Statistical Analysis of Hydrology in California under Climate Variability

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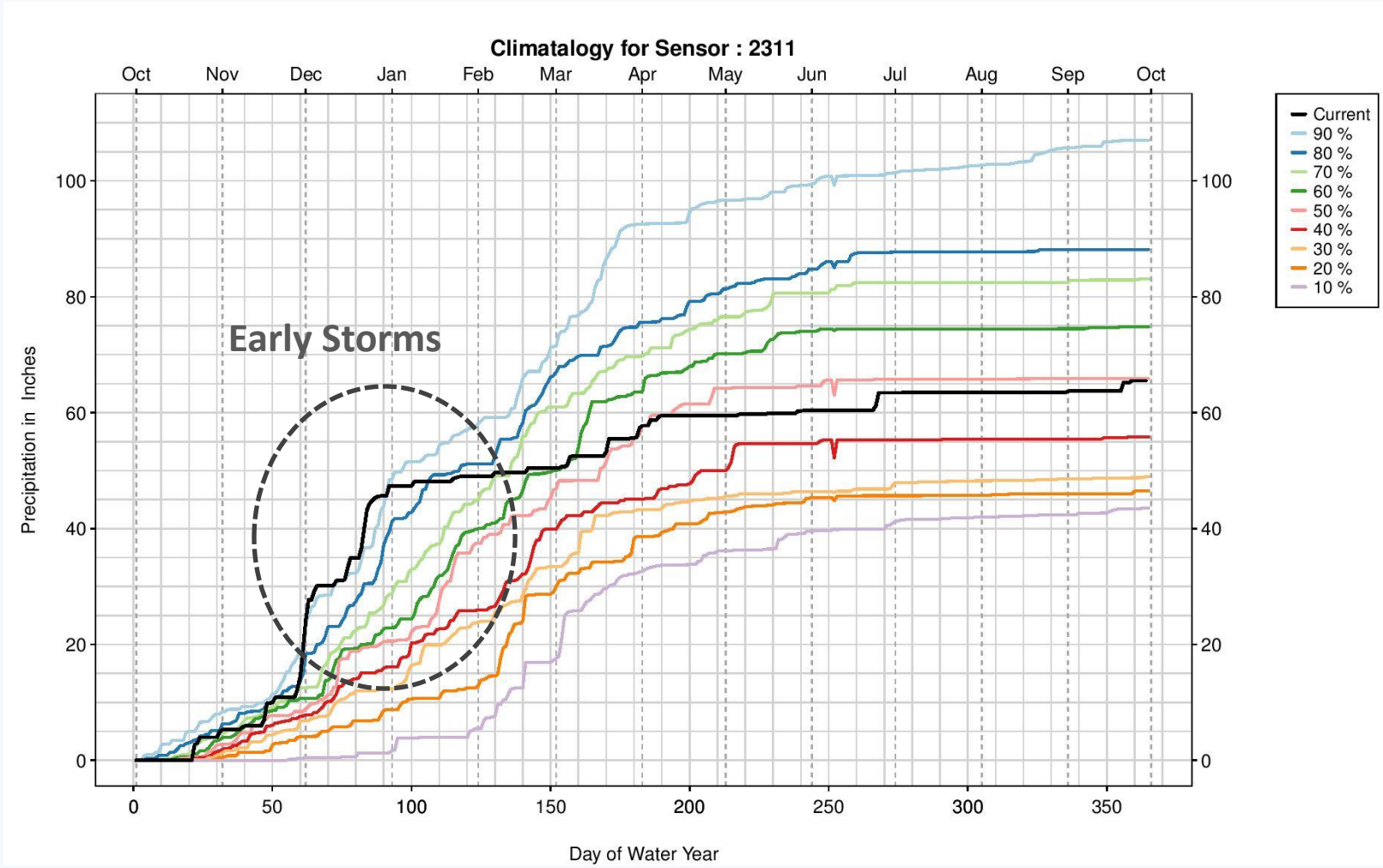
Consulting Engineers and Scientists

Outline

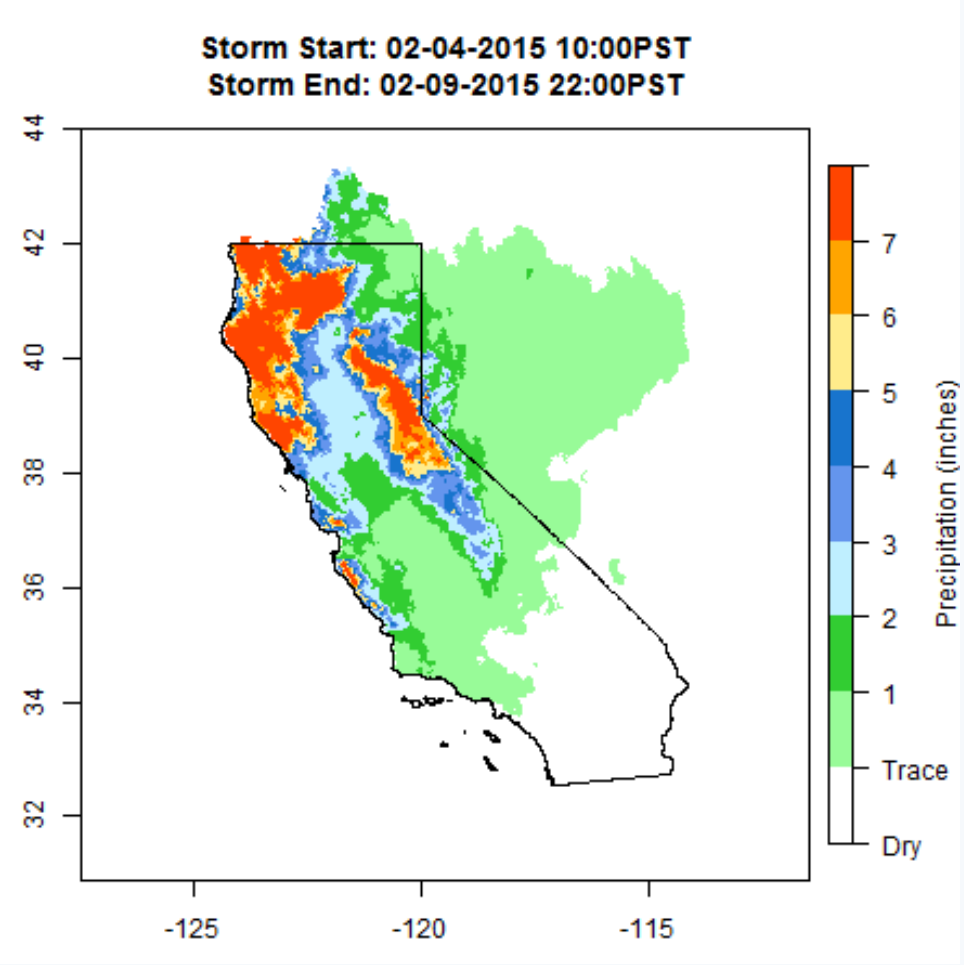
- Motivation: Forecasting Challenges
- California Storm Characteristics Database
- Analysis of Storms and Climate Variability
- Integration with CHRS Storm Database
- Other Statistical Climatology Applications

Sensor View of Seasonal Precipitation

WY 2013: Very high early season precipitation, only minor events after Jan 1st



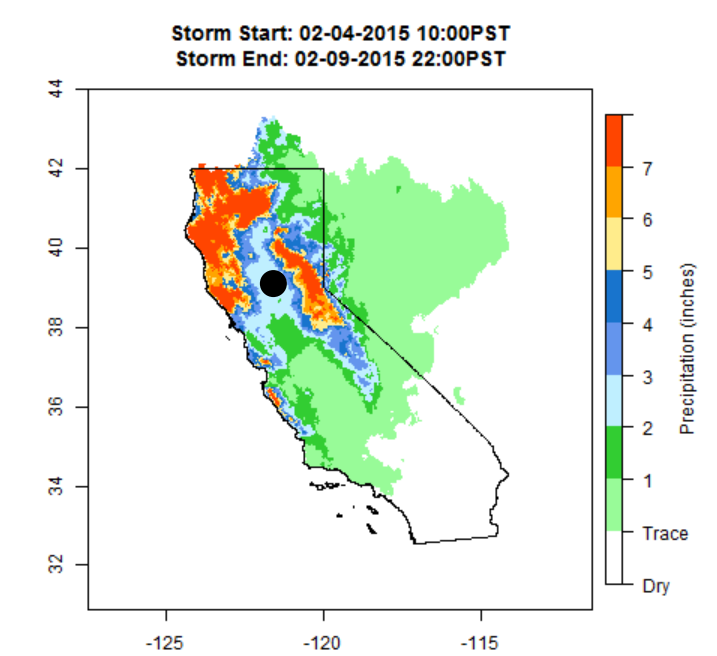
Migrating to a Storm View of Precipitation



