Adapting to a Warming World

Dr. Michael Anderson, State Climatologist

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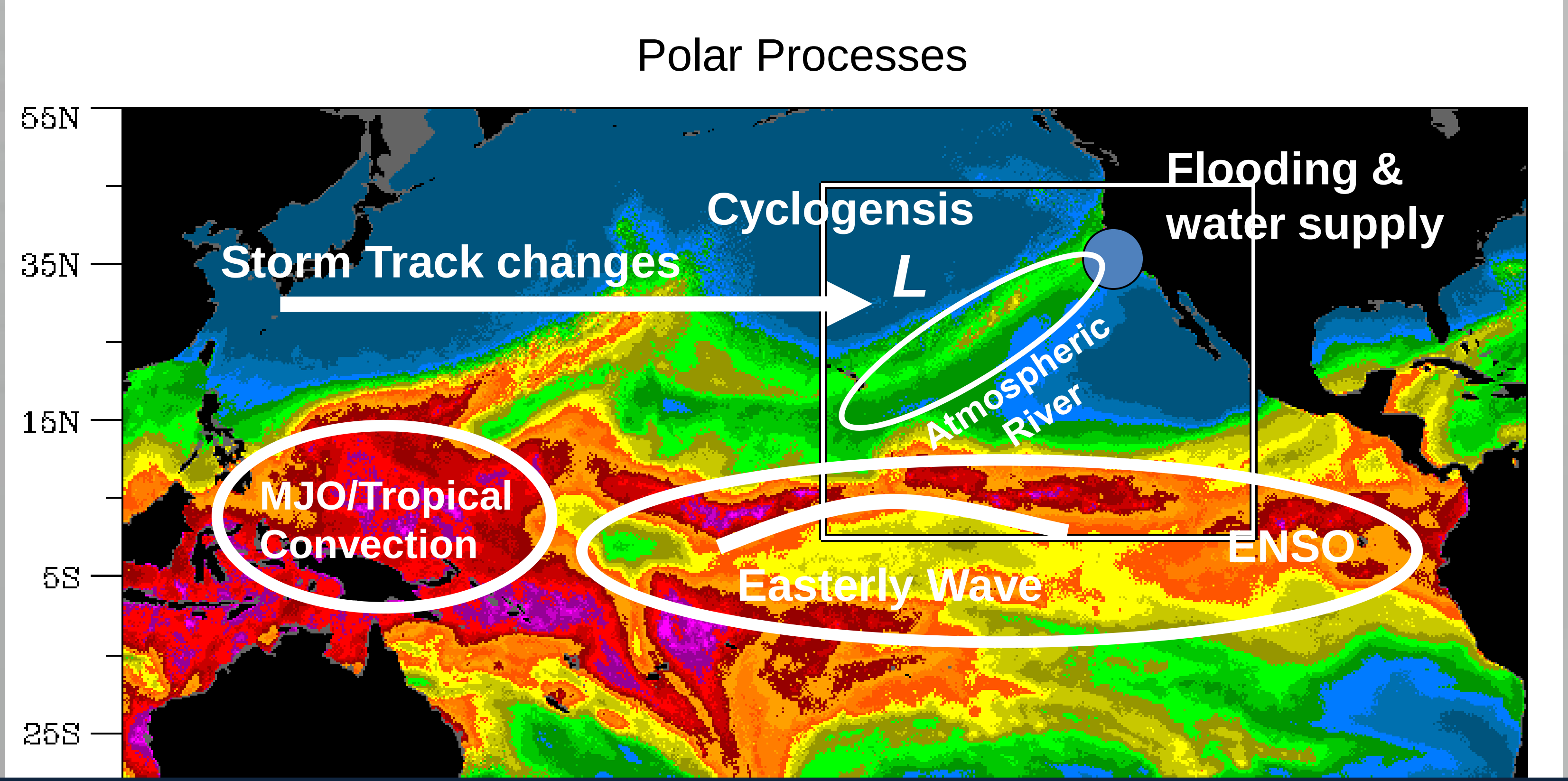
FIRO Workshop

SIO, La Jolla, CA

Talk Overview

- Background
- Intel for Water Management in a Changing Climate
- FIRO as an Adaptive Strategy

Key Phenomena Affecting California Water Supply/Flooding:



The size, number, and strength of atmospheric river events (ARs) result from the alignment of key physical processes operating on different space and time scales that will change with climate change

Statewide Impacts

CALIFORNIA'S FOURTH
CLIMATE CHANGE
ASSESSMENT

BY 2100
AVERAGE ANNUAL MAXIMUM
DAILY TEMPERATURE
IS PROJECTED TO
INCREASE BY
5.6°–8.8°

Depending on greenhouse gas emissions reductions. The greatest increase is seen with business-as-usual emissions levels.

