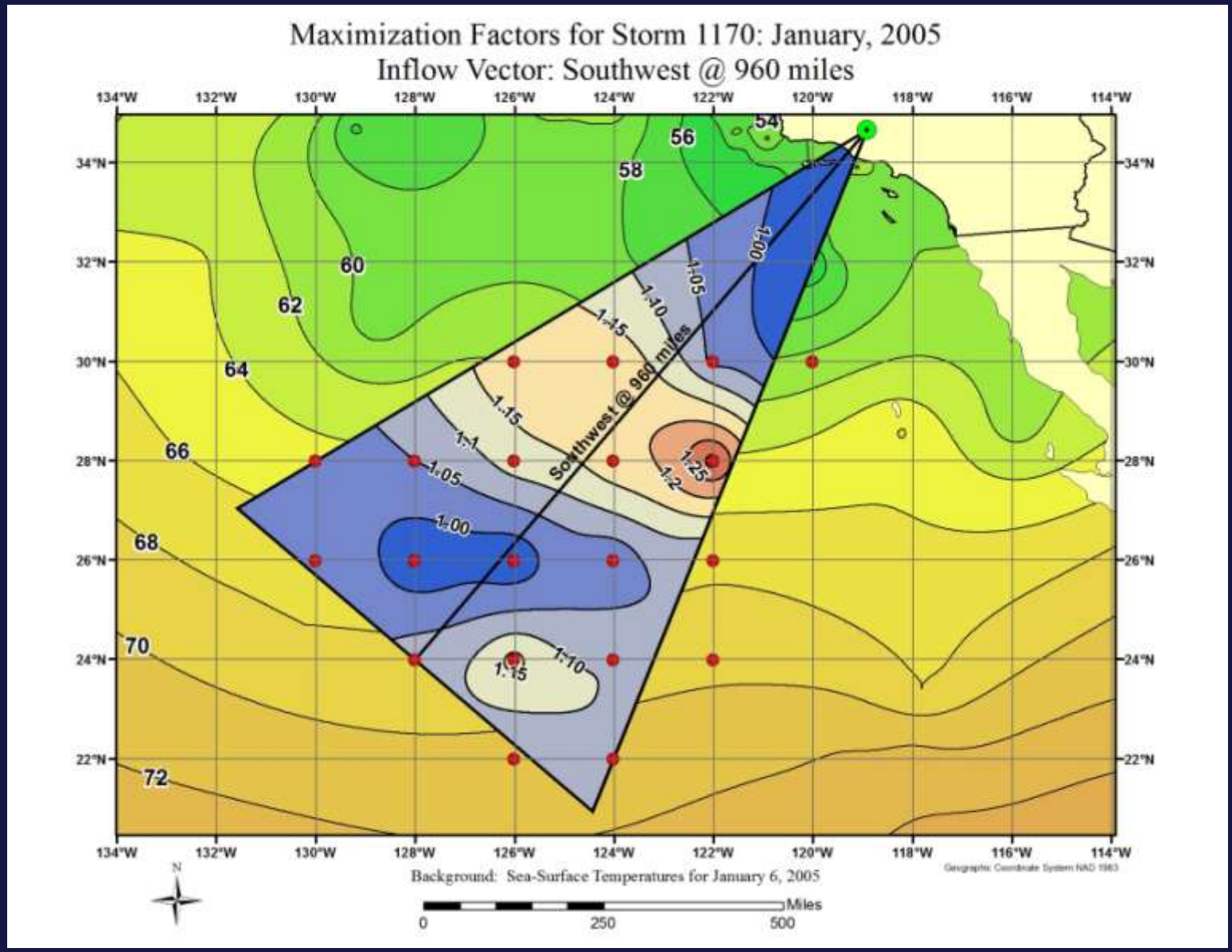


How Did We Compute PMP?

- 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

Applied Weather Associates

+2-sigma SST Maximization Sensitivity



How Did We Compute PMP?

