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# Historic California Floods Contrasted with Potential Future Floods

California Extreme Precipitation Symposium, June 22, 2021

Michael Anderson, P.E., Ph.D. State Climatologist

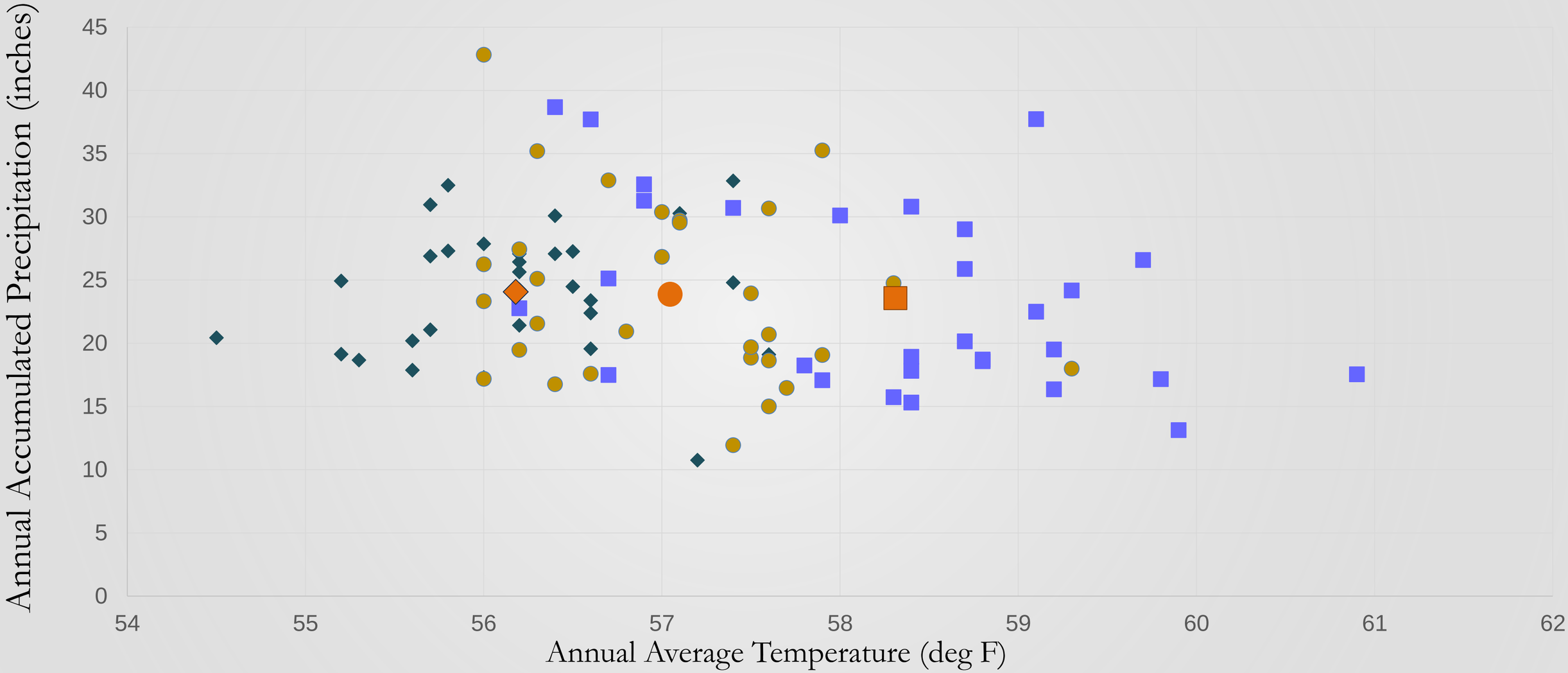
# Overview

- Atmosphere and watershed interact dynamically during extreme precipitation events leading to floods – relationships likely to change with climate change

- Atmospheric Rivers (AR) characteristics give insight into atmospheric component and its evolution with a warming world

- Work remains to be done to connect science insights of ARs into meaningful planning tools for infrastructure responses to future floods