77%
AVERAGE AREA BURNED
INCREASE BY 2100
IF EMISSIONS CONTINUE TO RISE

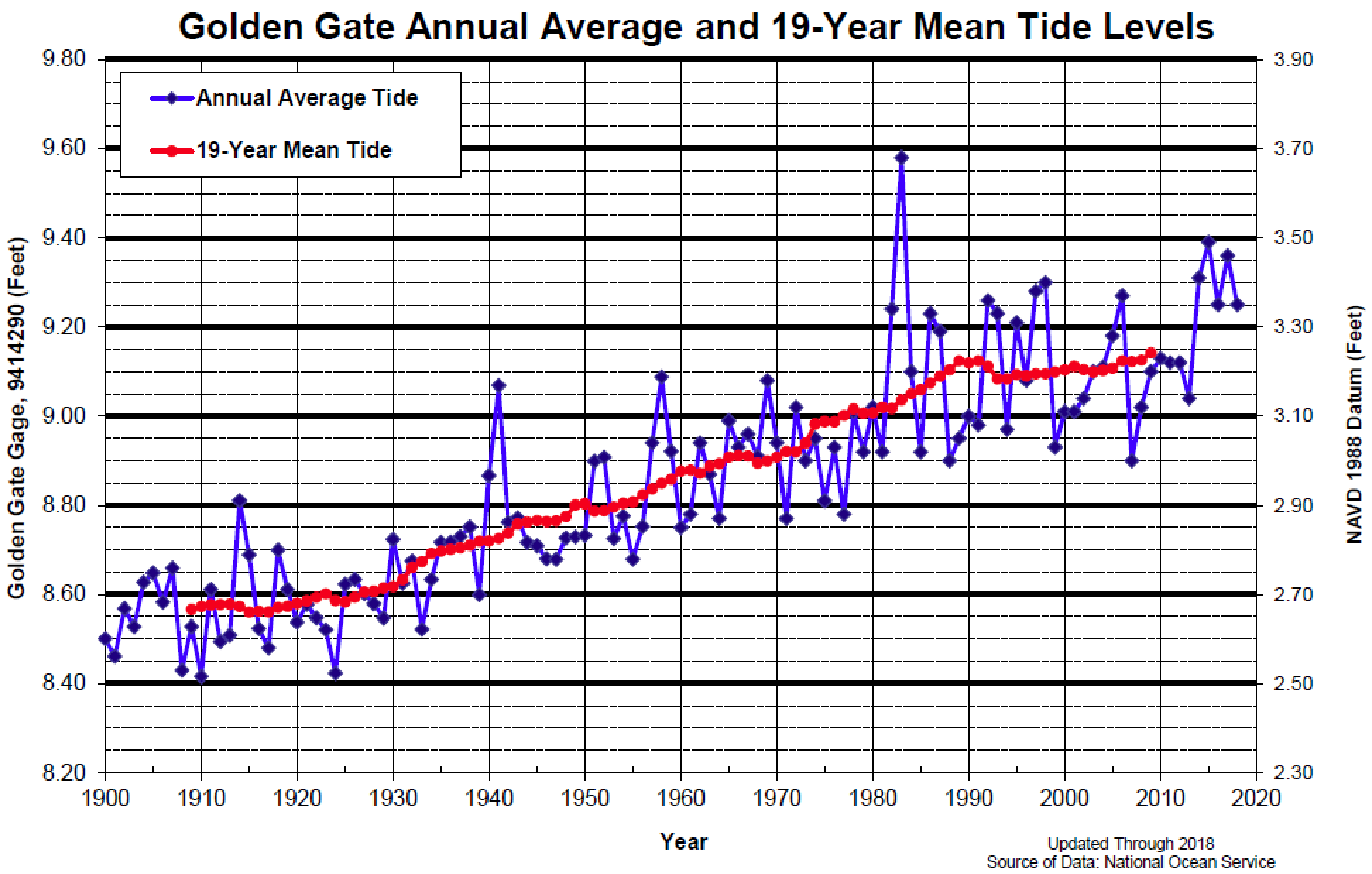
BY 2050
HEAT WAVES IN CITIES
COULD CAUSE
2-3 TIMES MORE
HEAT-RELATED DEATHS

Vulnerable populations will experience the worst of these effects.