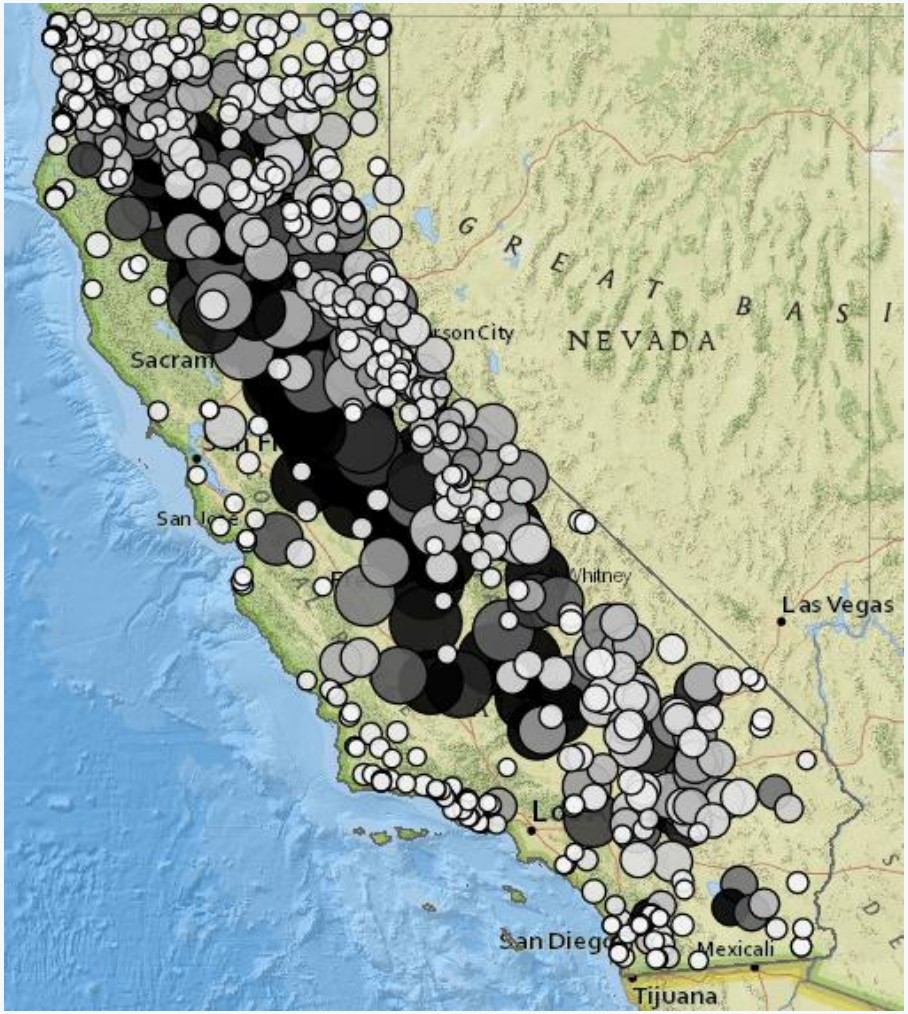
Storm Detail

Storm ID	**Start Date**
2015020410	2015-02-04
Average Depth	**Max Depth**
3.16 inches	19.29 inches
Long Mass Center	**Lat Mass Center**
-121.886	39.507
Length Wet Coast	**Max Storm Elevation**
685 miles	473.0 meters
Madden Julian Oscillation	**El Nino Southern Oscillation**
Weakly Suppressed	El Nino
Area	**Volume**
73,076,100 acres	19,260,081 acre-feet
Long Max Depth	**Lat Max Depth**
-124.150	40.225
Long Area Center	**Lat Area Center**
-120.784	38.282
Time Between Storms	**Storm Duration**
222 hours	132 hours
Pacific Decadal Oscillation	**Oceanic Nino Index**
Positive	Neutral

Assembling the Storms Characteristics Database



- Over 700 storms from 2004 to present
- Derived from 6-hourly NOAA CNRFC QPE grids



Climate Phases from ONI, PDO and MJO Indices

	Definition	**Time in Phase (%)**
ONI Cold	ONI < -0.5 for at least 5 months	21%
ONI Neutral	Neither Warm nor Cold phase	62%
ONI Warm	ONI > 0.5 for at least 5 months	17%
Negative PDO	5-year moving average PDO < 0	78%
Positive PDO	5-year moving average of PDO > 0	22%
Strongly Suppressed MJO	MJO at 120°W between -3 to -1.5	4%
Weakly Suppressed MJO	MJO at 120°W between -1.5 to 0	41%
Weakly Enhanced MJO	MJO at 120°W between 0 to 1.5	46%
Strongly Enhanced MJO	MJO at 120°W between 1.5 to 3	9%

ONI=Oceanic Nino Index
PDO=Pacific Decadal Oscillation
MJO=Madden Julian Oscillation

Statewide Storm Characteristics by ONI Phase

	Cold	Neutral	Warm
Annualized Storm Count	77	**92**	73
Storm Area (million acres)	6.7	3.8	**9.7**
Precipitation Volume (thousand acre-feet)	27	14	**48**
Average Precipitation Depth (in)	0.05	0.04	**0.06**
Peak Precipitation Depth (in)	**0.40**	0.28	0.36
Mean Storm Event Date	Jan	Apr	Dec
Calendar Month with Most Storms	Nov	May	Oct
Time Between Storms (hr)	24	24	24
Mean Storm Event Duration (hr)	18	12	18

Statewide Storm Characteristics by PDO Phase

	Negative	Positive
Annualized Storm Count	90	73
Storm Area (million acres)	4.5	4.5
Precipitation Volume (thousand acre-feet)	18	16
Average Precipitation Depth (in)	0.05	0.05
Peak Precipitation Depth (in)	0.31	0.34
Mean Storm Event Date	Mar	Feb
Calendar Month with Most Storms	Oct	Oct
Time Between Storms (hr)	24	24
Mean Storm Event Duration (hr)	12	12

Statewide Storm Characteristics by MJO Phase

	Strongly Suppressed	Weakly Suppressed	Weakly Enhanced	Strongly Enhanced
Annualized Storm Count	89	91	82	90
Storm Area (million acres)	22.0	2.9	4.9	5.0
Precipitation Volume (1000 acre-ft)	250	11	24	15
Average Precipitation Depth (in)	0.14	0.04	0.05	0.04
Peak Precipitation Depth (in)	1.17	0.27	0.34	0.28
Mean Storm Event Date	Mar	Mar	Mar	Jan
Calendar Month with Most Storms	Apr	Feb	Dec	Oct
Time Between Storms (hr)	24	24	24	30
Mean Storm Event Duration (hr)	30	12	12	12

Analyzing Characteristics by Drainage Region

Drainage Region	Storms (%)
Central Coast (CC)	40%
Colorado River (CR)	34%
North Coast (NC)	74%
North Lahontan (NL)	55%
Sacramento River (SR)	58%
San Francisco Bay (SF)	32%
San Joaquin River (SJ)	46%
South Coast (SC)	44%
South Lahontan (SL)	46%
Tulare Lake (TL)	39%

