The NEXRAD Revolution: Scientific Basis for Updating the HMR-49 Statistical Storm Intensities and PMPs

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2014 AIPG/AHS National Conference

September 15, 2014 Prescott, AZ

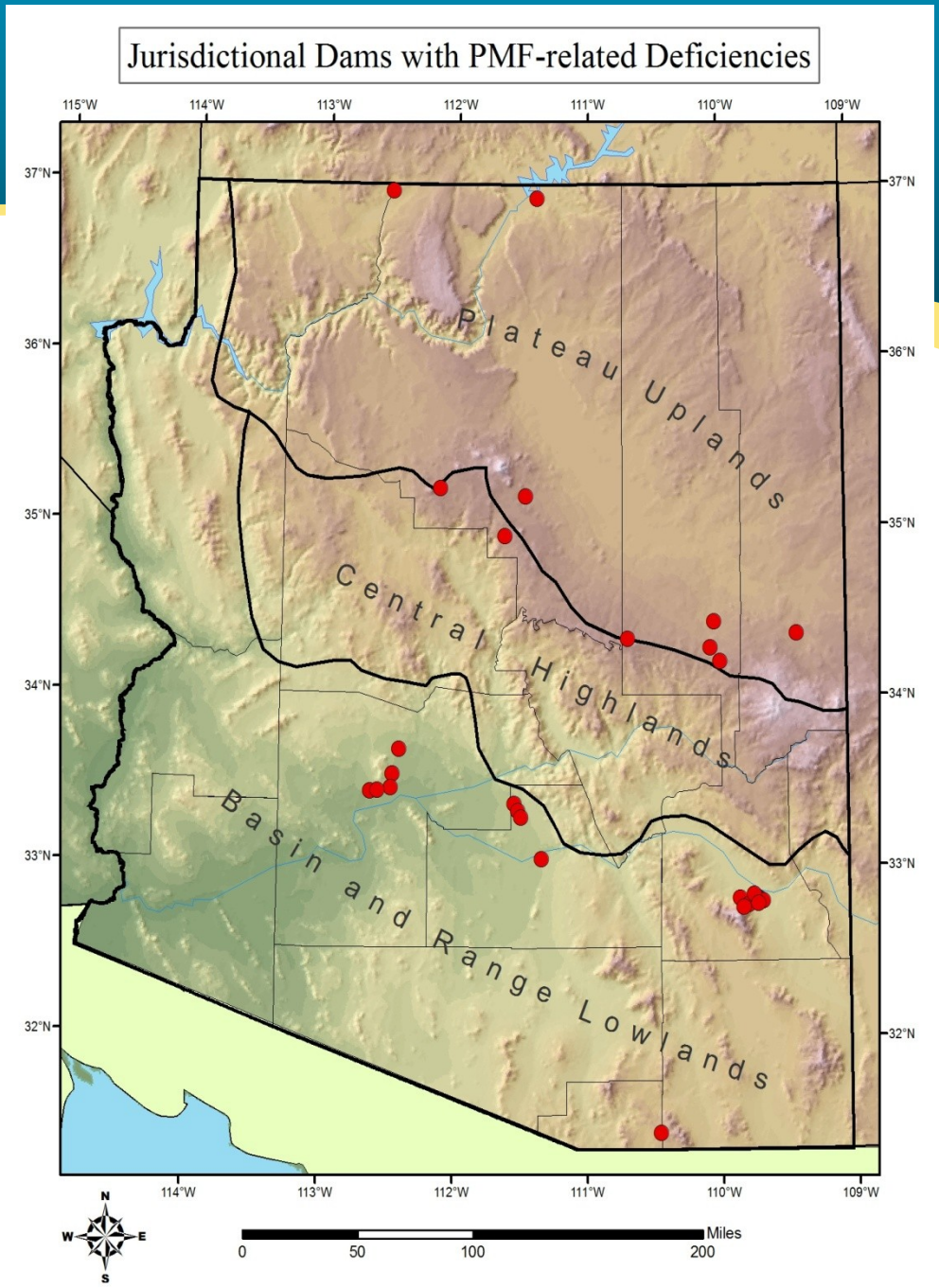
Reasons For Study

Deficient Dams:
29 state-regulated

>$75,000,000 estimated upgrade costs

State-of-practice data and understanding

Regulator/Owner confidence in results/applications



Reasons For Study

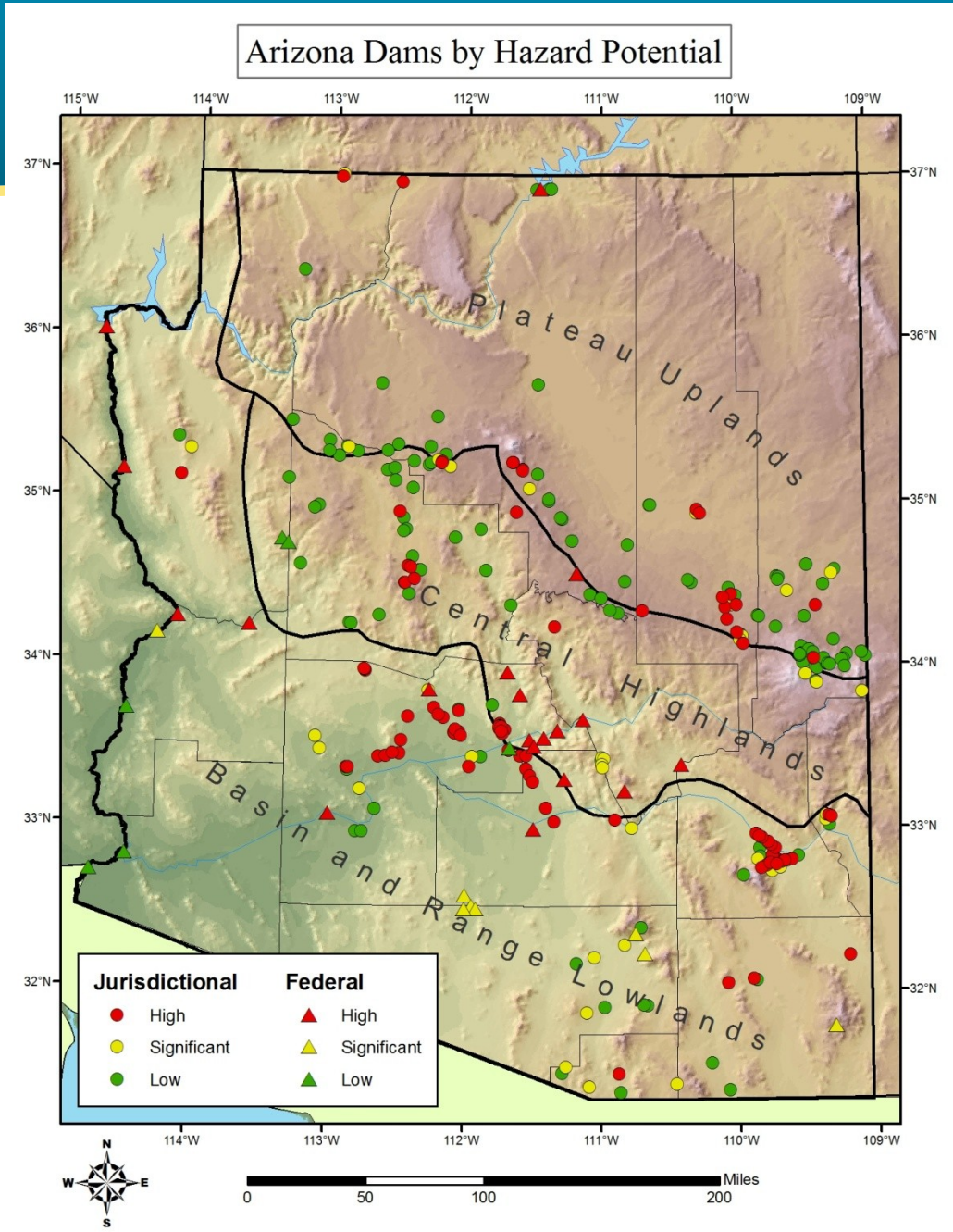
“Hazard creep”

In past 3 years:

17 dams reclassified

More than half deficient

156 more could be reclassified in the future



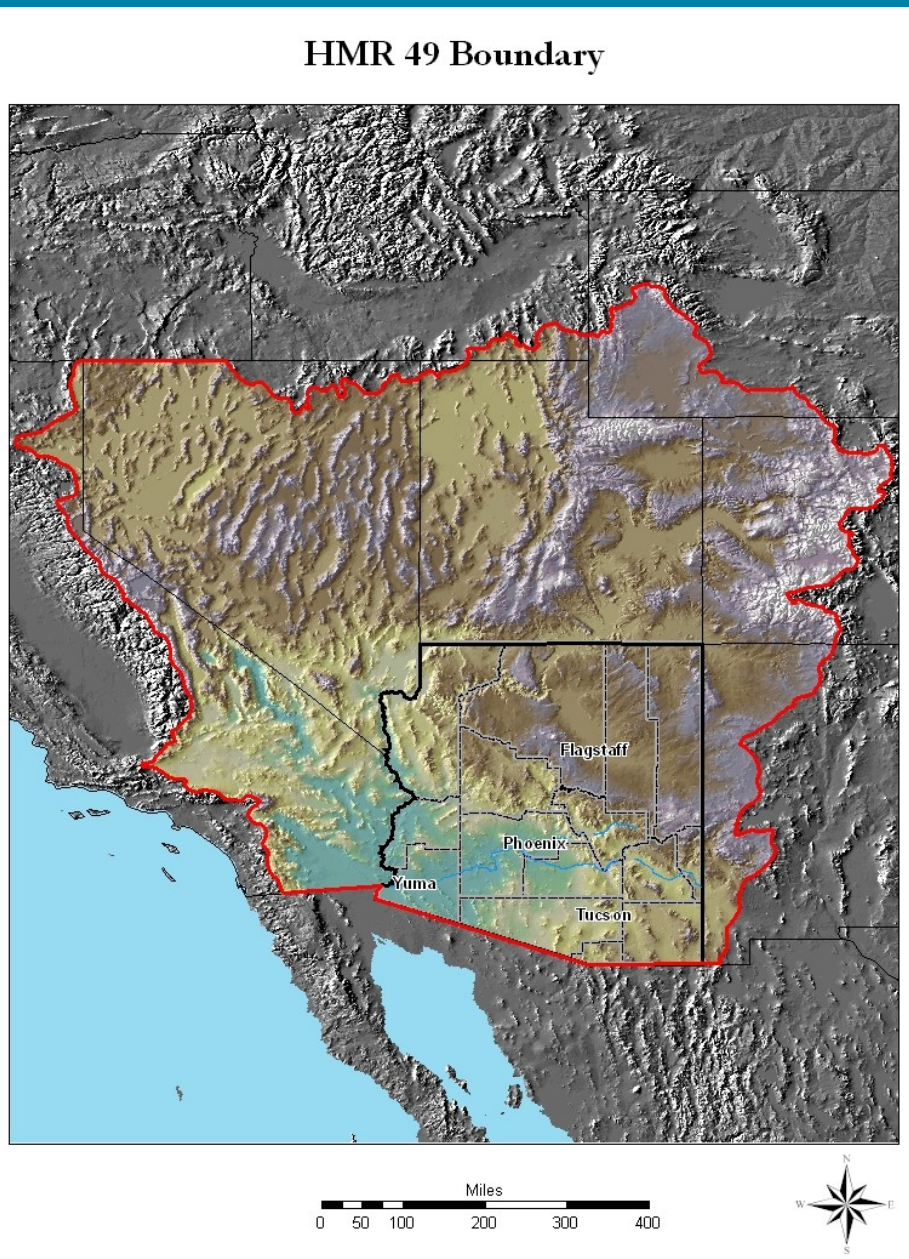
Cooperative Efforts

- Funding/Cooperating Partners
  - Arizona Department of Water Resources
  - Arizona Game & Fish Department
  - Maricopa County FCD
  - Navajo County FCD
  - NRCS
  - FEMA (NDSP State Assistance Grant)
- Working together all partners achieve desired results
- State/Users benefit at a reduced cost

Background

- HMR 49-Published in 1977
  - The oldest of the HMRs currently in use
  - Based on outdated methods and techniques
    - Subsequently been improved
      - Better understanding of meteorology
      - Updated datasets
      - Improved spatial analysis
    - Methods and techniques updated in newer HMRs
- Major issues with HMR 49
  - Lack of storm data used to develop the PMP values
    - Only a handful of storms were investigated
    - None were analyzed using individual storm Depth-Area-Duration (DAD) values
  - Covers a widely varying region
    - Climatologically/Topographically

HMR 49 Domain



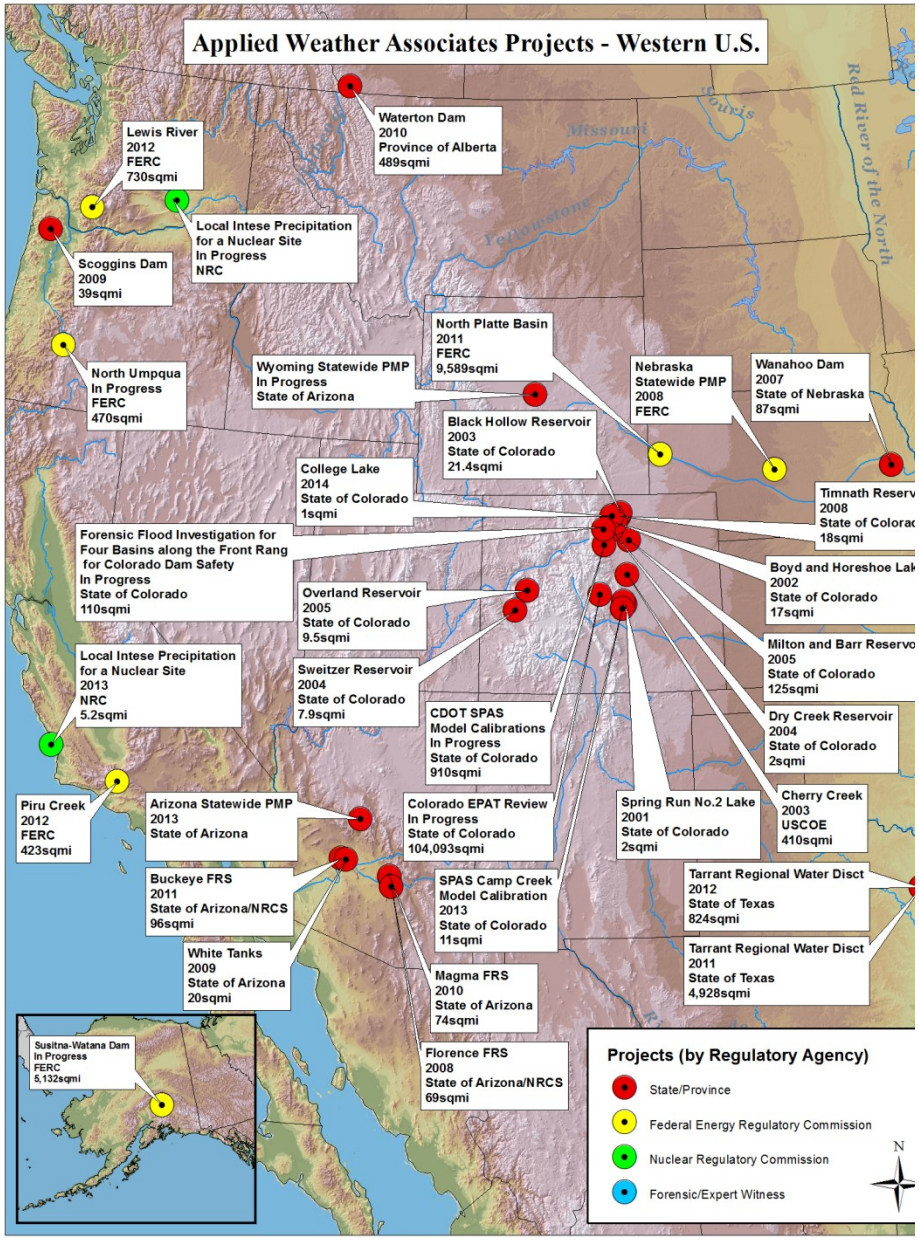
How Did We Compute PMP?