BY 2100
WATER SUPPLY FROM SNOWPACK
IS PROJECTED TO
DECLINE BY TWO-THIRDS

Department of Water Resources

Division of Flood Management



Factors Impacting Sea Level

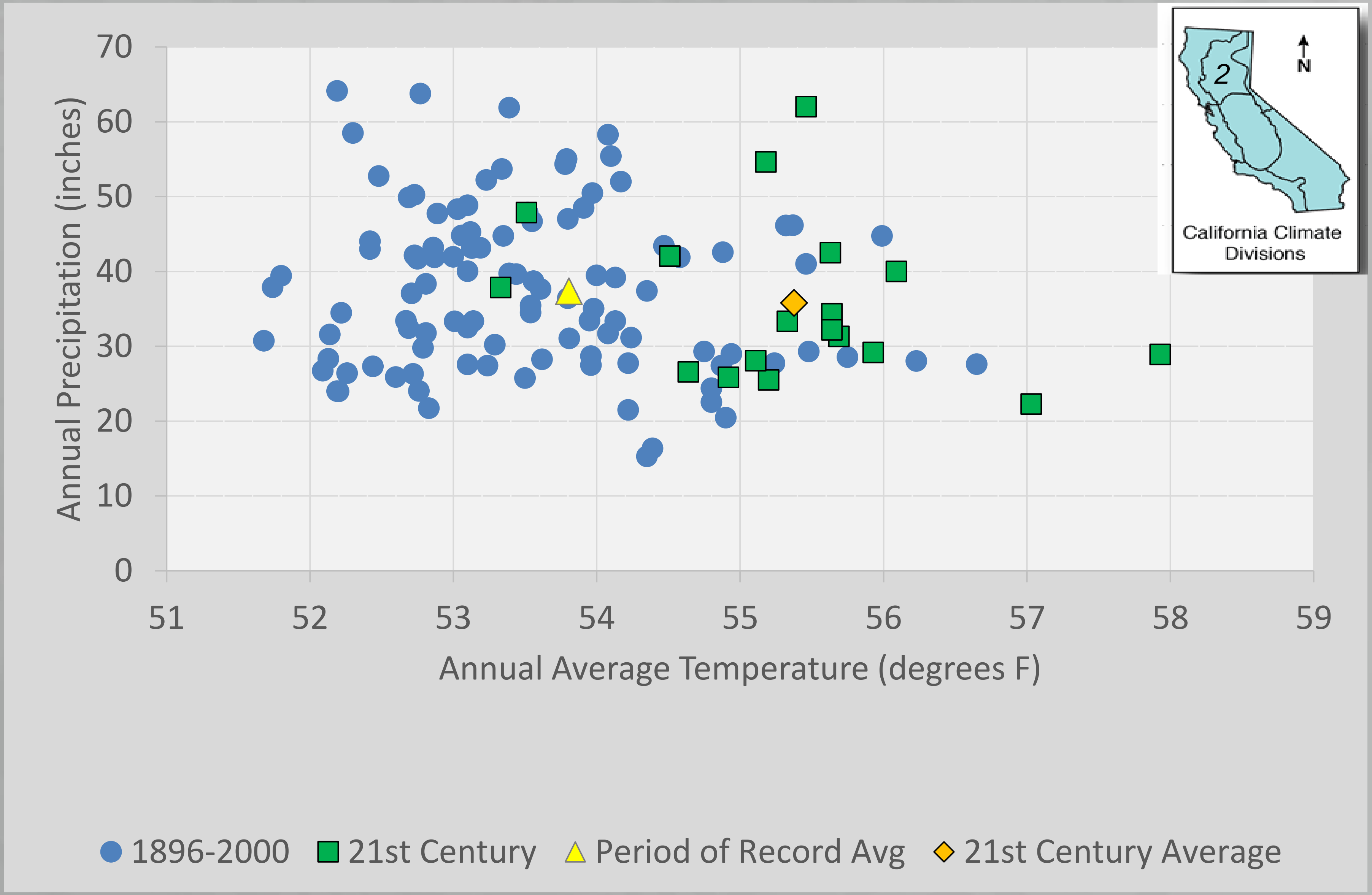
ENSO
King Tides
Spring Tides
Storm Surge