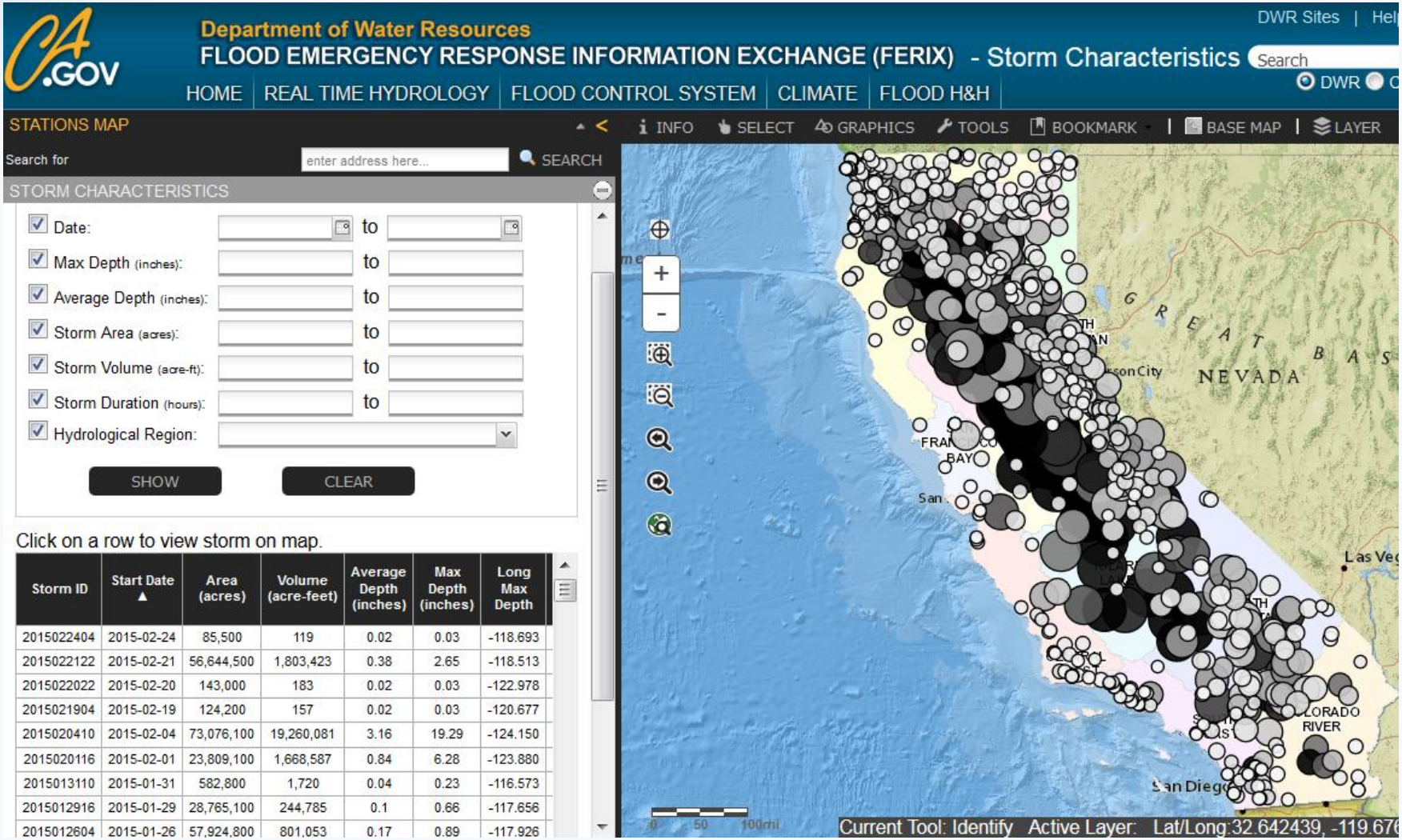
Drainage Region Patterns: Peak Storm Frequency

	CC	CR	NC	NL	SR	SF	SJ	SC	SL	TL	All
ONI Cold (La Niña)	Dec	Feb	Nov	Apr	Apr	Nov	Oct	Nov	Nov	Nov	**Nov**
ONI Neutral	Mar	Aug	May	May	May	Mar	May	Apr	May	May	**May**
ONI Warm (El Niño)	Nov	Dec	Oct	Oct	Oct	Nov	Nov	Dec	Nov	Jan	**Oct**
Negative PDO	Apr	Aug	Oct	May	May	Mar	May	Apr	Mar	May	**Oct**
Positive PDO	Feb	Feb	Nov	Jan	Jan	Jan	Jan	Feb	Jan	Jan	**Oct**
Strongly Suppressed MJO	Feb	Apr	Apr	Apr	Apr	Feb	Apr	Apr	Apr	Apr	**Apr**
Weakly Suppressed MJO	Apr	Aug	Oct	May	May	Feb	Mar	Feb	Aug	Aug	**Oct**
Weakly Enhanced MJO	Dec	Dec	Nov	Dec	Dec	Dec	Dec	Dec	Dec	Dec	**Dec**
Strongly Enhanced MJO	Feb	Dec	Oct	Feb	Feb	Nov	Oct	Oct	Oct	Oct	**Oct**

Peaks Earlier Than Statewide

Peaks Later Than Statewide

Storm Characteristics Database on FERIX



Storm Characteristics by Drainage Region

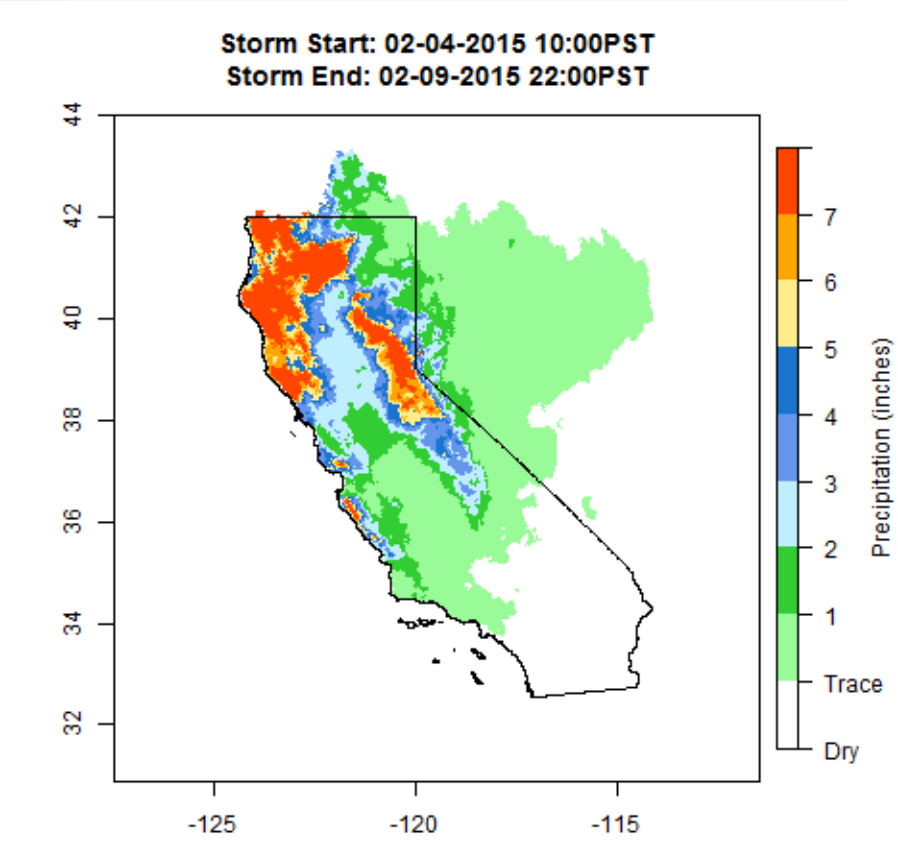
Storm Climatology Summary

Climate State ▼	Number of Storms	Annualized Storm Count	Percent Time in Climate State (%)	Median Area (acres)	Median Volume (acre-feet)	Median Avg Depth (inches)	Median Max Depth (inches)	Median Long Max Depth
ONI Cold	174	77.3	20	6,065,900	24,294	0.01	0.40	-123.699
ONI Neutral	673	93.9	64	2,988,500	10,189	0.00	0.30	-121.534
ONI Warm	133	72.7	16	6,289,600	23,863	0.01	0.36	-123.609