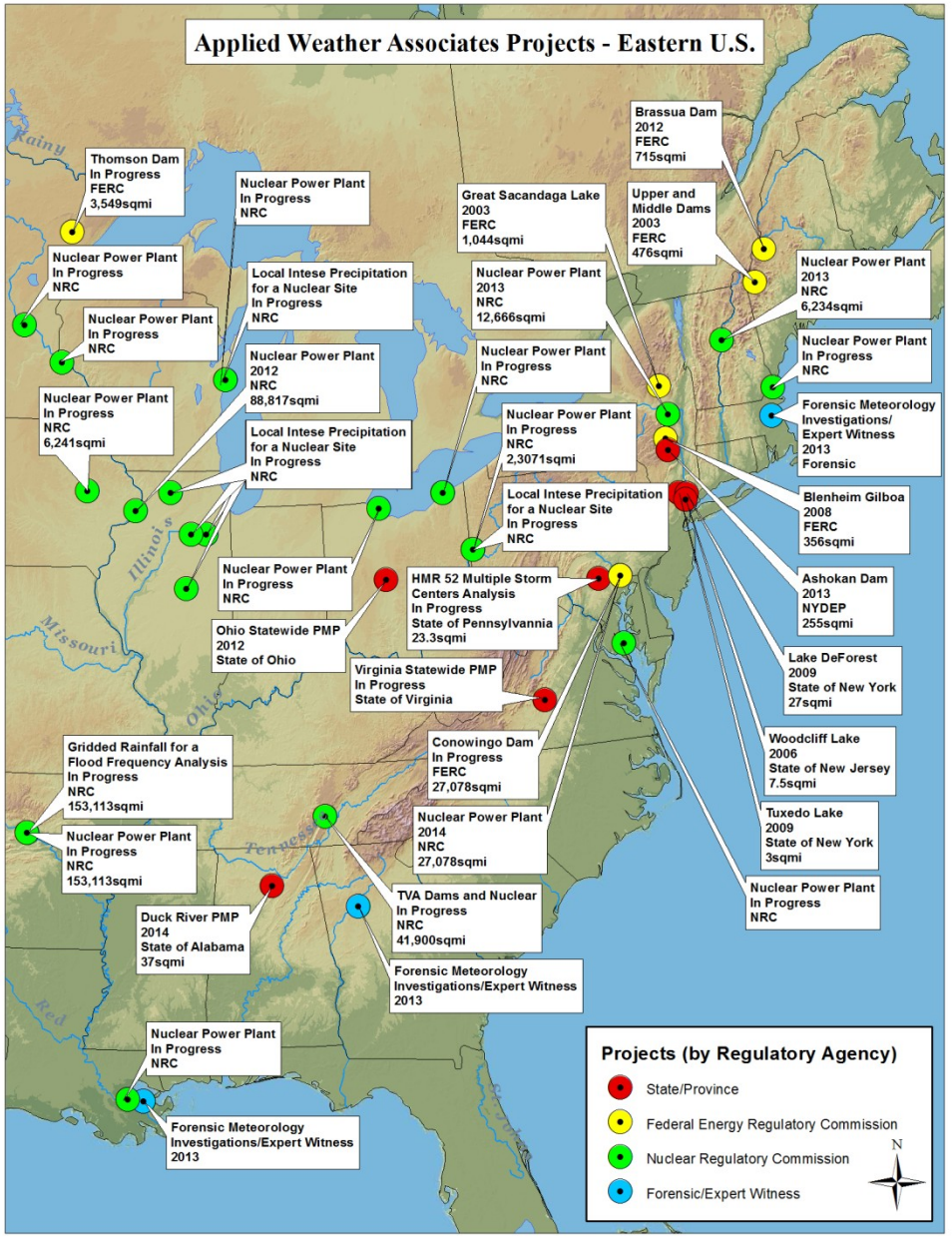
Storm Based Approach

- Similar to HMR/WMO procedures
- Deterministic

- Maintain consistency with AWA PMP studies
  - Improvements in understanding
  - Expanded data base
  - Use of computer technologies
  - Use of NEXRAD weather radar
  - Better understanding of meteorology

Not Our First PMP Study



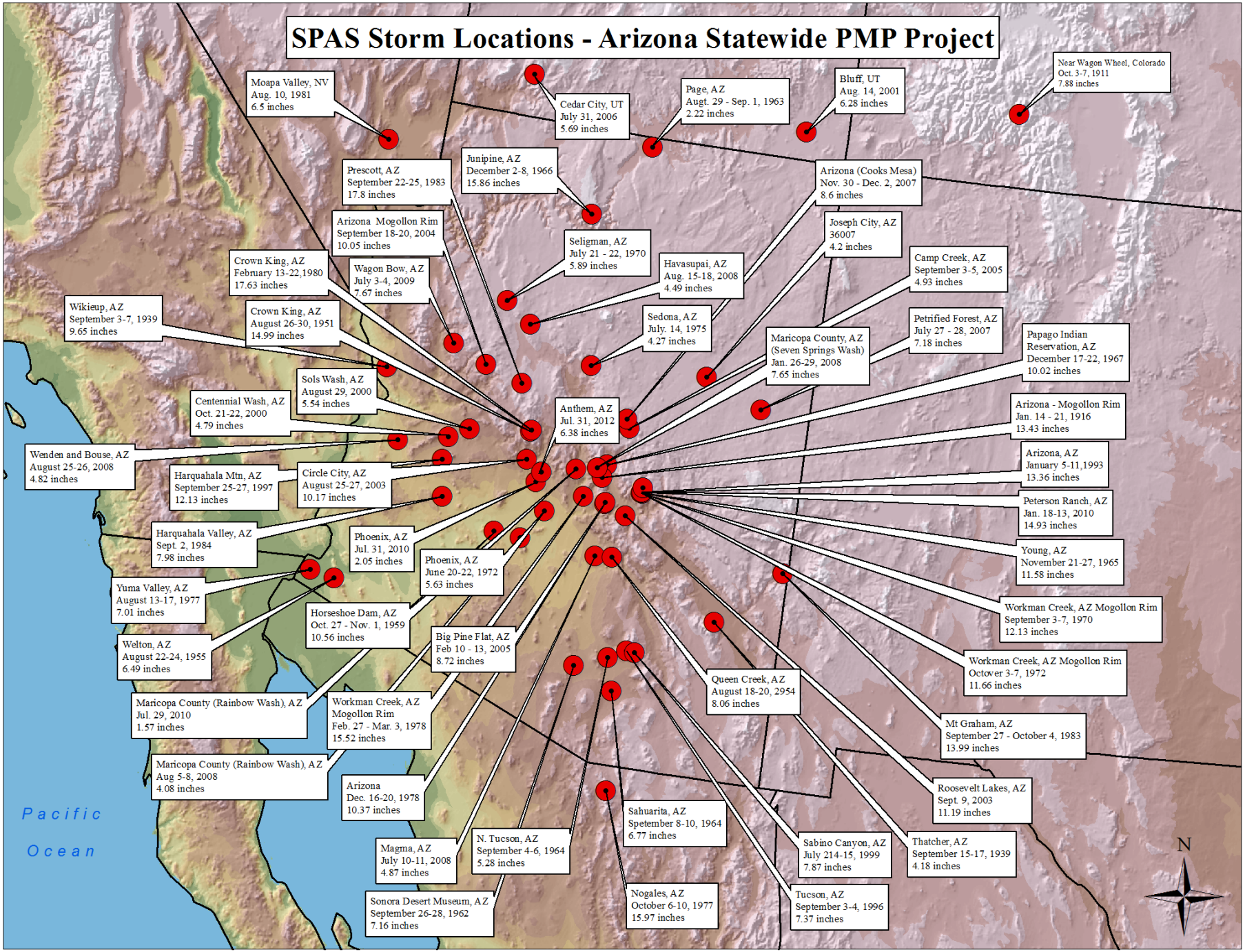


Updating PMP-What Did We Do

- Storm Search
  - Update the storm database
  - Identify the most extreme rainfall events
    - Throughout the state
    - Surrounding regions
  - Identify Storm Types
    - Local Convective
    - Remnant Tropical
    - General Frontal

Storm Data-The Foundation of It All

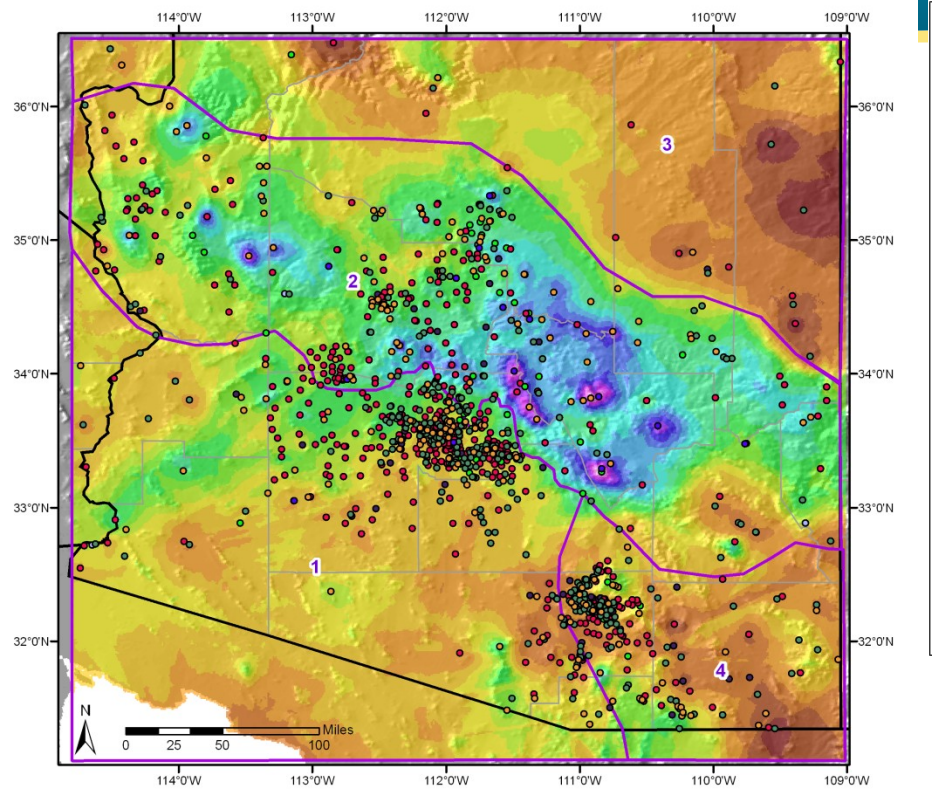
- Gridded rainfall foundation of all analyses
- Utilize the Storm Precipitation Analysis System (SPAS)
- Have analyzed hundreds of storms since 2002
  - Out of necessity
  - Follow basic procedures from NWS/USACE Storm Studies
- Provide valuable information on storm characteristics
  - Magnitude-Spatial-Temporal
- NEXRAD provides information to 5-minutes
  - Must correct NEXRAD data
  - Rain gauges ground truth
  - Dynamic adjustment of ZR equation