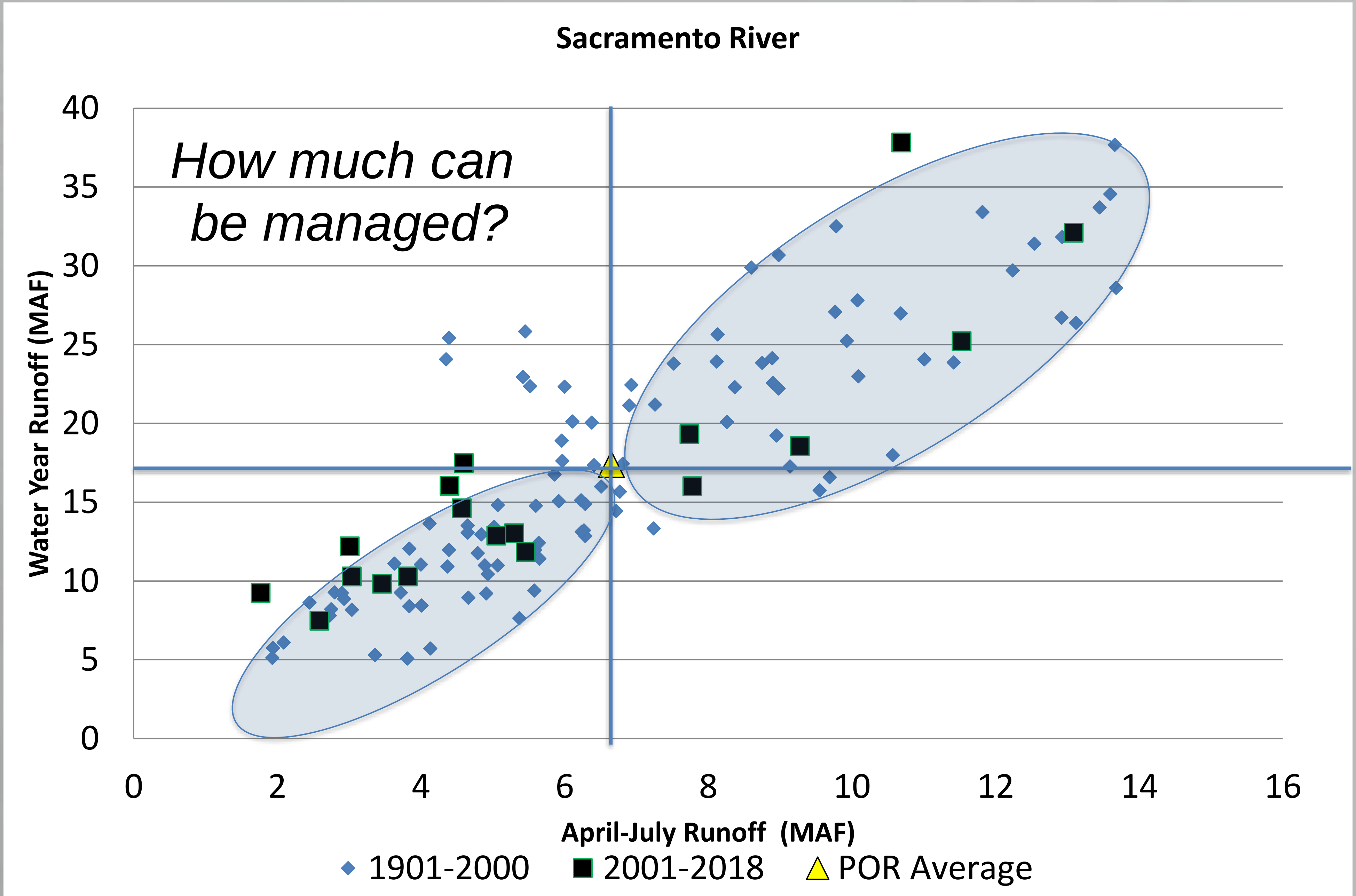
Flooding Is:
Rare
Episodic
Periodic
Permanent

Cascading Time Scales and Variability

- Single Event – Hours to Days
- Timing of Events and Inter-Event Times
- Seasonal Accumulation and Variability
- Annual Accumulation and Interannual Variability
- Decadal Scale Variability
- Climate Change over a Century