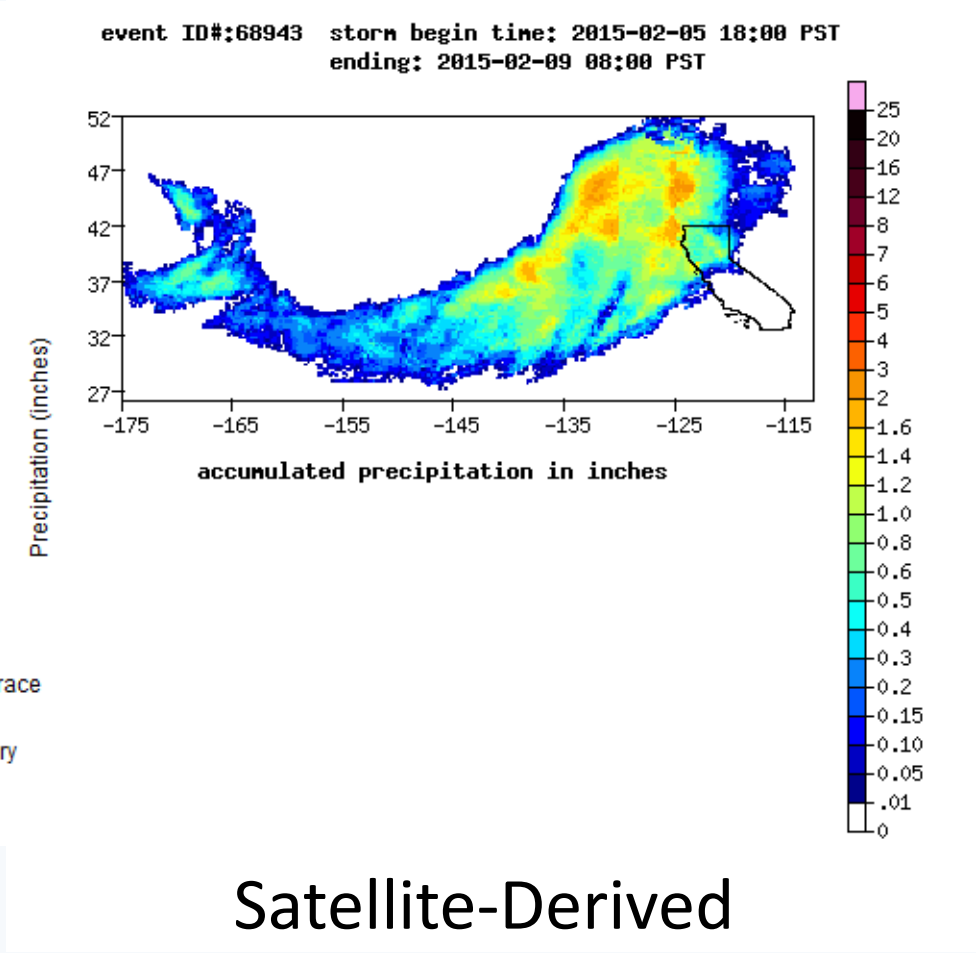
Individual Storms

Storm ID	Start Date ▲	Drainage Region	Area (acres)	Volume (acre-feet)	Average Depth (inches)	Max Depth (inches)	Long Max Depth	Lat Max Depth	Long Mass Center
2015022022	2015-02-20	North Coast	104,100	0	0	0.03	-122.932	38.303	-122.923
2015020410	2015-02-04	North Coast	12,144,100	7,165,000	7.08	19.29	-124.150	40.225	-123.289
2015020116	2015-02-01	North Coast	10,311,100	1,196,000	1.39	6.28	-123.880	41.578	-123.334