# CA Temperature and Precipitation

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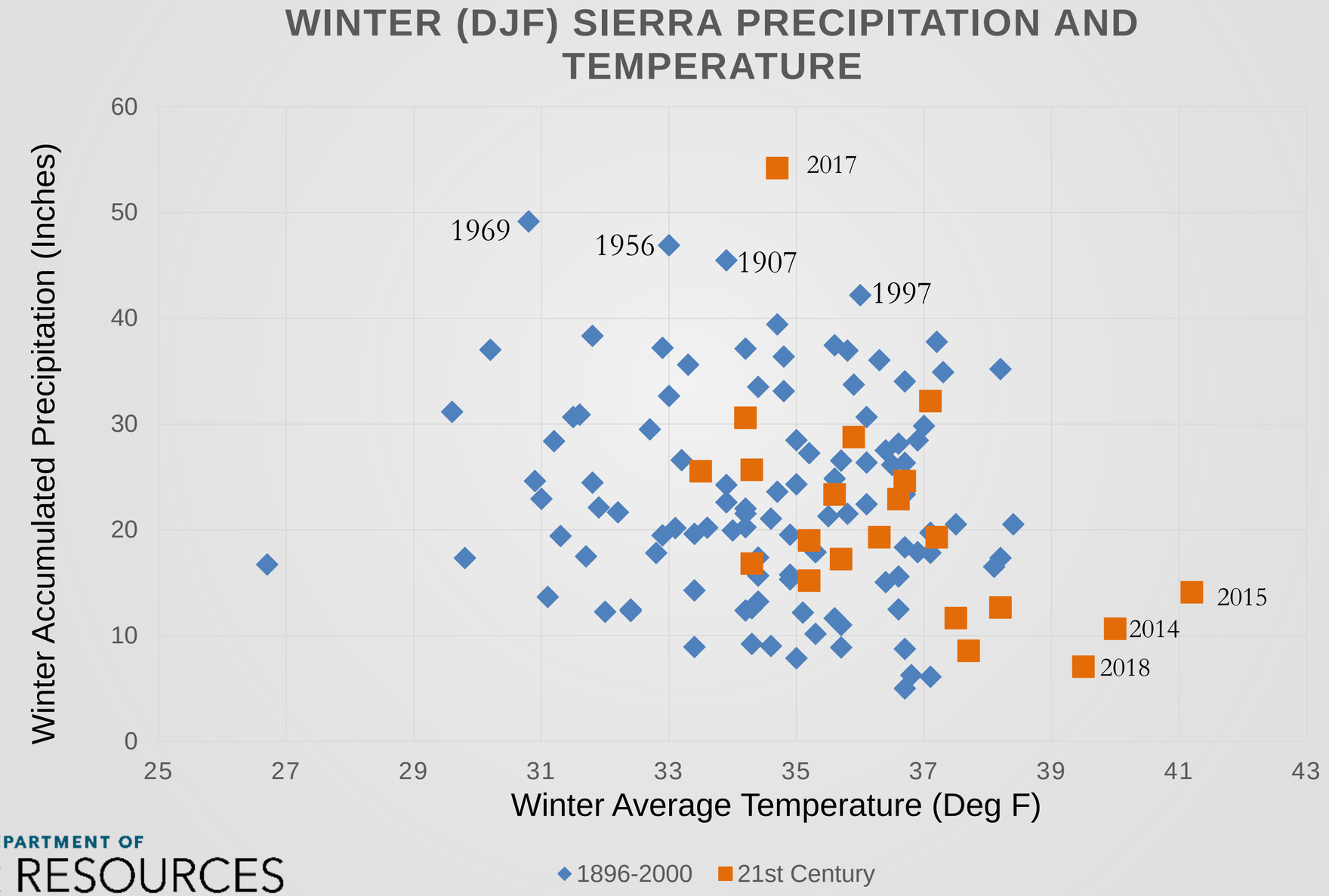
# A Changing Climate

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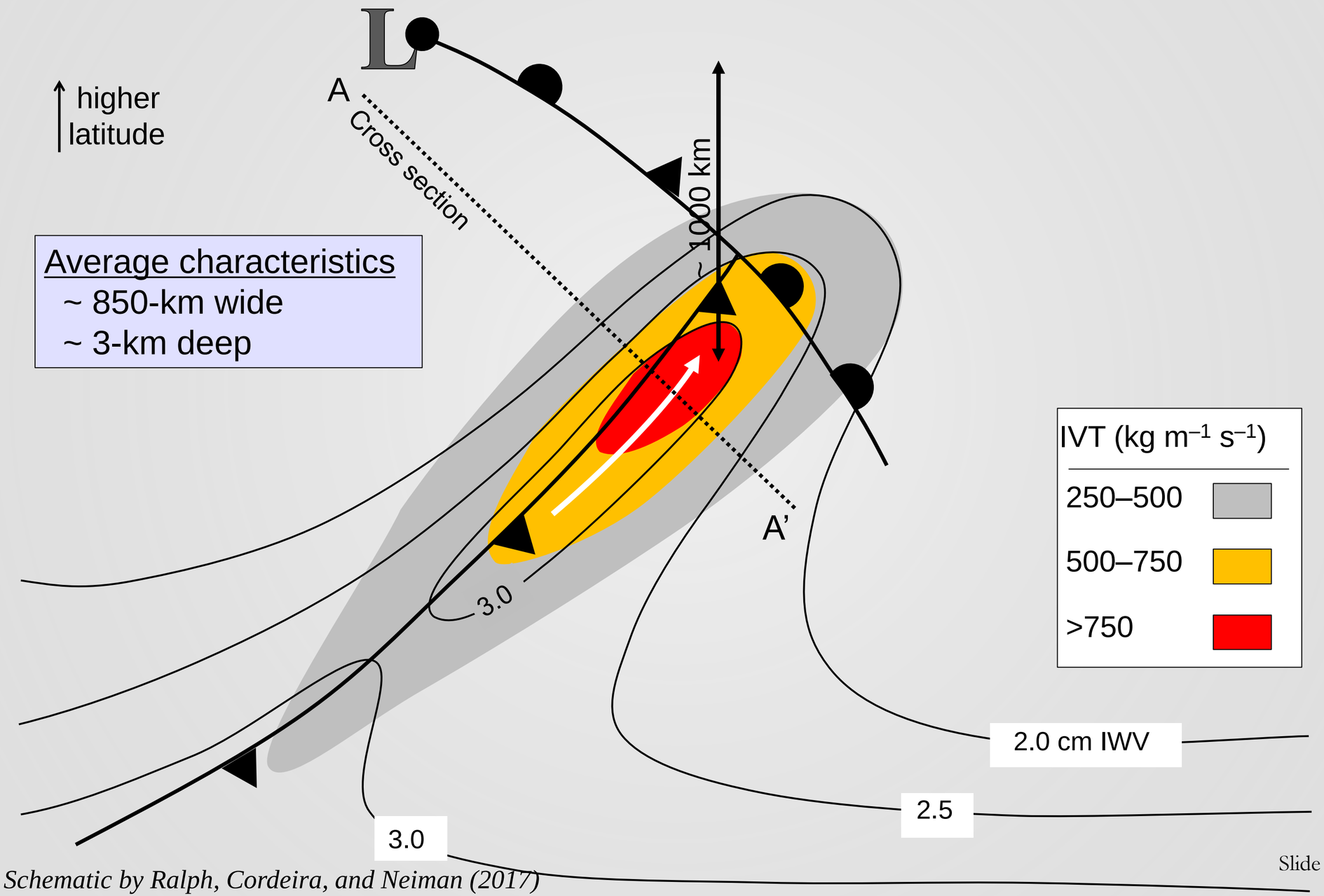
# AR Characteristics and Floods