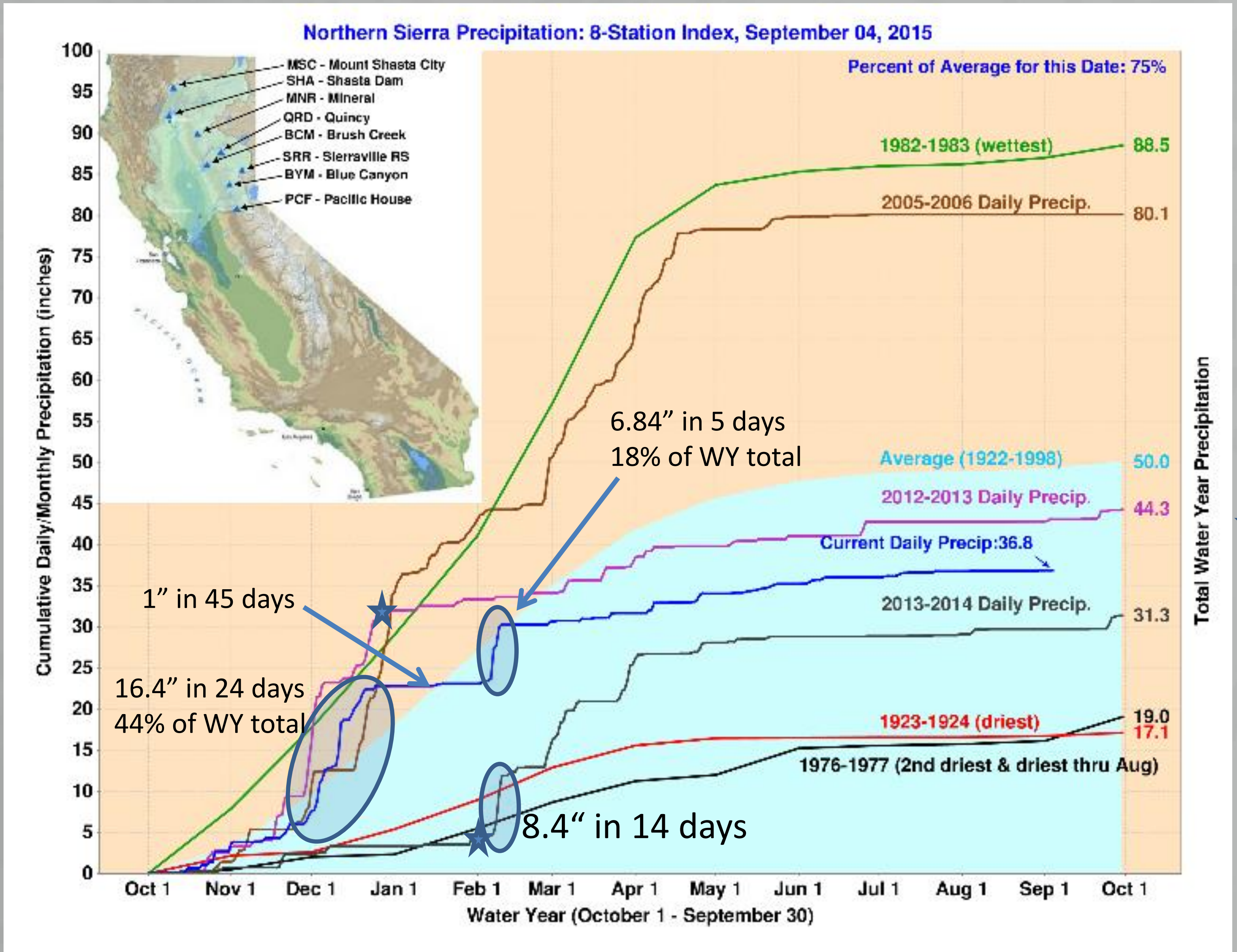
Climate Division 2 Water Year Data





Sacramento River
How much can be managed?
Water Year Runoff (MAF)
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
April-July Runoff (MAF)
1901-2000
2001-2018
POR Average

Variability on Multiple Scales
Atmospheric Rivers and Precipitation Accumulation



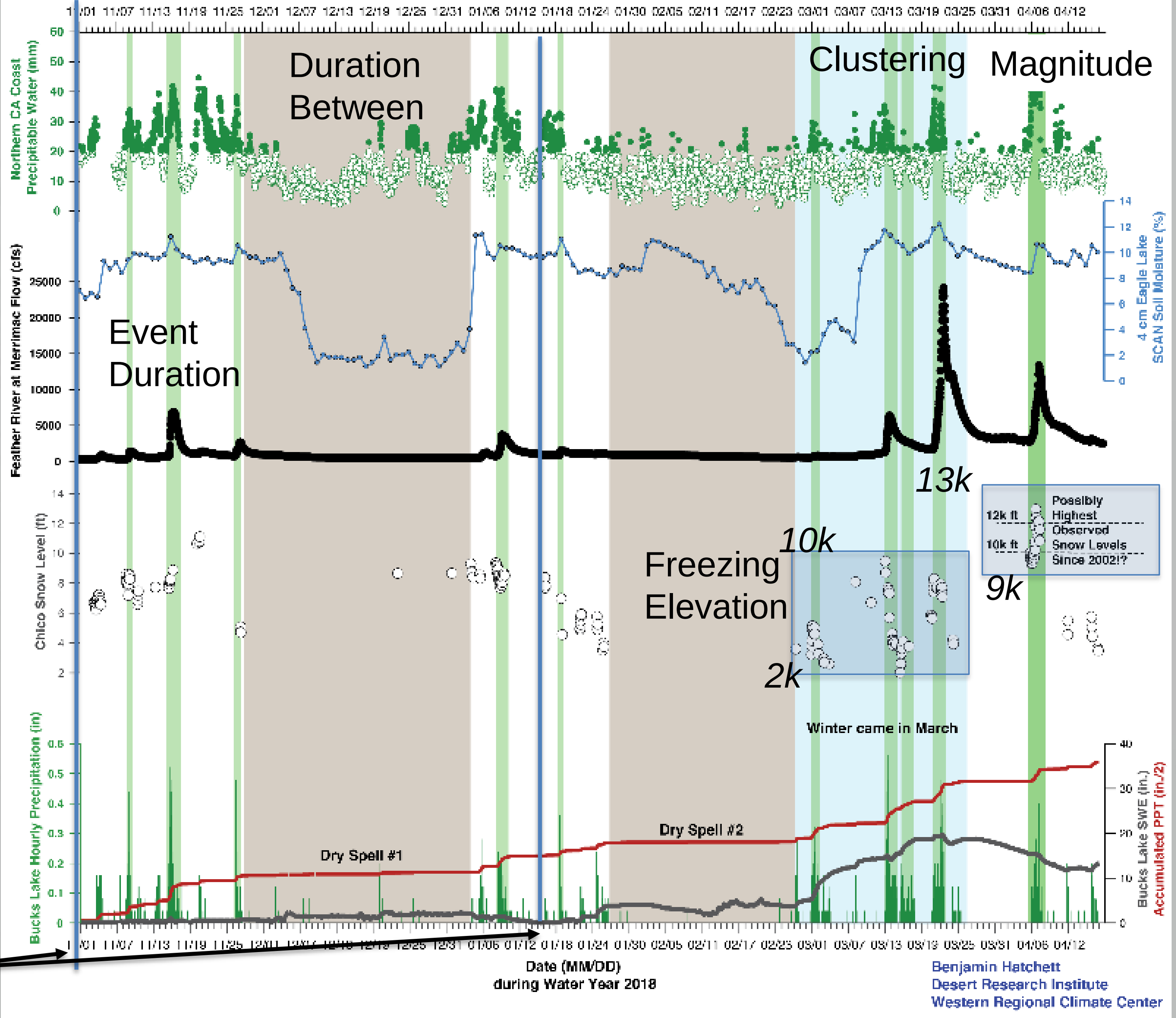
WY2015:
121 days
37.24”