SPAS Storm Locations - Arizona Statewide PMP Project
Moapa Valley, NV
Aug. 10, 1981
6.5 inches
Cedar City, UT
July 31, 2006
5.69 inches
Page, AZ
Augt. 29 - Sep. 1, 1963
2.22 inches
Bluff, UT
Aug. 14, 2001
6.28 inches
Near Wagon Wheel, Colorado
Oct. 3-7, 1911
7.88 inches
Prescott, AZ
September 22-25, 1983
17.8 inches
Junipine, AZ
December 2-8, 1966
15.86 inches
Arizona (Cooks Mesa)
Nov. 30 - Dec. 2, 2007
8.6 inches
Arizona Mogollon Rim
September 18-20, 2004
10.05 inches
Seligman, AZ
July 21 - 22, 1970
5.89 inches
Joseph City, AZ
36007
4.2 inches
Crown King, AZ
February 13-22,1980
17.63 inches
Wagon Bow, AZ
July 3-4, 2009
7.67 inches
Havasupai, AZ
Aug. 15-18, 2008
4.49 inches
Camp Creek, AZ
September 3-5, 2005
4.93 inches
Wikieup, AZ
September 3-7, 1939
9.65 inches
Crown King, AZ
August 26-30, 1951
14.99 inches
Sedona, AZ
July. 14, 1975
4.27 inches
Petrified Forest, AZ
July 27 - 28, 2007
7.18 inches
Maricopa County, AZ
(Seven Springs Wash)
Jan. 26-29, 2008
7.65 inches
Papago Indian
Reservation, AZ
December 17-22, 1967
10.02 inches
Sols Wash, AZ
August 29, 2000
5.54 inches
Centennial Wash, AZ
Oct. 21-22, 2000
4.79 inches
Anthem, AZ
Jul. 31, 2012
6.38 inches
Arizona - Mogollon Rim
Jan. 14 - 21, 1916
13.43 inches
Wenden and Bouse, AZ
August 25-26, 2008
4.82 inches
Harquahala Mtn, AZ
September 25-27, 1997
12.13 inches
Circle City, AZ
August 25-27, 2003
10.17 inches
Arizona, AZ
January 5-11,1993
13.36 inches
Peterson Ranch, AZ
Jan. 18-13, 2010
14.93 inches
Harquahala Valley, AZ
Sept. 2, 1984
7.98 inches
Phoenix, AZ
Jul. 31, 2010
2.05 inches
Phoenix, AZ
June 20-22, 1972
5.63 inches
Young, AZ
November 21-27, 1965
11.58 inches
Yuma Valley, AZ
August 13-17, 1977
7.01 inches
Horseshoe Dam, AZ
Oct. 27 - Nov. 1, 1959
10.56 inches
Workman Creek, AZ Mogollon Rim
September 3-7, 1970
12.13 inches
Welton, AZ
August 22-24, 1955
6.49 inches
Big Pine Flat, AZ
Feb 10 - 13, 2005
8.72 inches
Workman Creek, AZ Mogollon Rim
Octover 3-7, 1972
11.66 inches
Queen Creek, AZ
August 18-20, 2954
8.06 inches
Maricopa County (Rainbow Wash), AZ
Jul. 29, 2010
1.57 inches
Workman Creek, AZ
Mogollon Rim
Feb. 27 - Mar. 3, 1978
15.52 inches
Mt Graham, AZ
September 27 - October 4, 1983
13.99 inches
Maricopa County (Rainbow Wash), AZ
Aug 5-8, 2008
4.08 inches
Arizona
Dec. 16-20, 1978
10.37 inches
Roosevelt Lakes, AZ
Sept. 9, 2003
11.19 inches
Sahuarita, AZ
Spetember 8-10, 1964
6.77 inches
Pacific
Ocean
Magma, AZ
July 10-11, 2008
4.87 inches
N. Tucson, AZ
September 4-6, 1964
5.28 inches
Sabino Canyon, AZ
July 214-15, 1999
7.87 inches
Thatcher, AZ
September 15-17, 1939
4.18 inches
Nogales, AZ
October 6-10, 1977
15.97 inches
Tucson, AZ
September 3-4, 1996
7.37 inches
Sonora Desert Museum, AZ
September 26-28, 1962
7.16 inches
N

Updating PMP-Storm Analysis

- Storm Precipitation Analysis System (SPAS)
  - Depth-Area-Duration
  - Mass Curves
  - Storm Isohyetal
  - Hourly (5-minute rainfall) at 1/3rd square mile
    - 200 –square meters with Dual-Pol
  - Dynamically adjusted radar and/or basemap for spatial interpolation

SPAS Storm Analysis Results

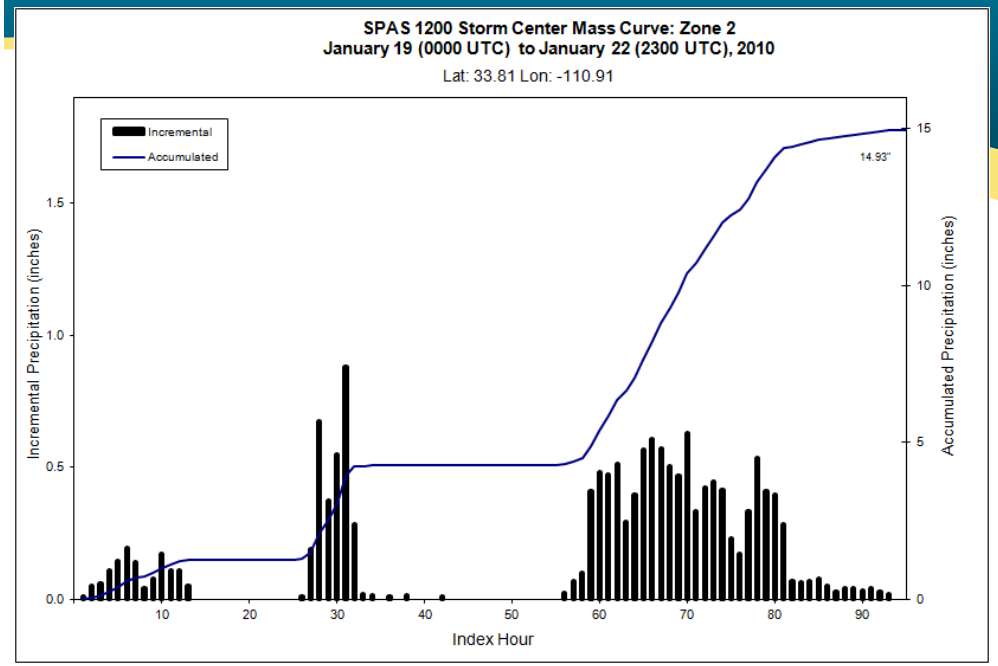


Hourly and daily station data extraction information:
SPAS storm number: 1200
Begin: 01/19/2010 0000Z
End: 01/22/2010 2359Z
Domain: 36.5 -114.8 31.1 -109.0

Precipitation (inches)

0.00 - 0.50	3.51 - 4.00	10.01 - 11.00	Daily
0.51 - 1.00	4.01 - 5.00	11.01 - 12.00	Hourly
1.01 - 1.50	5.01 - 6.00	12.01 - 13.00	Hourly Estimated
1.51 - 2.00	6.01 - 7.00	13.01 - 14.00	Hourly Estimated Pseudo
2.01 - 2.50	7.01 - 8.00	14.01 - 15.00	Hourly Pseudo
2.51 - 3.00	8.01 - 9.00		Supplemental
3.01 - 3.50	9.01 - 10.00		Supplemental Estimated