Expanded View of The Storm Event

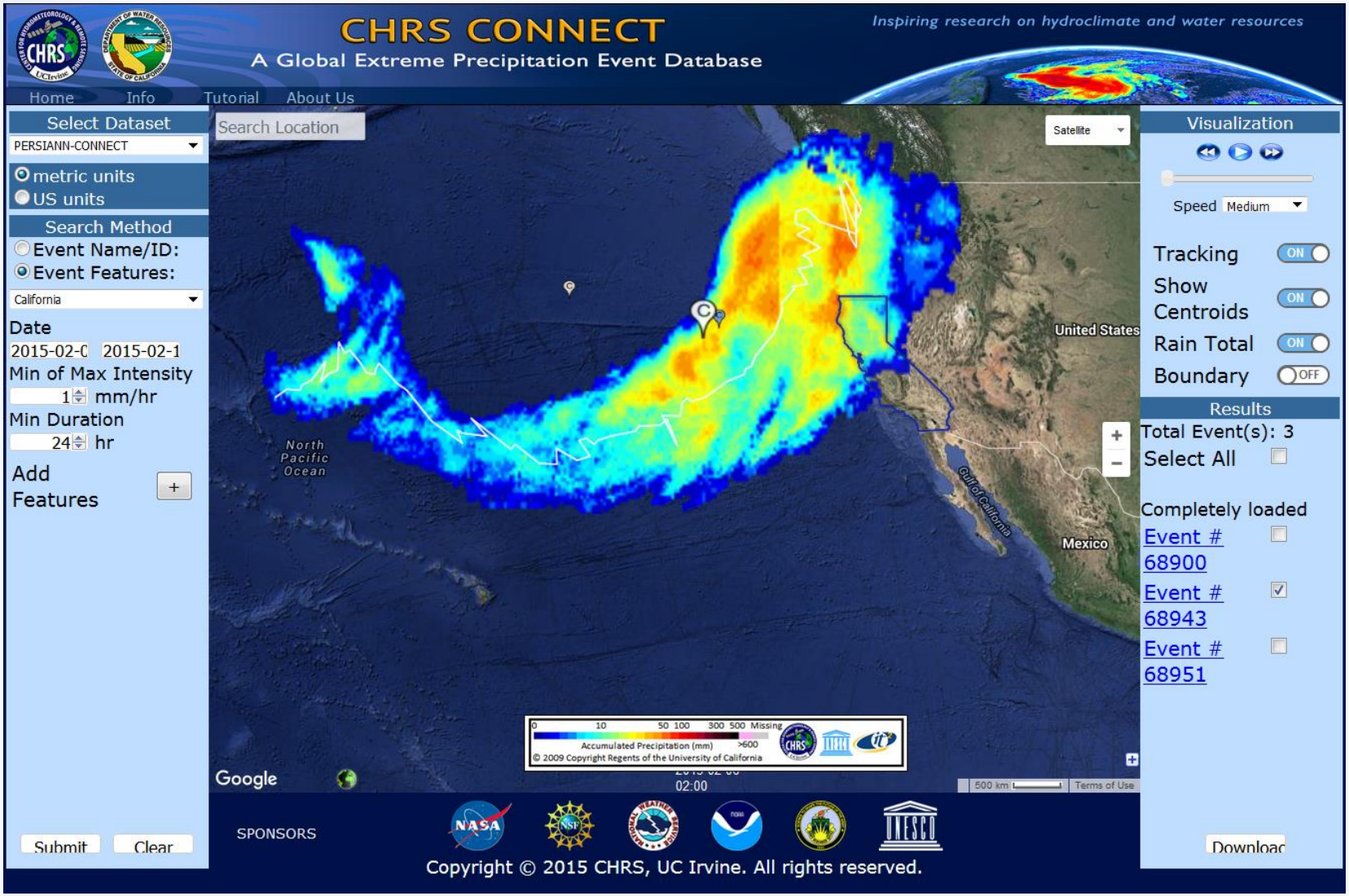


Gauge-Derived



Satellite-Derived

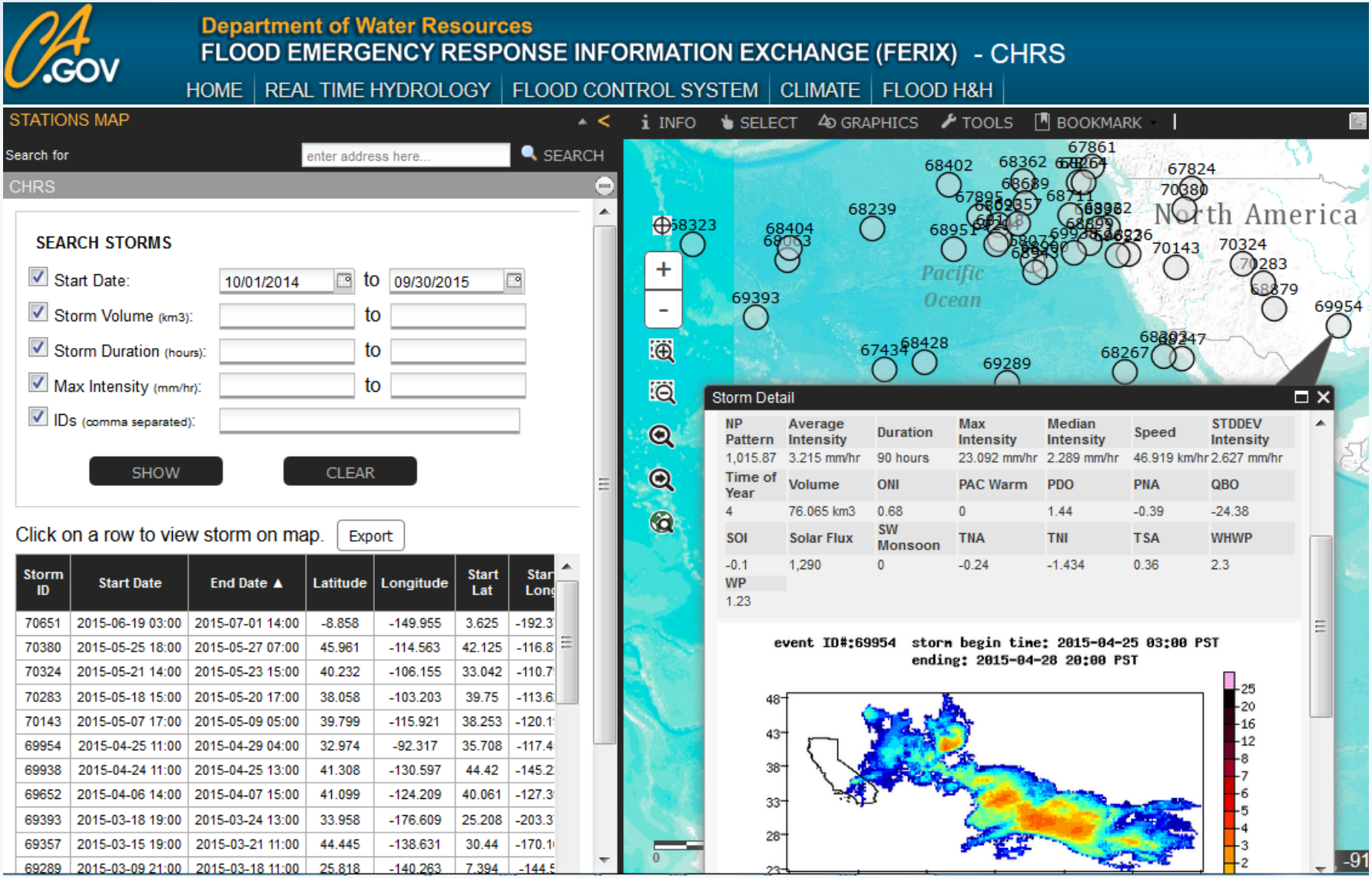
UC-Irvine CHRS Connect Storm Database



UC-Irvine CHRS Connect Storm Database

- **Source**: Extracted from PERSIANN, a satellite-derived precipitation dataset
- **Spatial Coverage**: global
- **Temporal Coverage**: 2000 to 2015; periodically updated
- **Attributes**: 55 fields including 15 storm characteristics and 40 weather/climate indices
- Dataset of 673 storms impacting California has been extracted and transferred to DWR

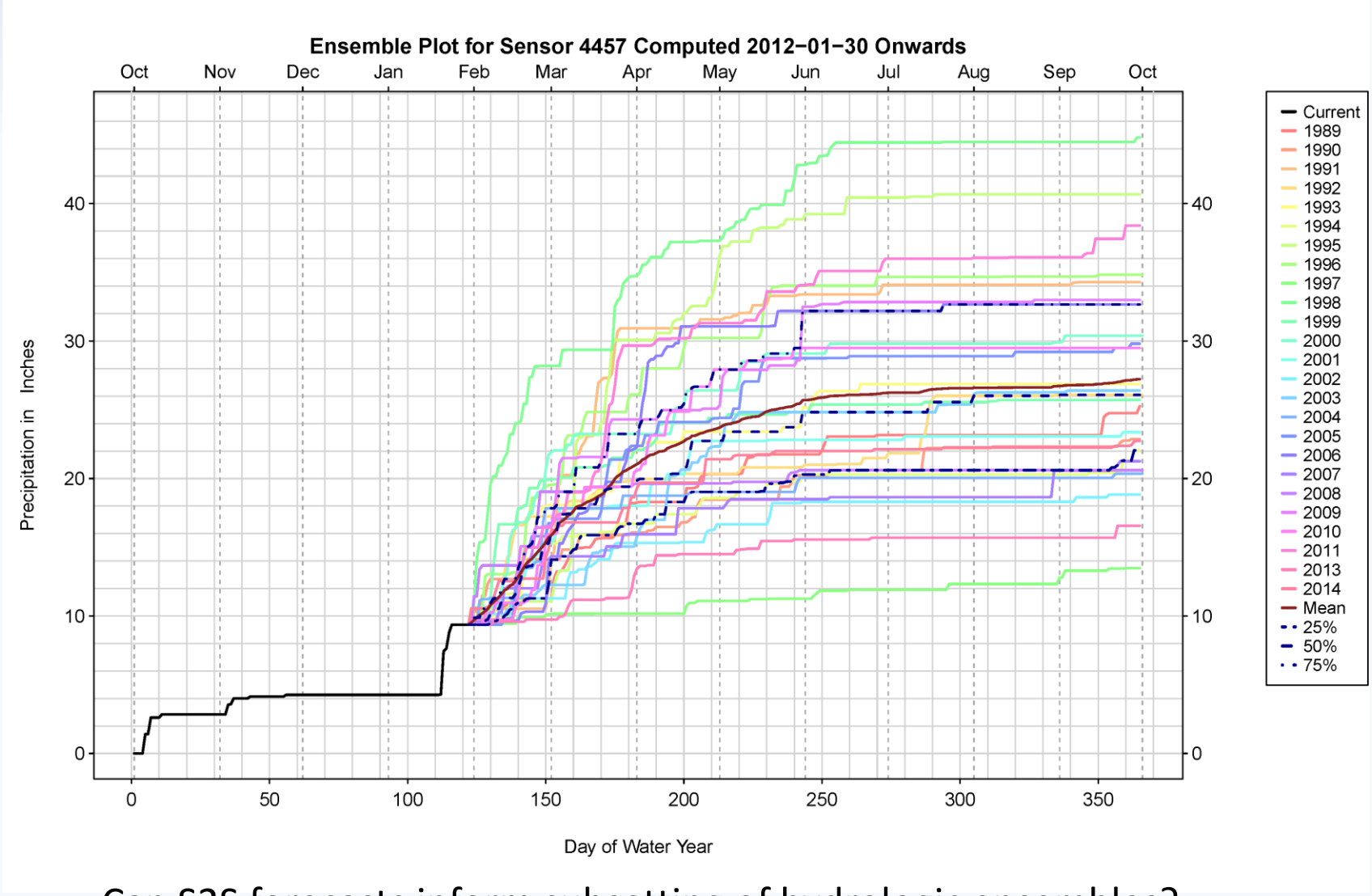
CHRS Connect Storm Database on DWR FERIX



Transitioning Storms to Other Applications

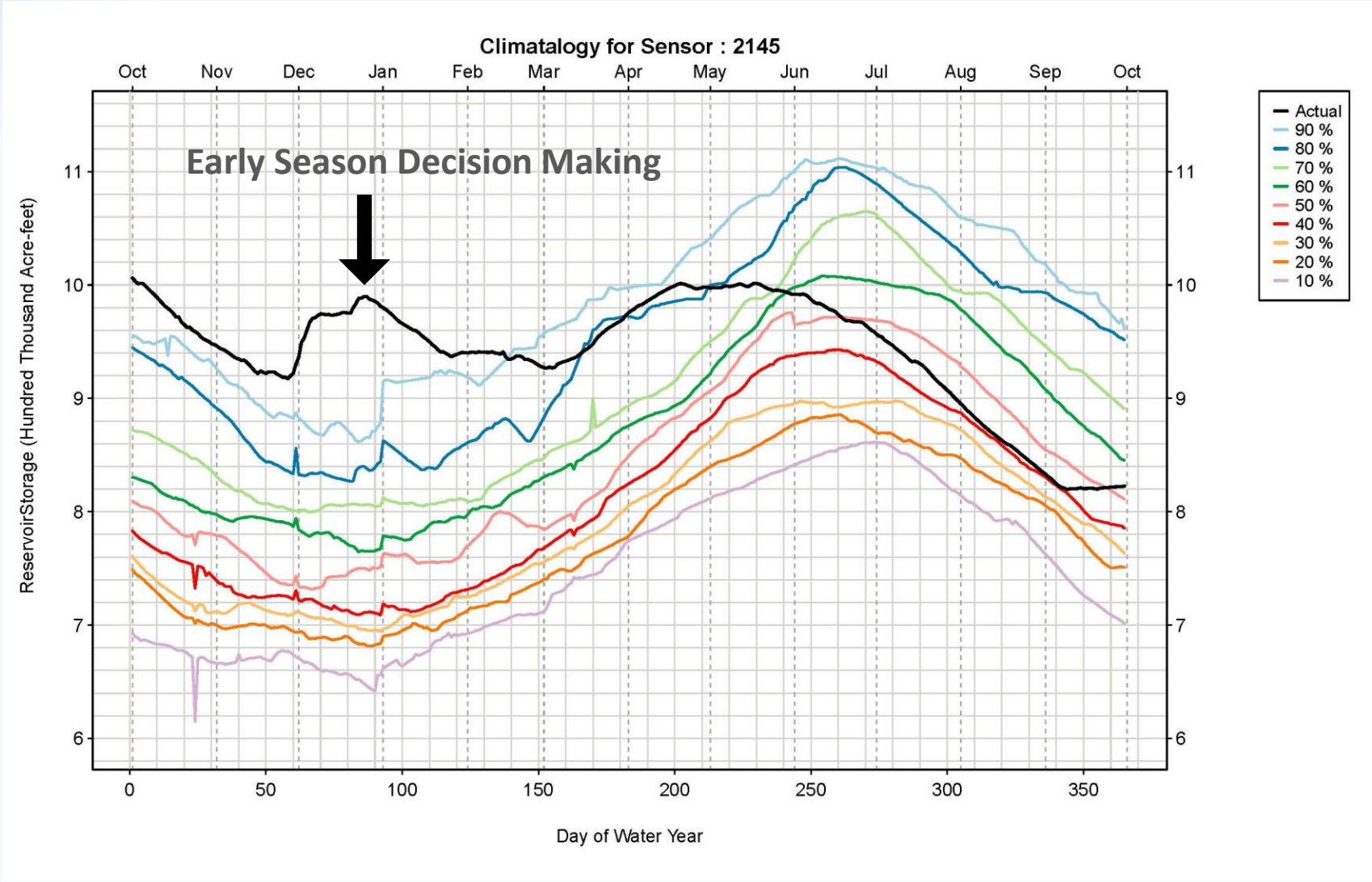
- Can predictable storm characteristics be used to improve precipitation and/or water supply forecasts?
- What else can we use predictable storm characteristics for?