16.8”
404 Days

Runoff Volume?
Freezing Elevation?
Rain/Snow Distribution?
Number of Events/Timing?
Blocking Ridges?

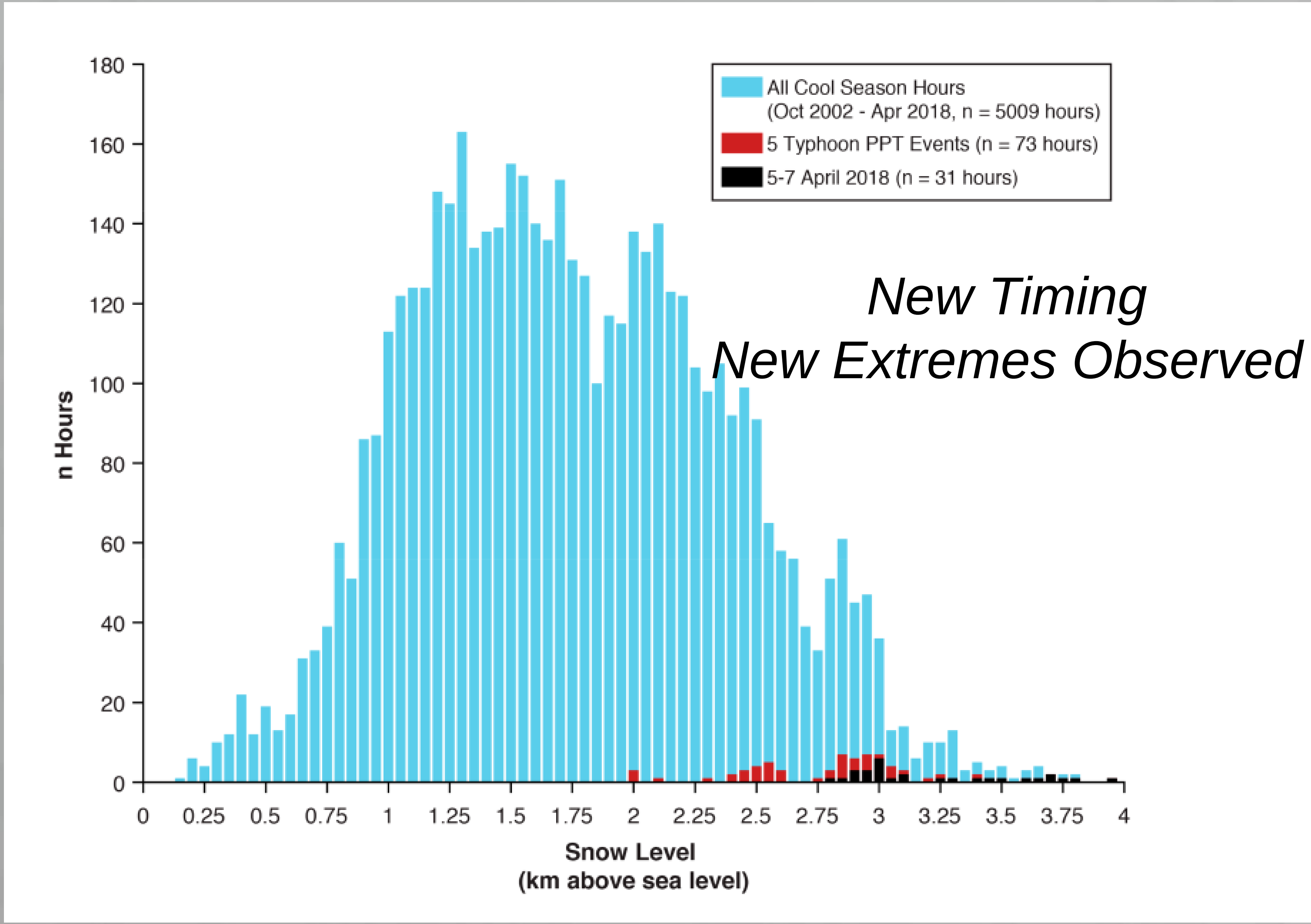
How do observations and forecasts inform decisions?