- Integrated Vapor Transport (IVT) – product of winds and moisture
- Orientation with respect to watershed
- Duration of AR conditions
- Freezing Elevation
- Groupings or AR Families

# Watershed Characteristics and Floods

- Area-Elevation relationship
- Antecedent conditions
- Watershed Orientation
- Watershed slope/area/length relationships

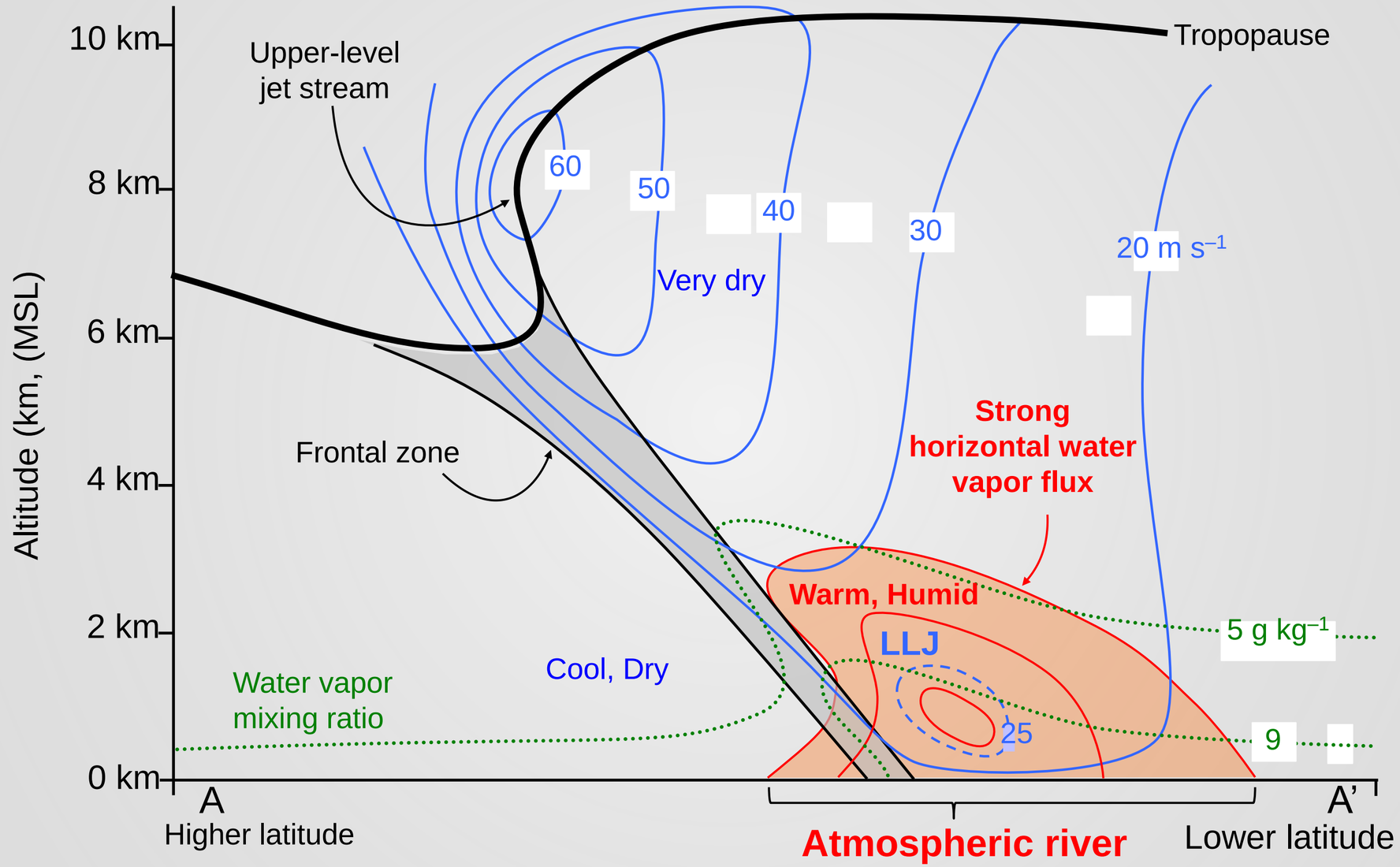
# Horizontal schematic of an Atmospheric River




*Schematic by Ralph, Cordeira, and Neiman (2017)*

Slide adapted from Jay Cordeira

# Cross-sectional schematic of an Atmospheric River

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*Schematic by Ralph, Cordeira, and Neiman (2017)*