Historical Ensemble Predictions



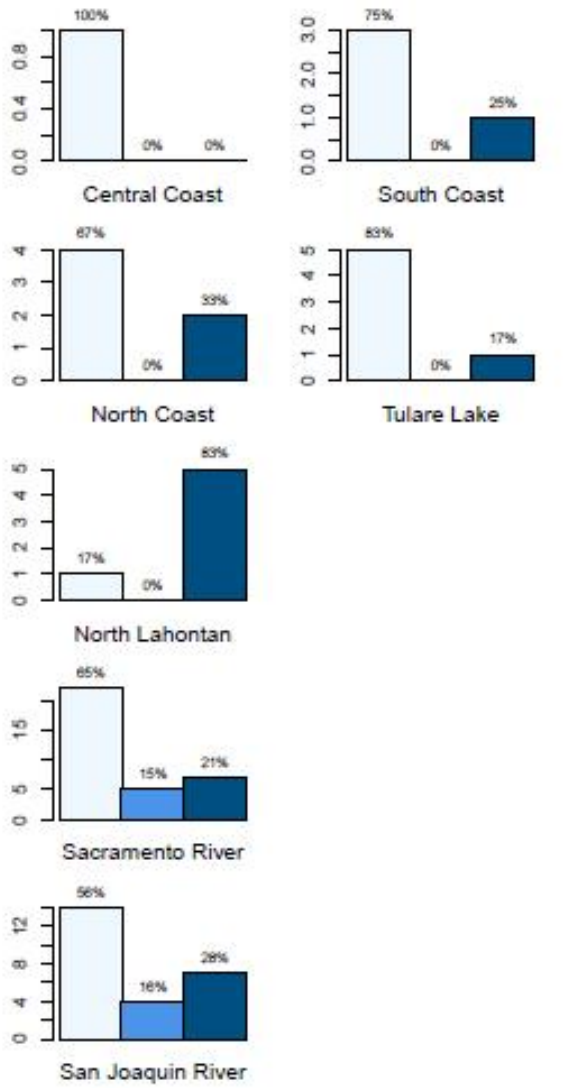
Can S2S forecasts inform subsetting of hydrologic ensembles?

Reservoir Storage Management



Can S2S forecasts tell us how long a given anomalous condition is likely to persist?

Reservoir Storage Forecast Maps



Could storm-based forecasts yield improved forecast storage probability maps?

Precipitation Area Adjustment Factors

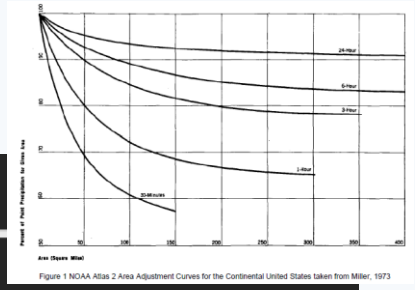
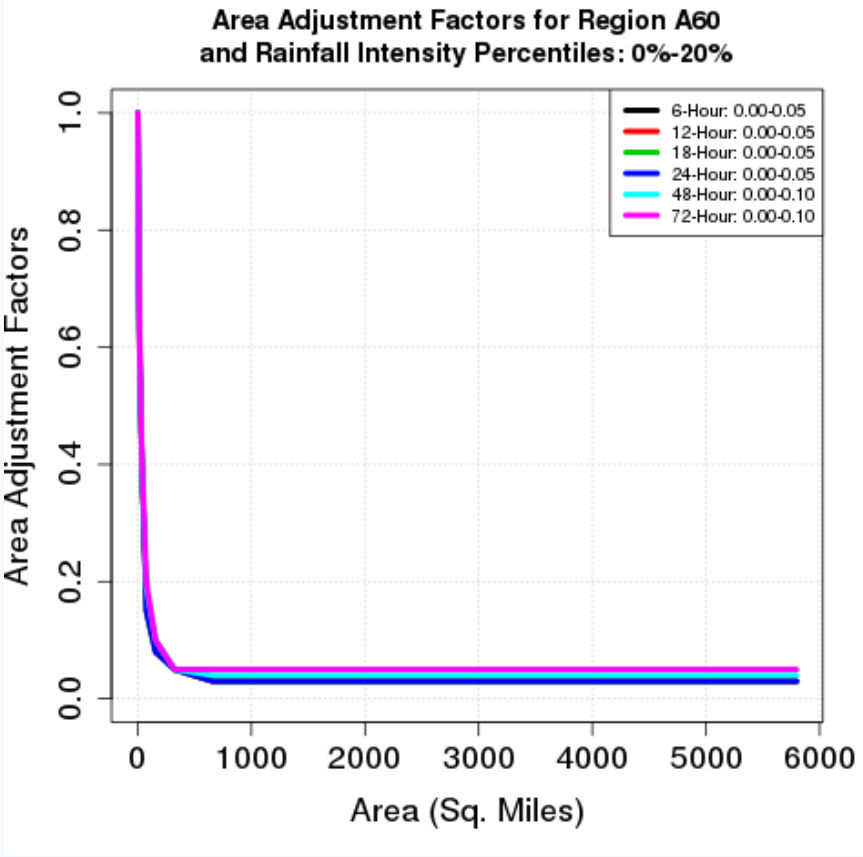
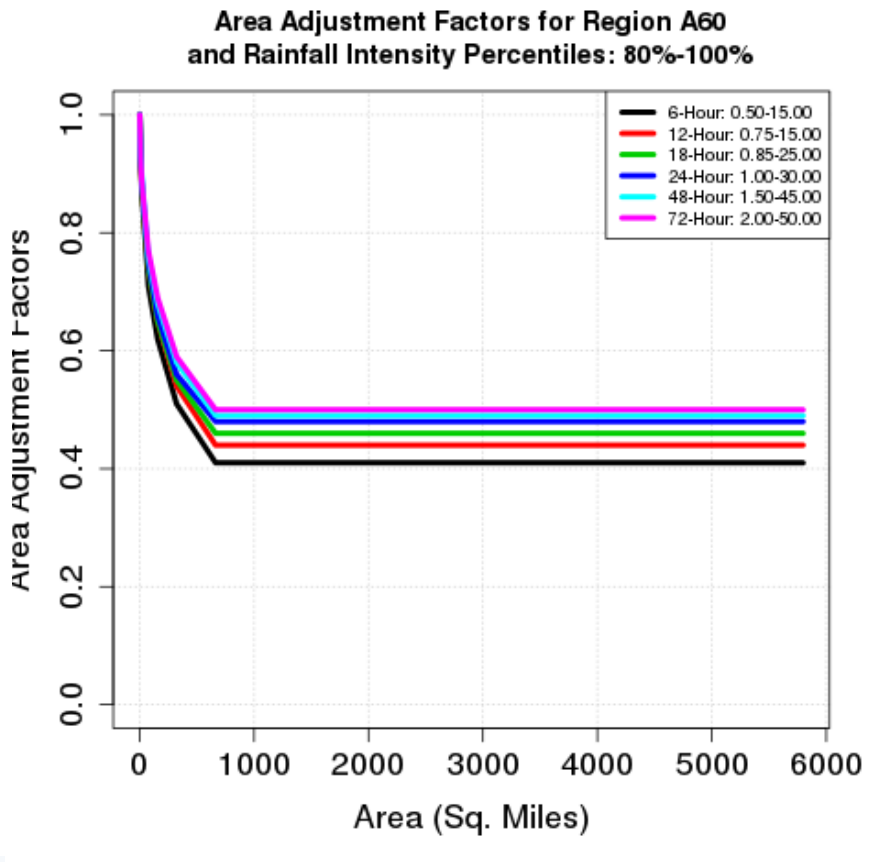