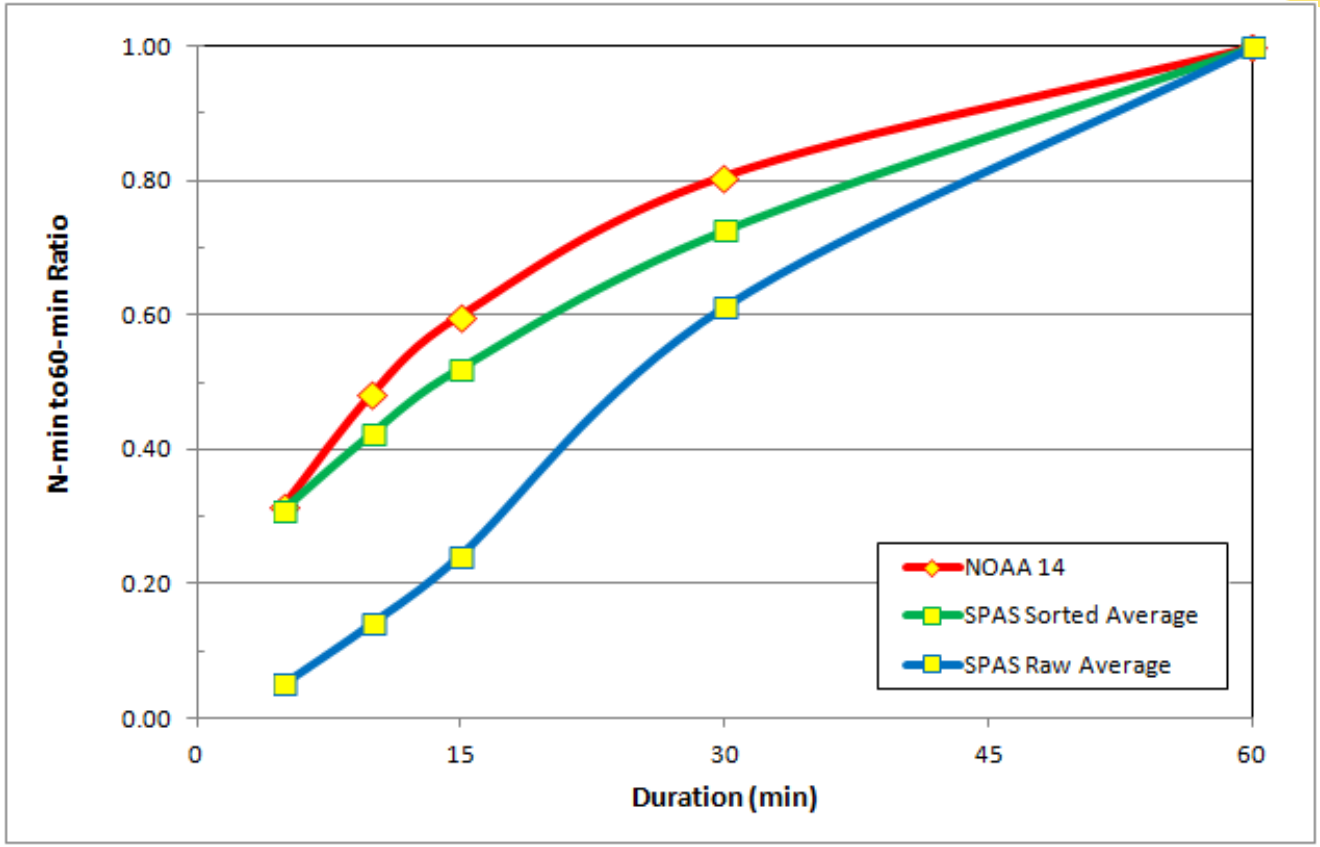
METSTAT 1/3/2011



Storm 1200 - January 19, 2010 (0000 UTC) - January 22, 2010 (0400 UTC)
MAXIMUM AVERAGE DEPTH OF PRECIPITATION (INCHES)

	Duration (hours)										
Area (mi²)	1	3	6	12	18	24	36	48	72	95	Total
0	1.15	2.33	3.8	6.03	8.09	9.98	10.6	10.99	13.66	14.93	14.93
1	1.1	2.26	3.71	5.81	7.92	9.72	10.39	10.7	13.43	14.57	14.57
10	1.04	2.09	3.64	5.75	7.56	9.1	9.94	10.27	12.95	14.52	14.52
25	0.96	2.01	3.54	5.56	7.31	8.7	9.62	9.89	12.53	13.99	13.99
50	0.88	1.97	3.39	5.38	7.02	8.46	9.33	9.51	12.16	13.44	13.44
100	0.85	1.89	3.31	5.09	6.84	8.05	8.98	9.15	11.67	12.82	12.82
150	0.82	1.83	3.21	4.86	6.57	7.95	8.79	8.9	11.34	12.44	12.44
200	0.8	1.79	3.14	4.72	6.53	7.7	8.56	8.73	11.18	12.18	12.18
300	0.73	1.72	3.02	4.58	6.26	7.57	8.36	8.52	10.89	11.79	11.79
400	0.72	1.66	2.94	4.48	6.04	7.36	8.14	8.31	10.6	11.51	11.51
500	0.71	1.61	2.87	4.4	5.76	7.1	7.97	8.12	10.29	11.28	11.28
1,000	0.62	1.34	2.34	4	5.53	6.37	7.05	7.51	8.75	10.48	10.48
2,000	0.52	1.29	2.28	3.6	4.95	5.93	6.64	6.64	8.51	9.78	9.78
5,000	0.43	1.08	1.93	2.92	4.4	5.1	5.78	5.78	7.49	8.6	8.60
10,000	0.39	0.9	1.59	2.77	3.78	4.39	5.04	5.21	6.57	7.58	7.58
20,000	0.28	0.71	1.29	2.32	2.88	3.53	4.28	4.59	5.51	6.37	6.37
40,231	0.19	0.53	1.02	1.74	2.35	2.77	3.23	3.43	4.36	4.74	4.74

SPAS Storm Analysis Results



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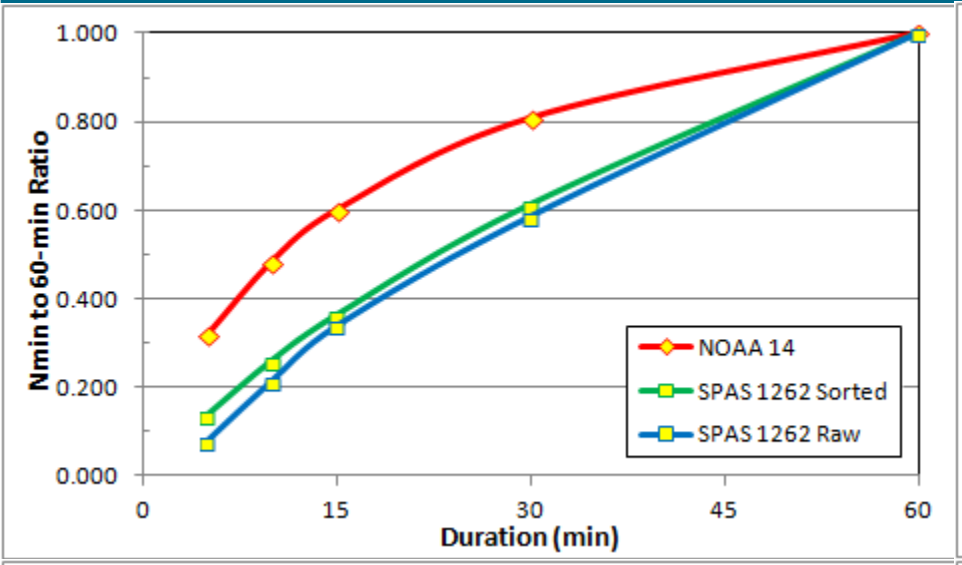