How and when should changed hydrology be reflected in regulatory frameworks?



What do I know here?

Snow Level Radar



New Timing

New Extremes Observed

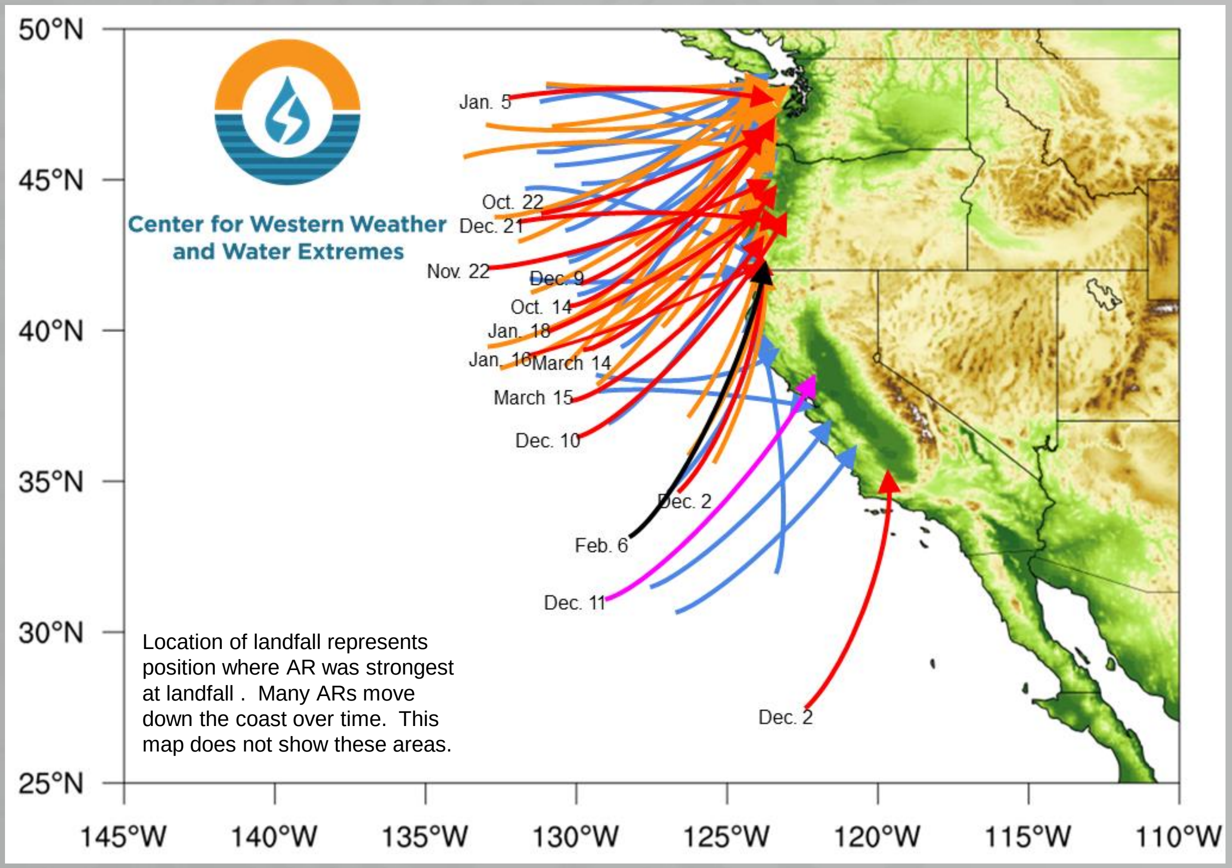
Distribution of Landfalling Atmospheric Rivers on the U.S. West Coast During Water Year 2015

- **57** Atmospheric Rivers made landfall on the USWC during the 2015 water year

AR Strength	AR Count
Weak	22
Moderate	20
Strong	13
Extreme	1
Exceptional	1

Ralph/CW3E AR Strength Scale

- Weak: IVT=250–500 kg m^{-1} s^{-1}
- Moderate: IVT=500–750 kg m^{-1} s^{-1}
- Strong: IVT=750–1000 kg m^{-1} s^{-1}
- Extreme: IVT=1000–1250 kg m^{-1} s^{-1}
- Exceptional: IVT>1250 kg m^{-1} s^{-1}