Figure 1 NOAA Atlas 2 Area Adjustment Curves for the Continental United States taken from Miller, 1973

Drainage Regions

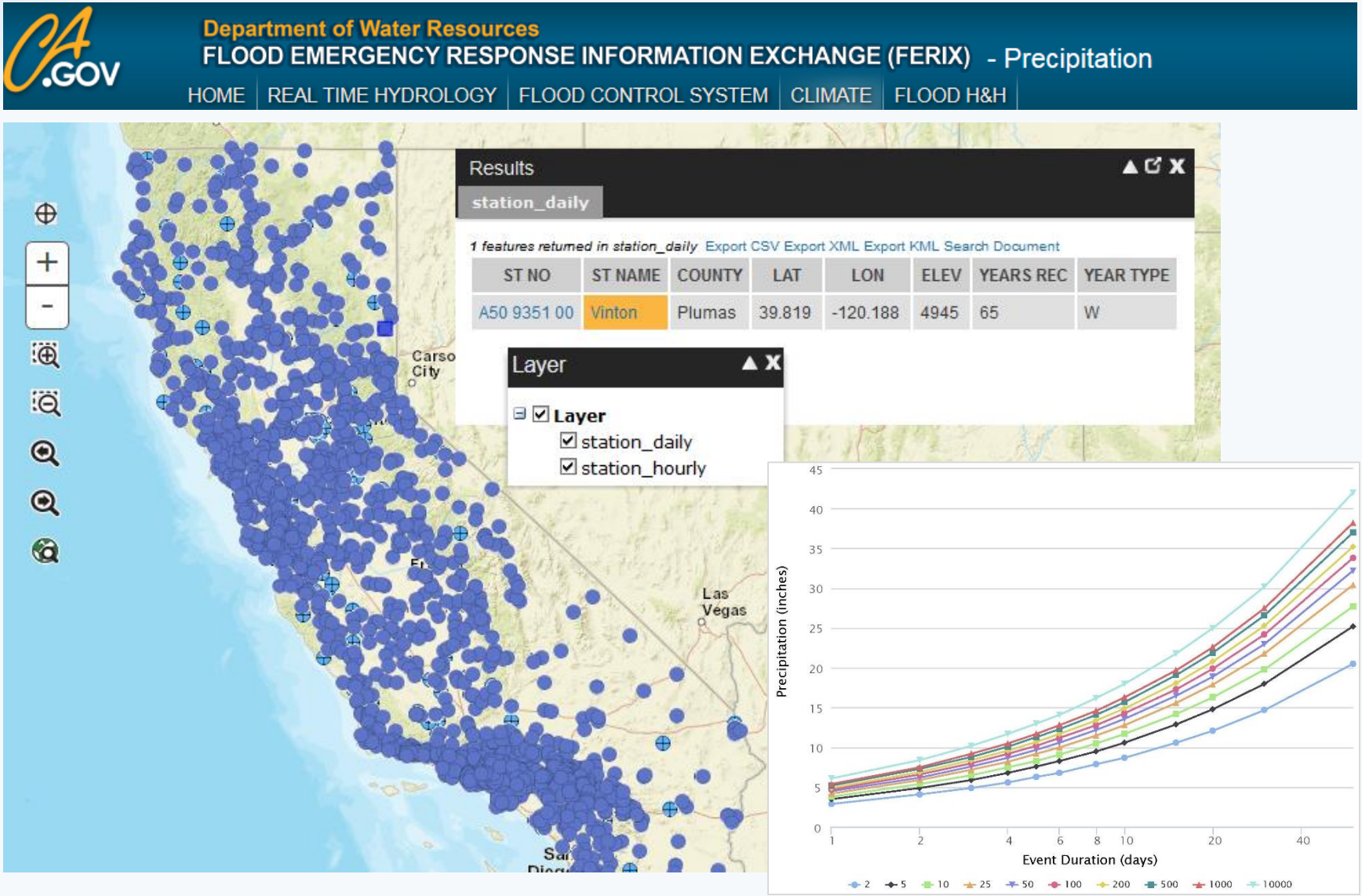
00-20%	20-40%	40-60%	60-80%	80-100%



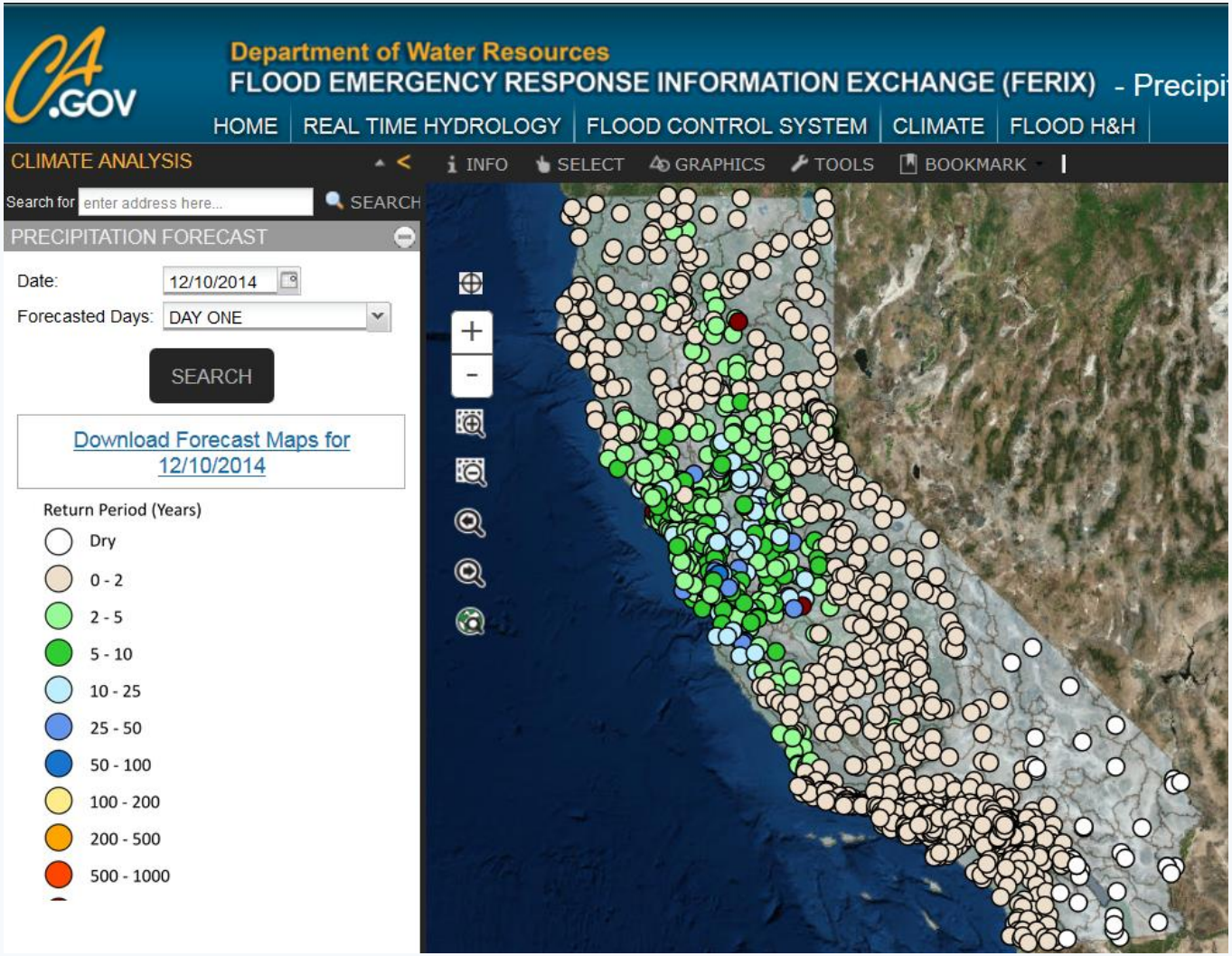


Could storm-derived factors be used to interpret storm forecasts?