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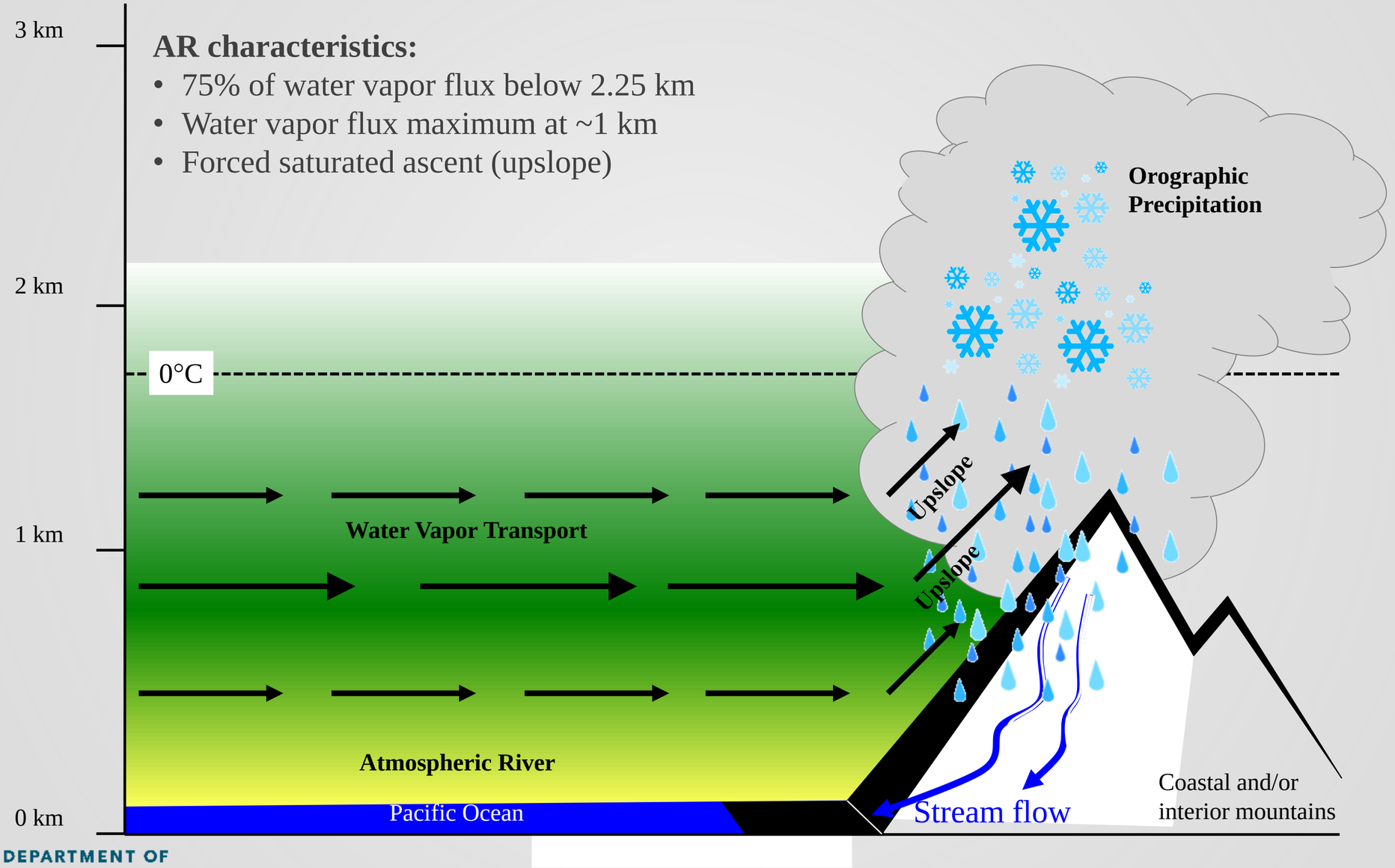
# Cross-sectional schematic of orographic precipitation

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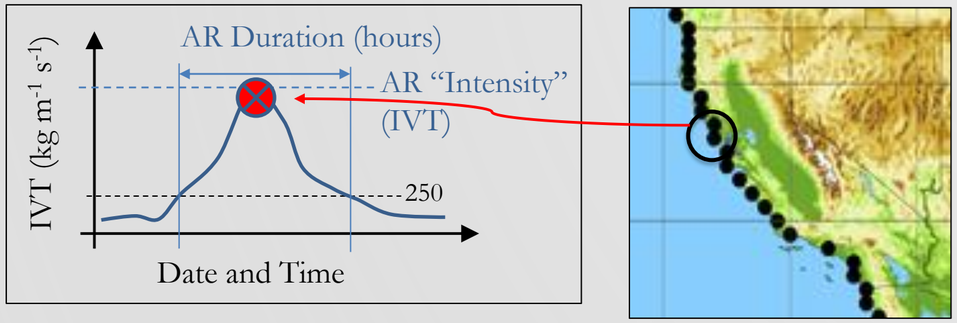
**The AR CAT level of an AR Event* is based on its *Duration*** and max *Intensity* (IVT)*****

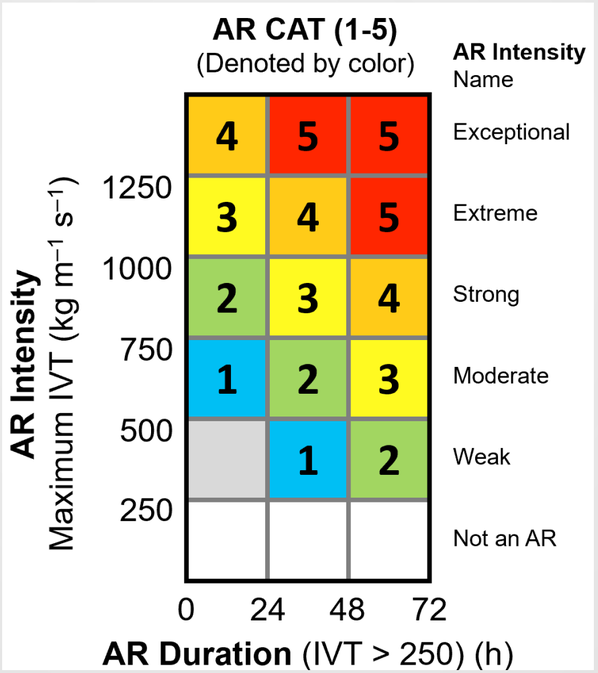
** An "AR Event" refers to the existence of AR conditions at a specific location for a specific period of time.*
*** How long IVT>250 at that location. If duration is <24 h, reduce AR CAT by 1, if longer than 48 h, add 1.*
**** This is the max IVT at the location of interest during the AR.*