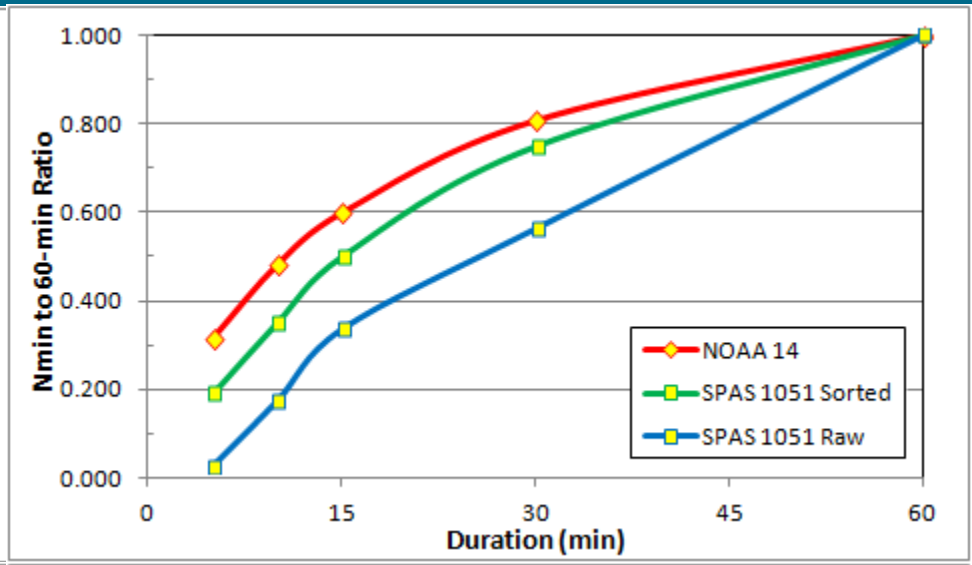

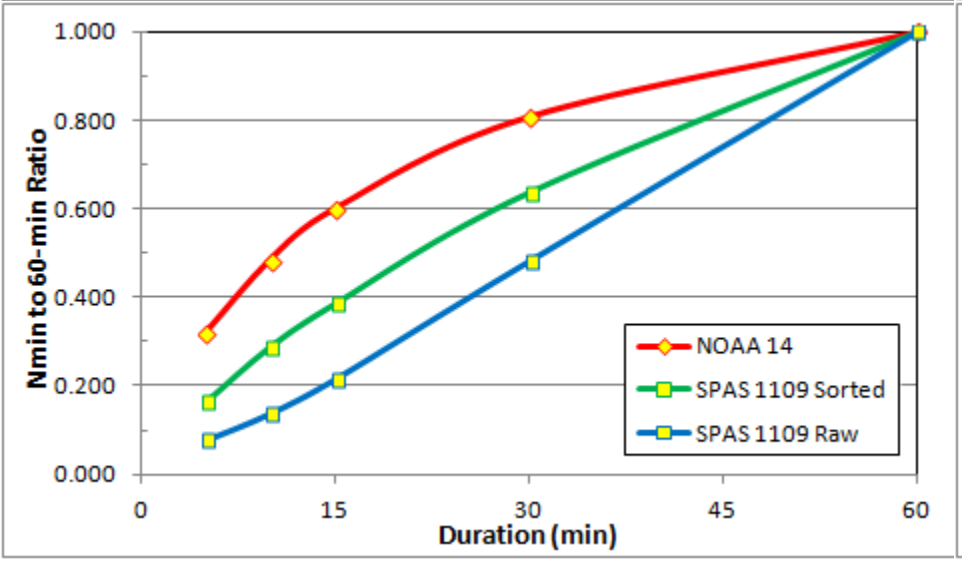

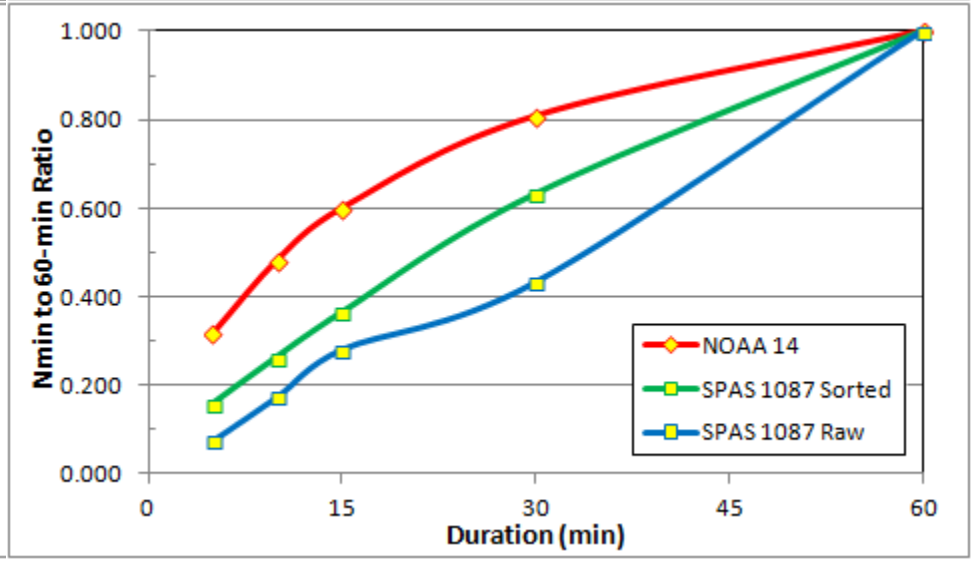

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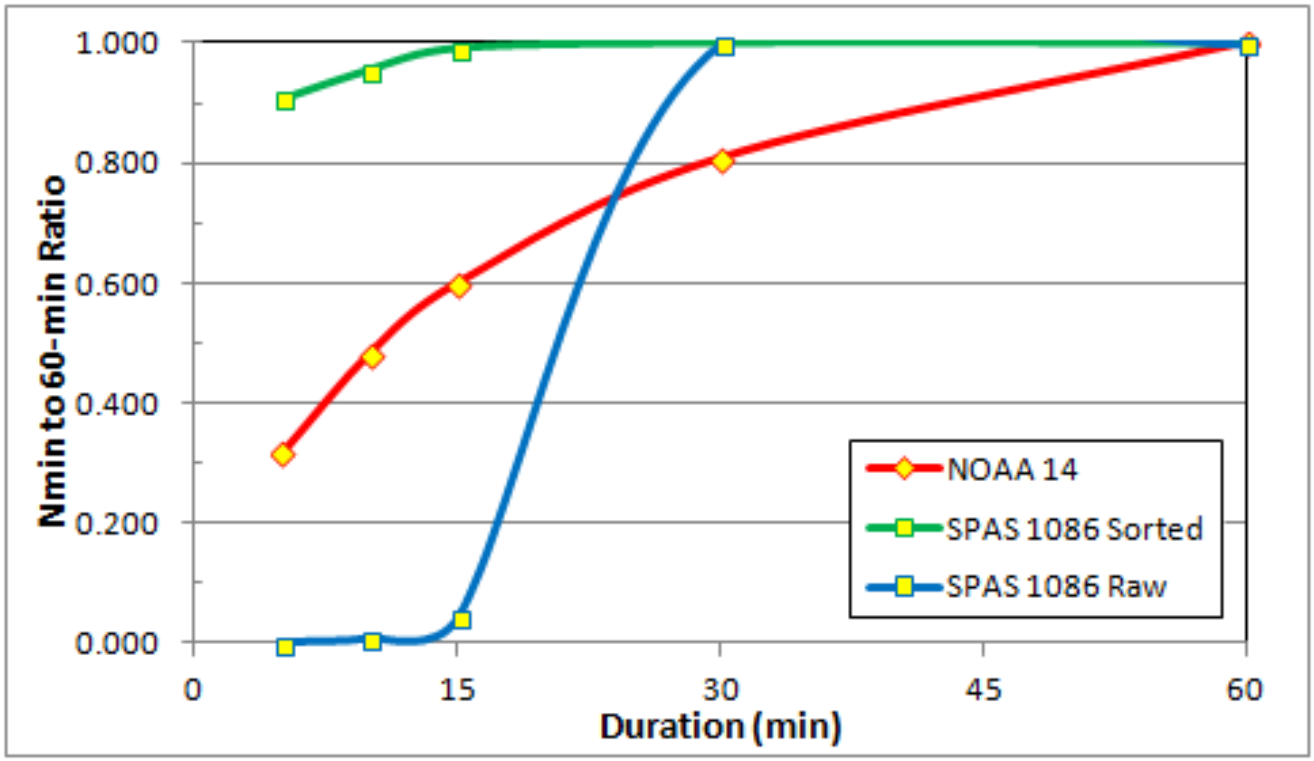
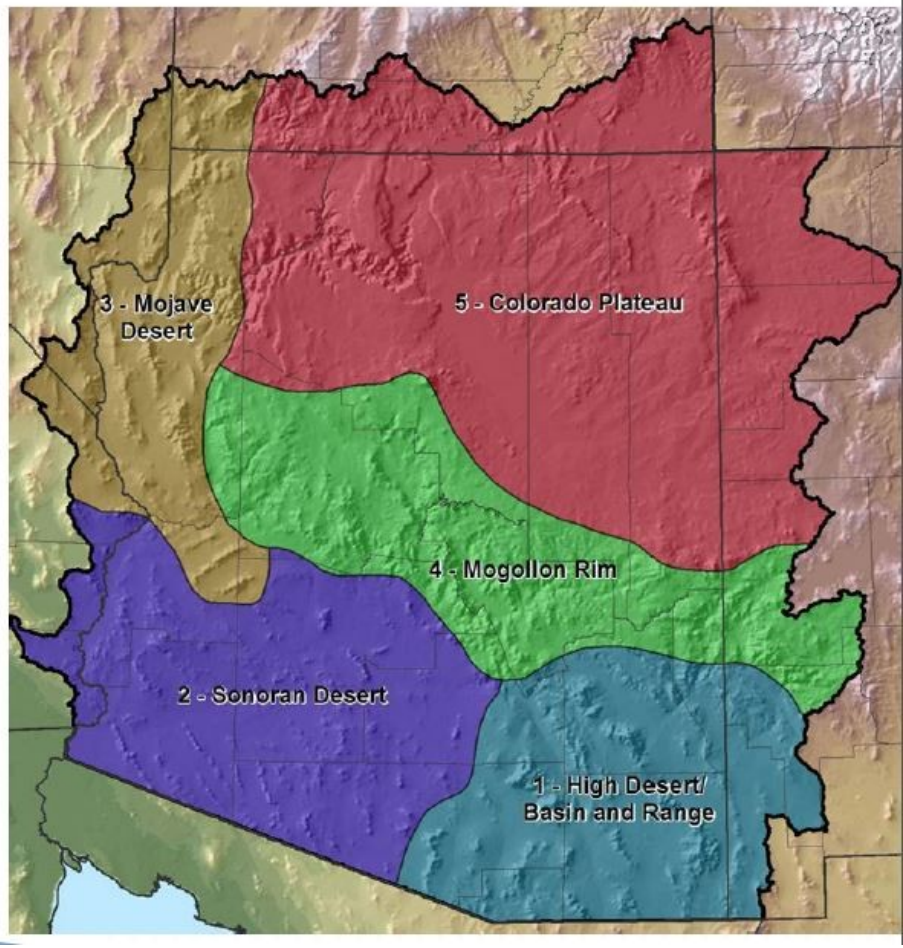