Bulletin 195: Precipitation Frequency Analysis



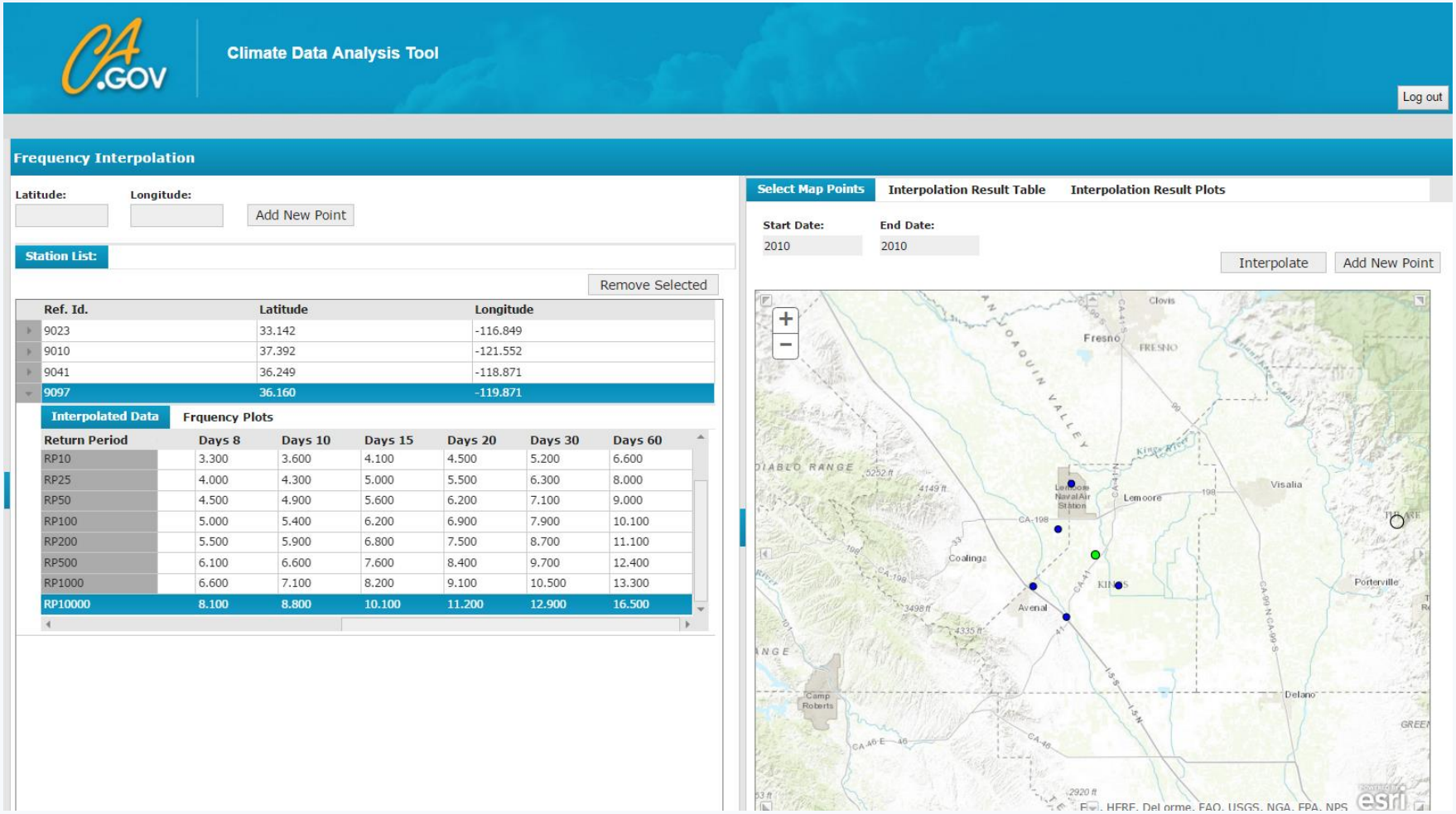
Severity Maps for 6-Day Precipitation Forecasts



Could storm severity thresholds be predicted at sub-seasonal time scales?

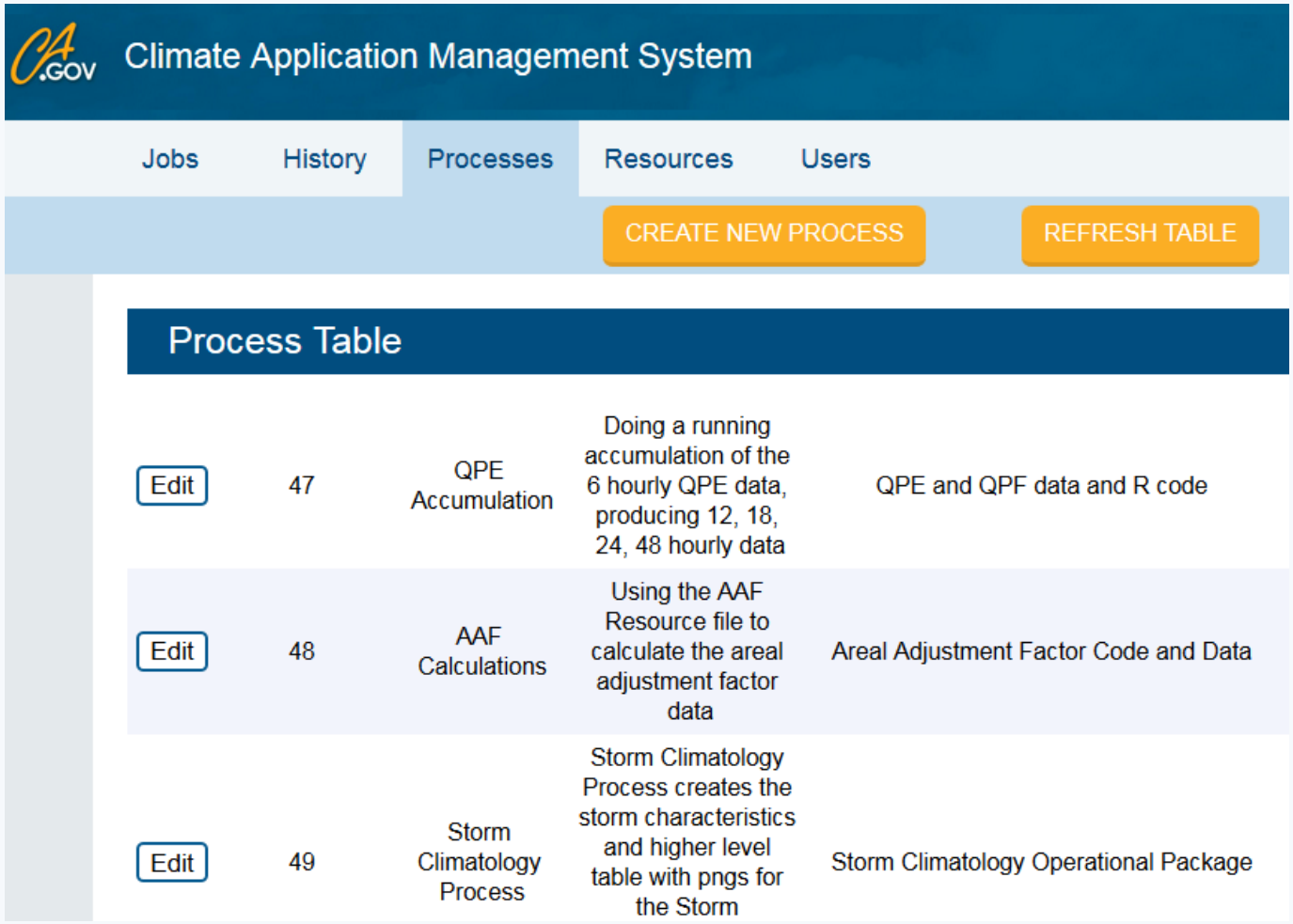
CDAT: Climate Data Analysis Tool

Tool for Performing Interactive Computations and Data Updates



CAMS: Climate Application Management System

System for Executing Repetitive Operational Tasks



Conclusions

- Select storm characteristics are amplified or suppressed in spatially consistent patterns under the climate phases analyzed.
- The altered storm characteristics could form the basis for generating storm-based forecasts at sub-seasonal to seasonal time scales.
- Statistically-derived storm impact databases and applications being developed can integrate storm forecasts into existing decision processes.