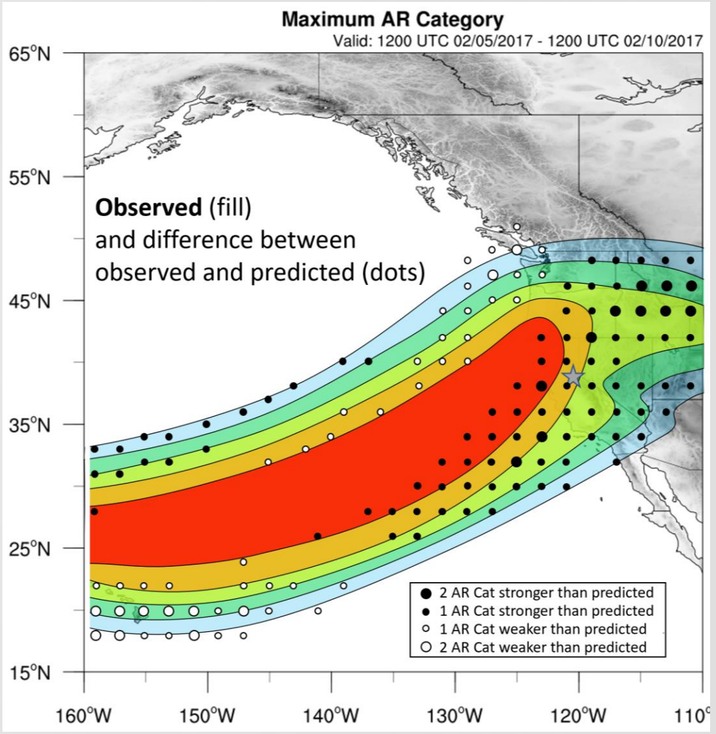
# *IMPACTS*

- AR Cat 5 – Primarily hazardous
- AR Cat 4 – Mostly hazardous, also beneficial
- AR Cat 3 – Balance of beneficial and hazardous
- AR Cat 2 – Mostly beneficial, also hazardous
- AR Cat 1 – Primarily beneficial



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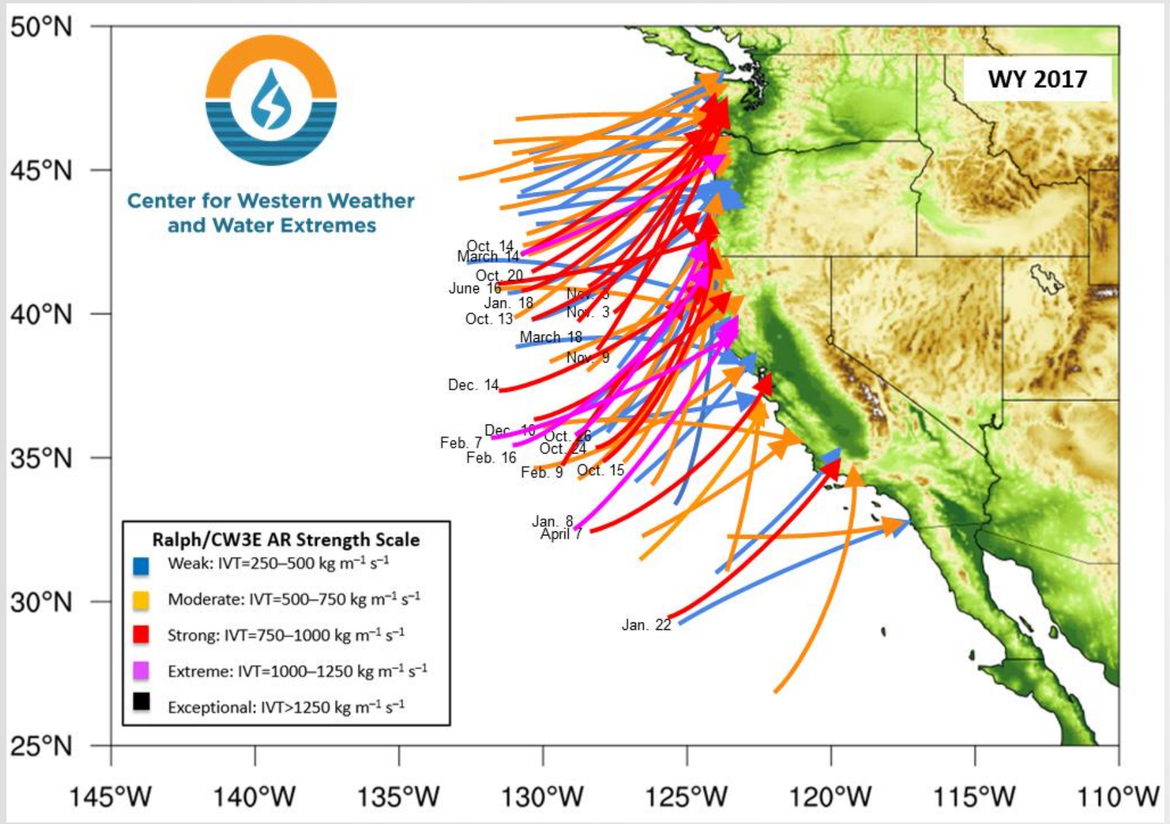
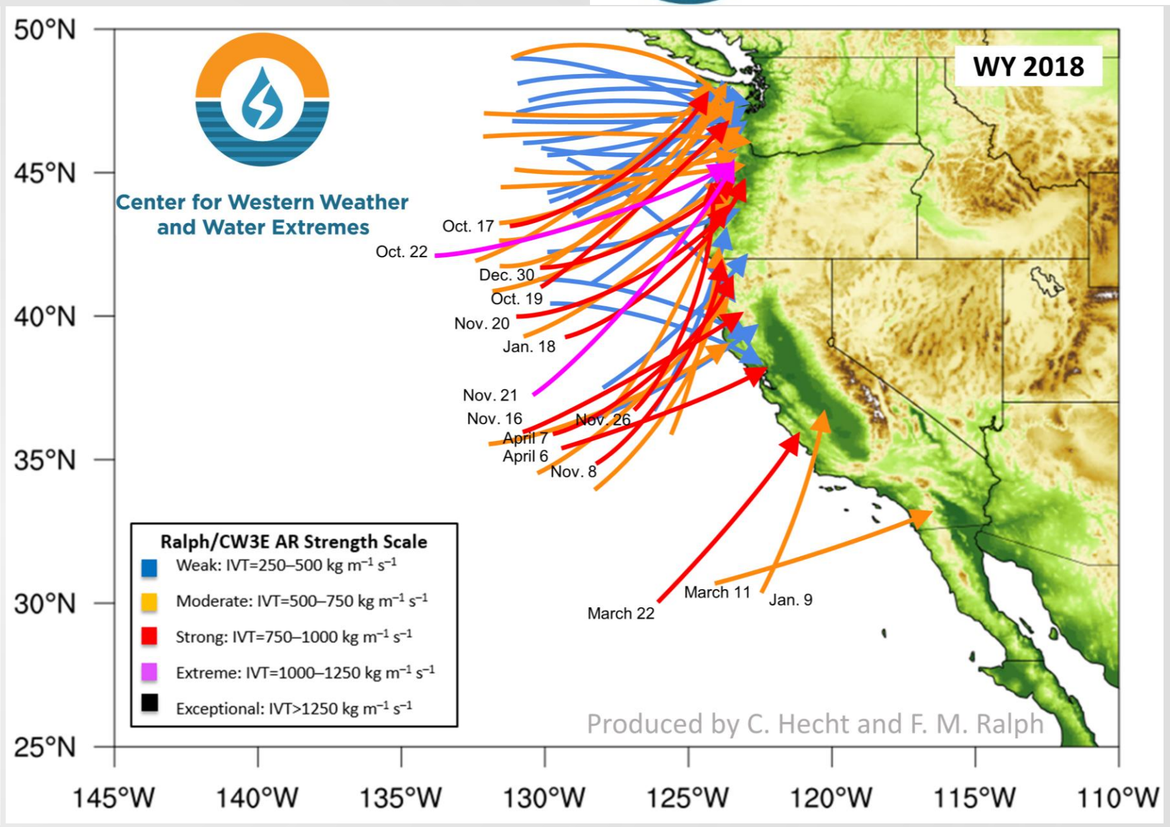
Center for Western Weather and Water Extremes