- PMP on a ~2.5mi^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

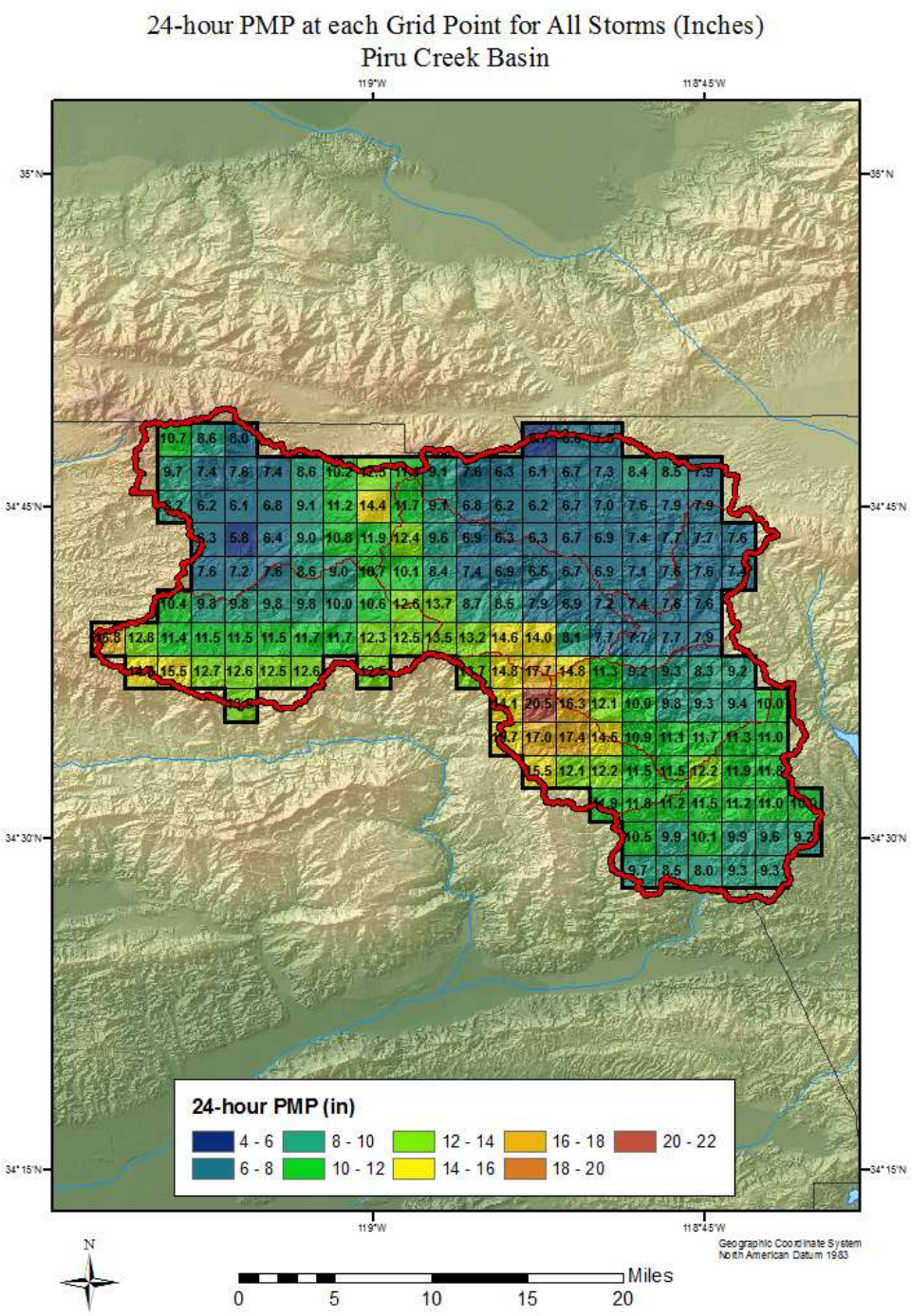
Applied Weather Associates

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



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

Applied Weather Associates

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-We 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 storm, short duration events (thunderstorms not considered)
  - AWA-Directed by BOC to focus on long-duration storms as short duration storms would in not result in the PMP/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 totally subjective and not reproducible. Misunderstanding of the process.

QUESTIONS

Bill Kappel, Applied Weather Associates
719-488-4311
billkappel@appliedweatherassociates.com
www.appliedweatherassociates.com

EXTRA SLIDES