Statewide Example PMP Results

- Percent Differences from HMR 49 for 1-hr, 1 mi^2 PMP Depth
  - Based on values at ≈60,000 grid cells

Region	*Min*	Mean	*Max*
STATEWIDE	*-56%*	**-10%**	*+34%*
High Desert/ Basin & Range	*-56%*	**-42%**	*-23%*
Sonoran Desert	*-26%*	**+1%**	*+14%*
Mohave Desert	*-36%*	**+4%**	*+17%*
Mogollon Rim	*-46%*	**+1%**	*+21%*
Colorado Plateau	*-41%*	**-14%**	*+34%*



Summary

- Immense amount of storm data
  - Ability to consider site-specific characteristics
- Higher confidence in results/data
- Significant cost savings
  - More accurate engineering/design
  - Infrastructure not overbuilt
- More storms need to be analyzed
- NEXRAD provides previously missing data
  - Must be used/adjusted appropriately

QUESTIONS

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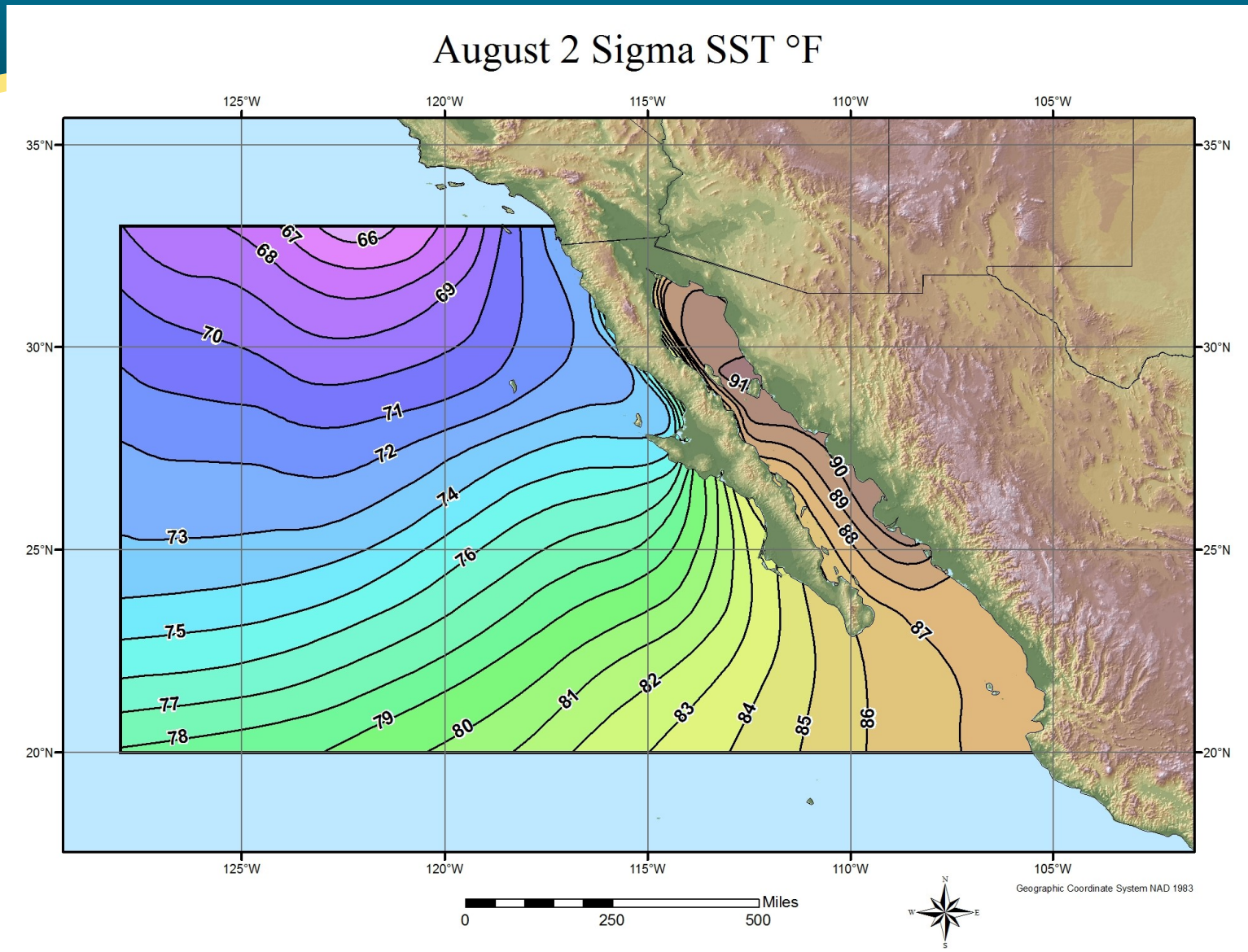
Sea Surface Temp, August +2-sigma



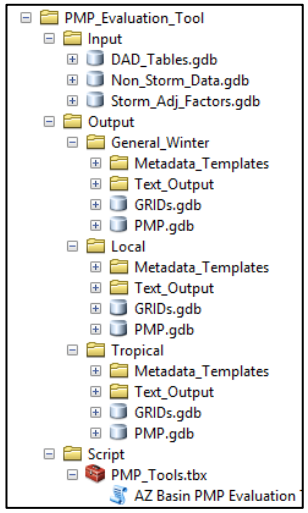
How Did We Compute PMP?

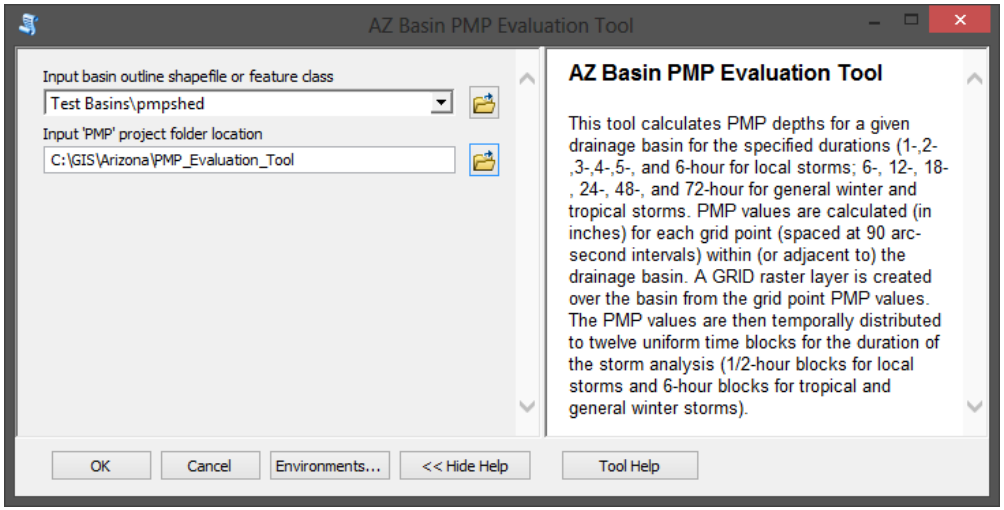
- PMP on a ~2.5mi^2 grid
  - 64,103 grid cells-that's a lot of data!
- Move maximized storms to each grid
- Account for differences in moisture and elevation
- Calculate the Orographic Transposition Factor (OTF)
  - Uses Precip Frequency-NOAA Atlas 14
  - Difference between source and target location
- OTF-Quantifiable/Reproducible
  - Replaces HMR SSM, K-Factor
    - Highly subjective
    - Not reproducible
- Results in total adjustment factor
- Apply to the DAD values