By F.M. Ralph, C. Hecht, J. Kalansky

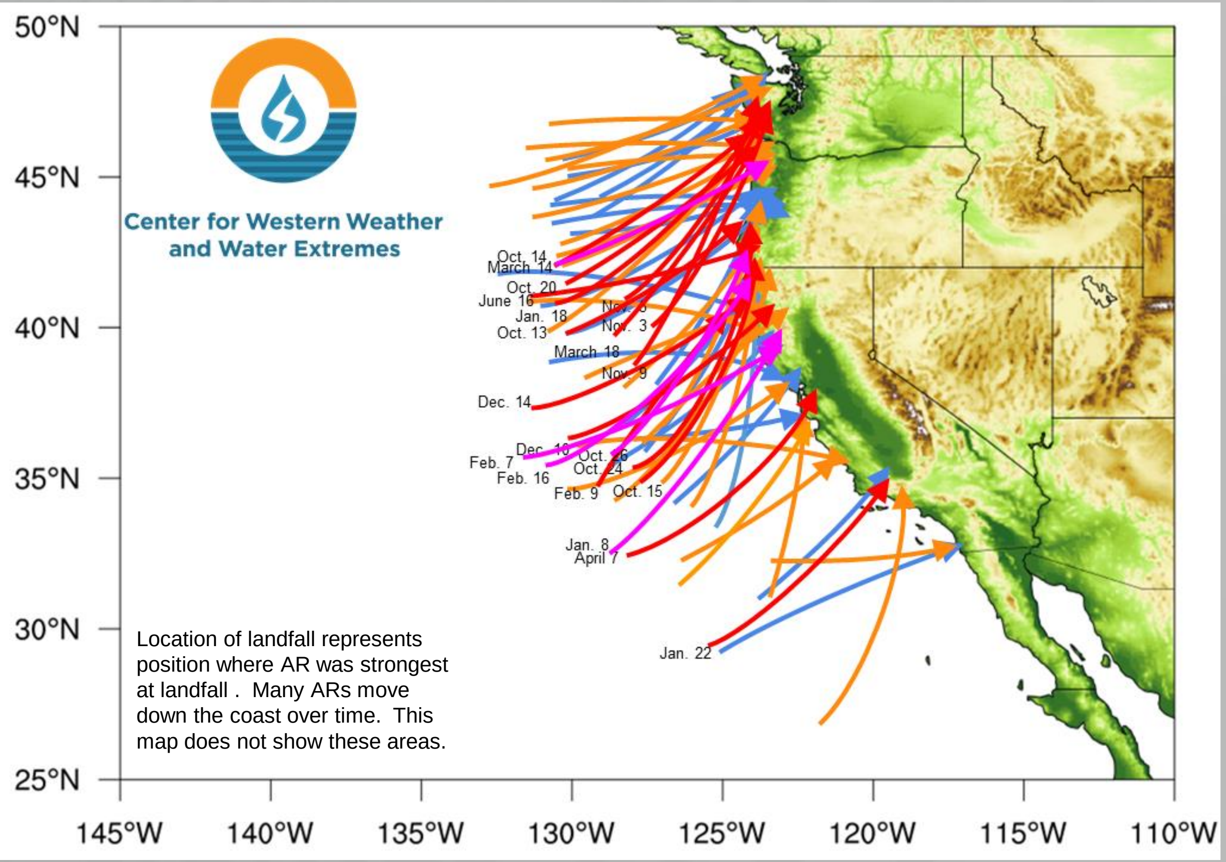
Distribution of Landfalling Atmospheric Rivers Over the U.S. West Coast During Water Year 2017

- **68** Atmospheric Rivers made landfall on the USWC during the 2017 water year

AR Strength	AR Count
Weak	21
Moderate	26
Strong	16
Extreme	5
Exceptional	0

Ralph/CW3E AR Strength Scale

- Weak: IVT=250–500 kg m^{-1} s^{-1}
- Moderate: IVT=500–750 kg m^{-1} s^{-1}
- Strong: IVT=750–1000 kg m^{-1} s^{-1}
- Extreme: IVT=1000–1250 kg m^{-1} s^{-1}
- Exceptional: IVT>1250 kg m^{-1} s^{-1}



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Summary Thoughts

- West Coast precipitation extremes have their origin in winter-time atmospheric rivers and spring/fall decaying tropical systems. How will timing and magnitude change in the future?
- The interaction of atmosphere and watershed is a key element in how the precipitation extreme manifests itself as well as the associated runoff.
- As the world continues to warm, the characteristics of atmospheric rivers/extreme precipitation drivers will change leading to potentially larger extremes or critical events in the coming decades. More work is needed to study the details of those characteristics and important thresholds motivating adaptive measures.

Summary Thoughts

- Trends are not the only important element of a warming world. Key thresholds for processes to happen or become extreme may be crossed more frequently without an identifiable trend. We need to ask the right questions.
- Water management can identify conditions that challenge existing operational practices and evaluate adaptive strategies should those conditions become more commonplace. Identifying triggers to employ those adaptive measures is important. Understanding resilience of adaptive strategies is also important.
- Continued collaboration with science community can provide key intel to facilitate improved water management in a warming world.

Questions?

Michael.L.Anderson@water.ca.gov