# Water Year 2017 Compared to Water Year 2018

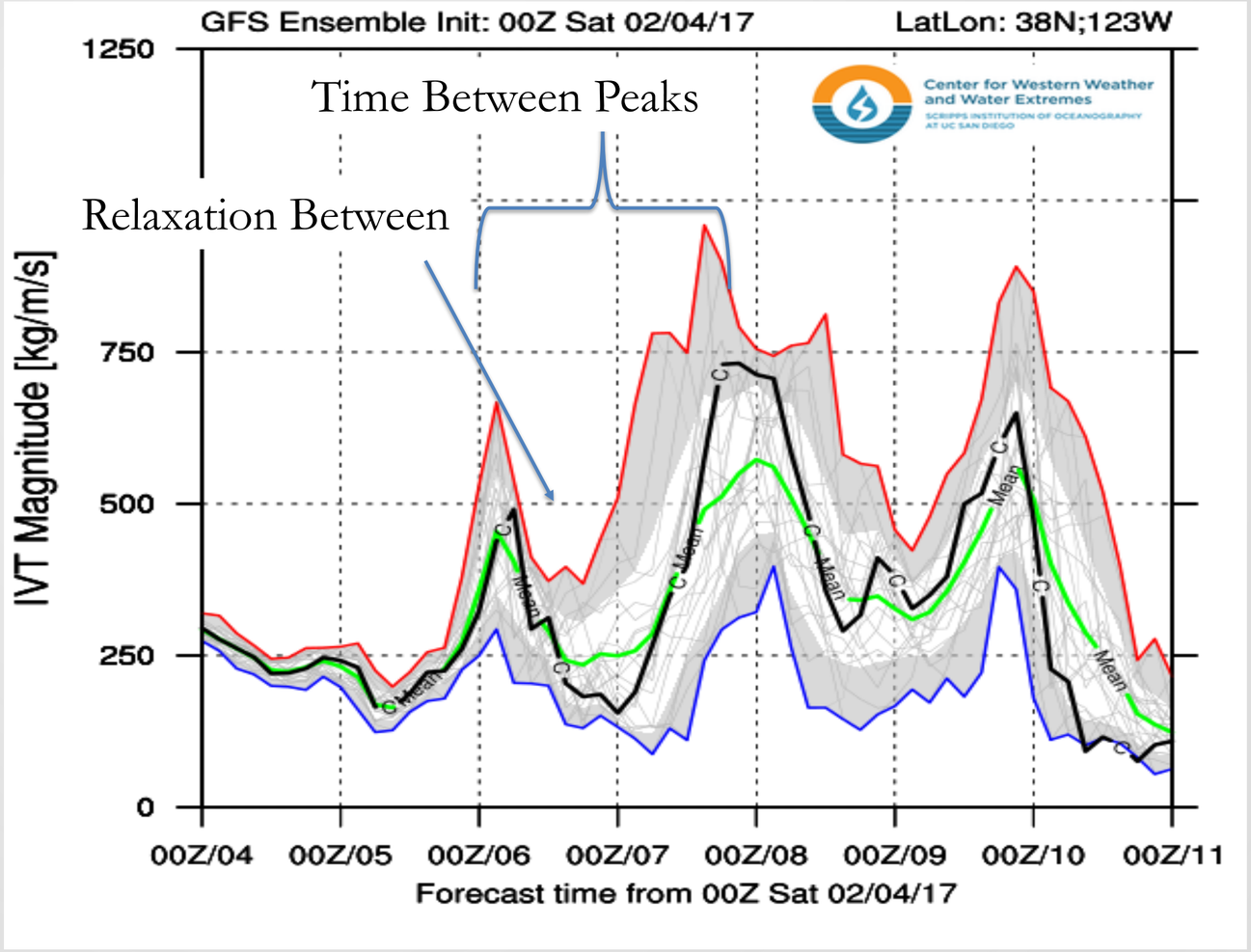
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO




- Water Year 2018 experienced a total of 55 landfalling ARs over the U.S. West Coast, 13 less than Water Year 2017
- Water Year 2018 also experienced 14 ARs that were associated with strong or greater IVT magnitudes compared to 13 during WY 2017

# AR Families – Clusters of ARs creating cascading impacts

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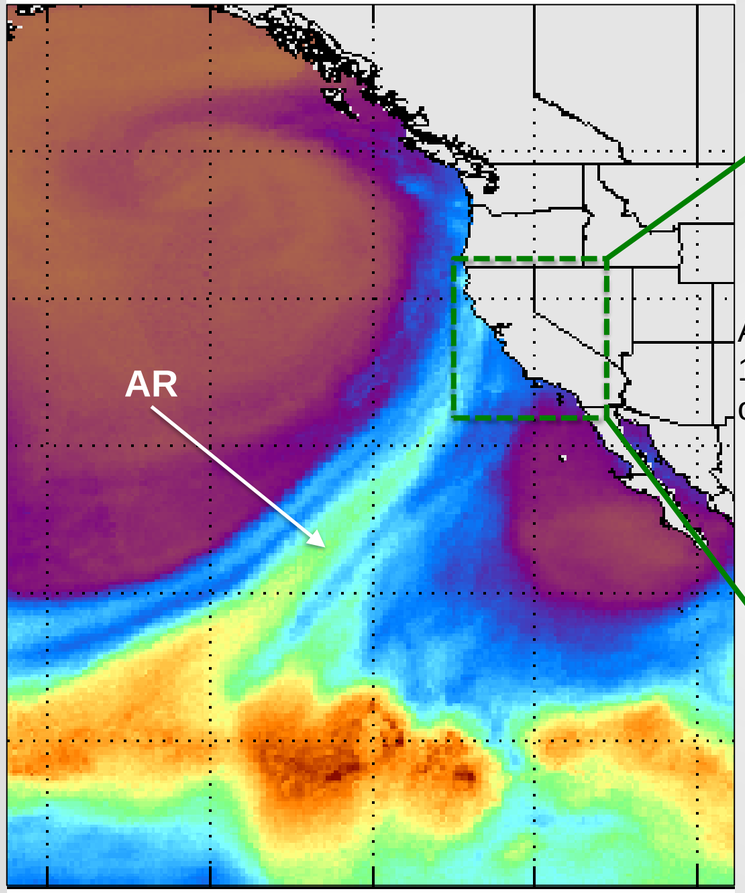
# Atmospheric Rivers and Streamflow

1800 UTC 8 Jan 2017
Satellite-derived Precipitable Water

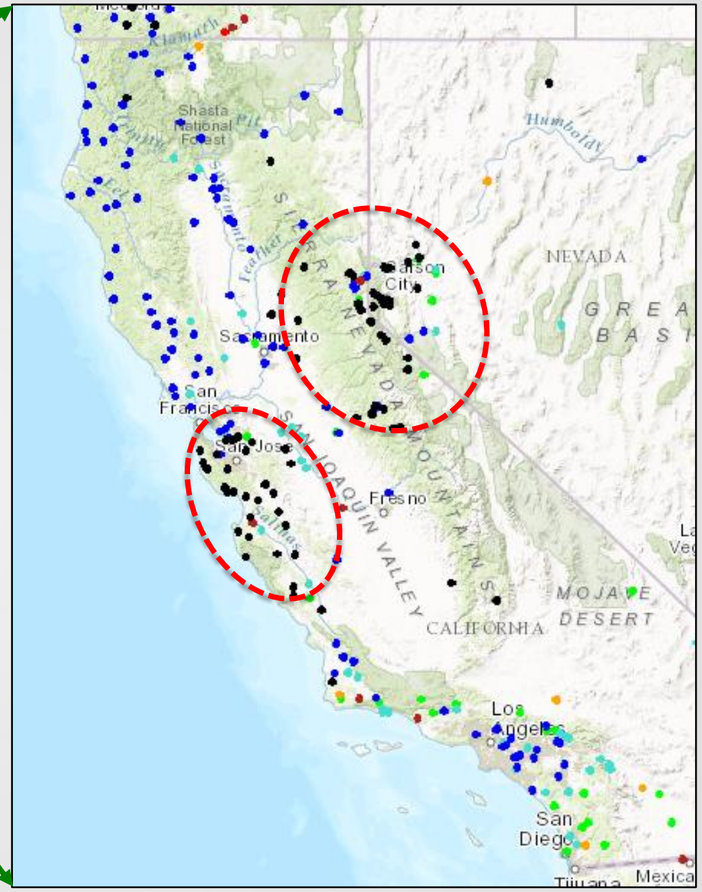


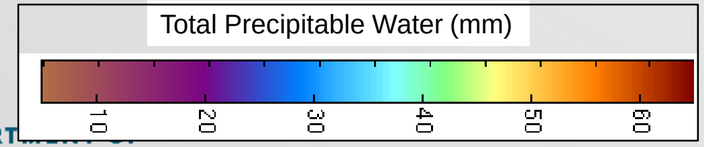

Day +1

Add
18–22 inches
of rain →

Day +1

1500 UTC 9 Jan 2017
USGS streamflow Percentile




| Explanation - Percentile classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Low | <10 | 10-24 | 25-75 | 76-90 | >90 | High | Not-ranked |
| | Much below normal | Below normal | Normal | Above normal | Much above normal | | |