Applied Weather Associates

PMP Evaluation Tool (PET)

- Calculates gridded PMP for a user-defined drainage basin
- Custom Python-based scripted tool
  - Designed to be used within the ArcGIS environment
  - Flexible for future updates/enhancements
- Iterates through a storm database
  - Currently 93 maximized historical DAD tables
  - Adjusted to each grid cell
- Produces temporally distributed PMP output in both vector and raster GIS file formats for the basin spatial extent





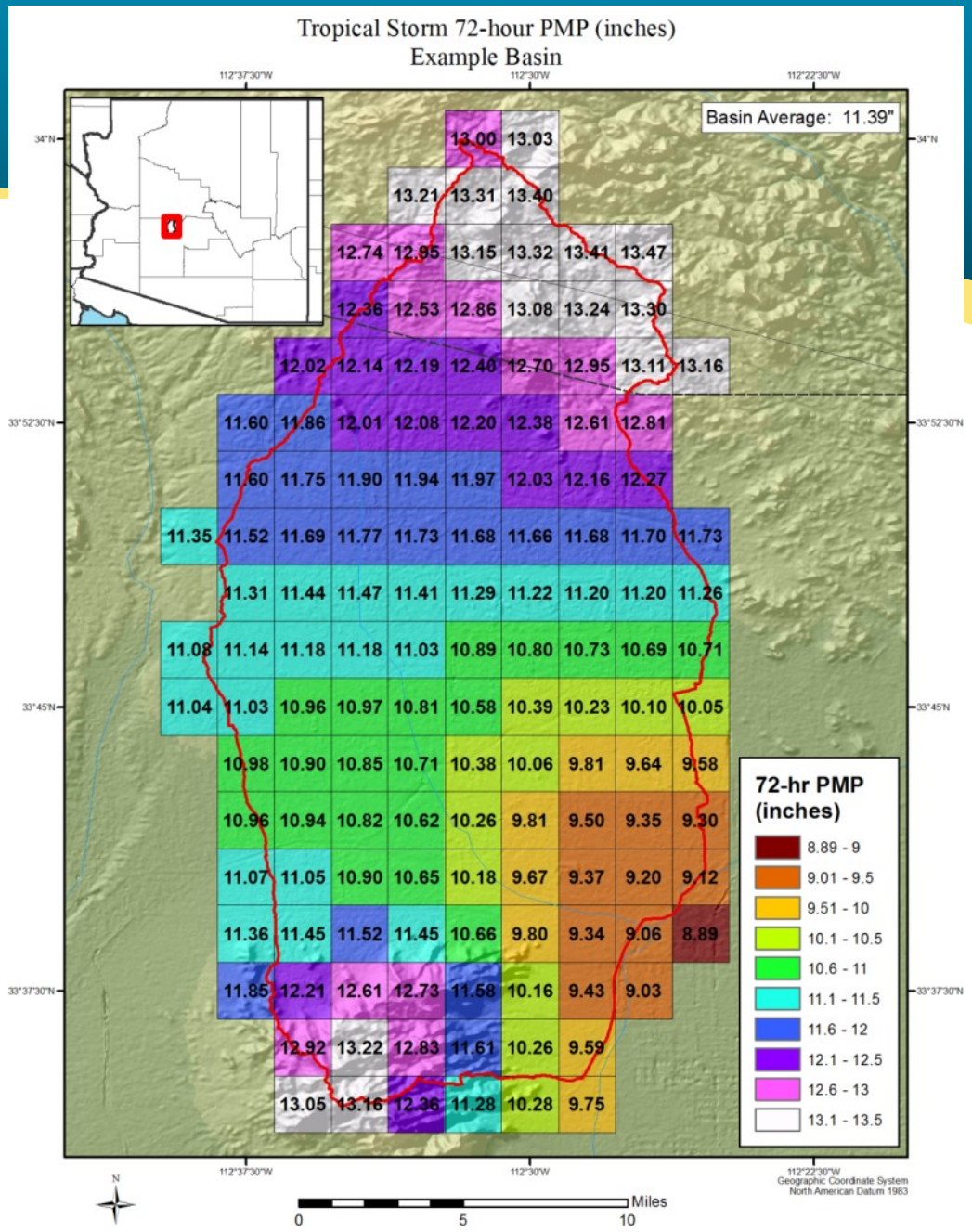
Applied Weather Associates

Example PMP Results

72-hour tropical storm PMP values

Provide basin, sub basin, or grid values/average

Associated with storm type temporal timing

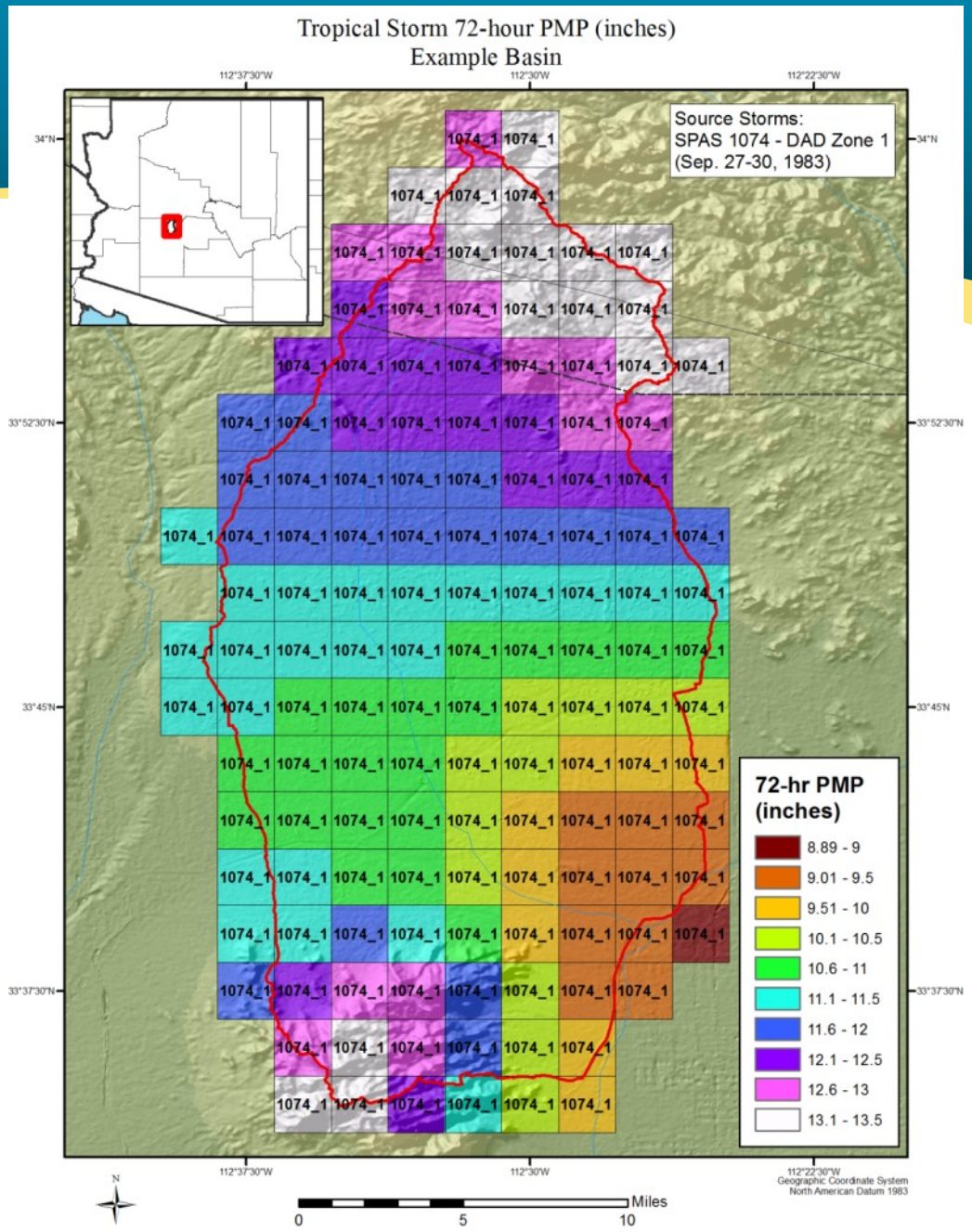


Example PMP Results

72-hour tropical storm PMP

Source storm ID by SPAS storm number

Allows for back calculation and verification



Elevations Across Arizona, 1,000 Foot Interval