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Slide adapted from Jay Cordeira

# Watershed Shape and AR Orientation

Vertical Structure matters
just as much as horizontal


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# Atmospheric River Ingredients

- What ingredients contribute to heavy rain and flooding?

$$\textit{Total Precipitation} = \textit{Precipitation Rate} \times \textit{Duration}$$

- Now consider which factors are associated with ARs…
  - Intensity of water vapor flux (quantified by IVT and IWV)
  - Orientation of water vapor flux (relative to terrain)
  - Depth of water vapor flux (relative to terrain)
  - Duration of water vapor flux (over one spot)
  - Timing of water vapor flux (relative to past storms)
  - Freezing level (rain versus snow in mtns)
  - Large-scale flow pattern (think synoptic dynamics)
  - Time of year (e.g., air mass/moisture/SST)



Slide adapted from Jay Cordeira

# What to do about Flood Planning?

- **Vulnerability Analysis** – At what points do flood management system components change performance leading to consequence
- **Scenario Planning** – Create a flood sequence and evaluate how flood management system performs; modify sequence and repeat
- **How do investment choices reduce vulnerability and improve performance?**

# From AR metrics to Flood Planning Scenario

- Work is ongoing on understanding changes in AR metrics due to climate change.
- AR metrics need to be translated to precipitation scenarios – in space and time.
- Precipitation scenarios need to be transformed to flood scenarios to use in flood planning from emergency response to land use planning.

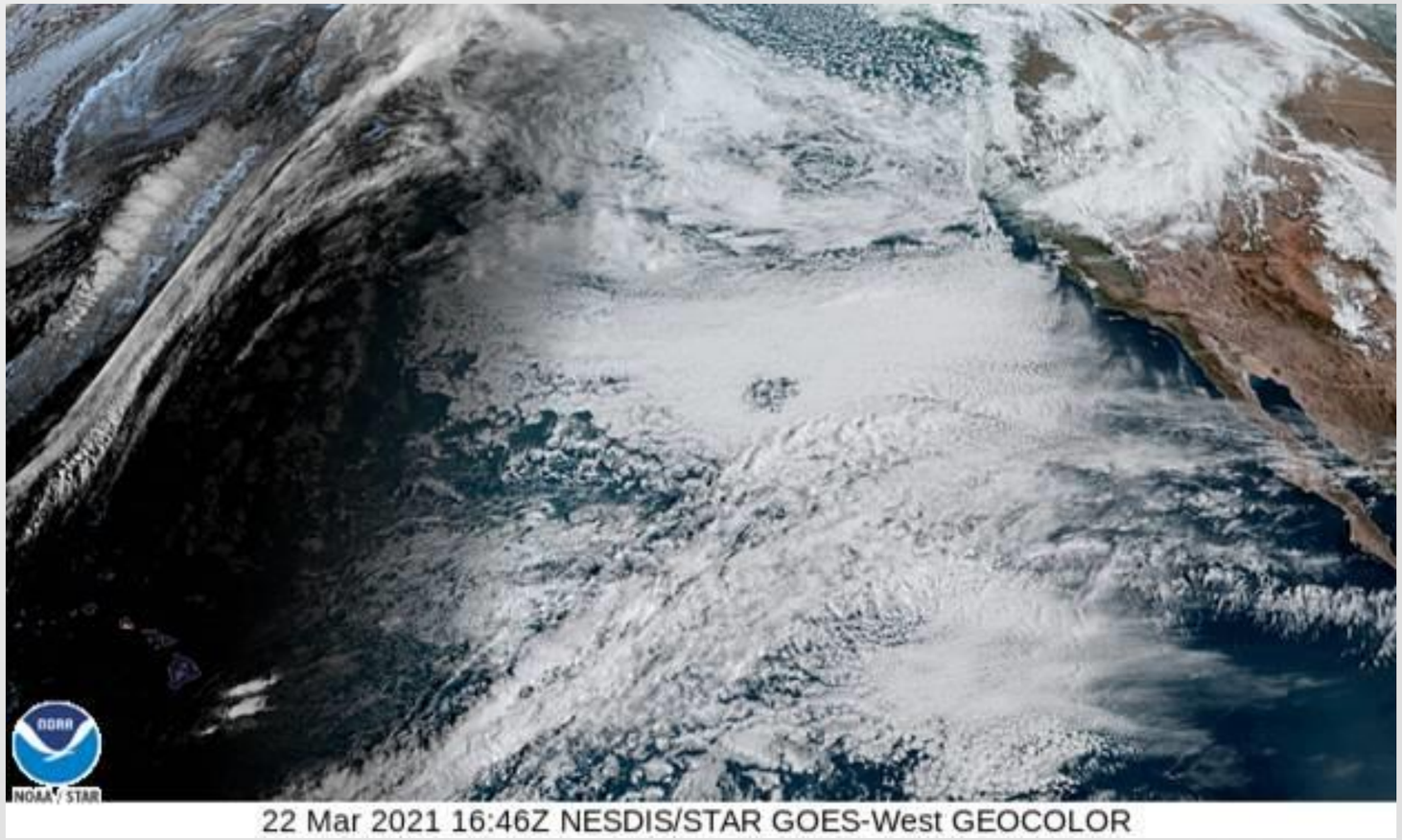
# Summary

- AR Characteristics will change with a warming world which will change how ARs interact with the terrain.
- The interaction between ARs and terrain drive spatial variability and intensity of precipitation.
- Spatial distribution of heavy precipitation driven in part by terrain structure which influences runoff timing from different parts of the watershed.

# Questions?

- Email:

Michael.L.Anderson@water.ca.gov

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