The Landfalling Atmospheric Rivers of Water Year 2023

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Introduction

- Water Year (WY) 2023 was characterized by several active stretches of atmospheric rivers that produced above normal to record breaking precipitation and snowfall across California
- This study utilizes a subjective climatology applying objective criteria to identify frequency, distribution, orientation and intensity of atmospheric rivers (ARs) during WY 2023 and previous WYs
- Goal of this analysis is to contextualize the anomalous winter of WY 2023 and how it compares to recent WYs

Methodology

- Identified ARs using 6-hourly GFS Analysis derived integrated water vapor transport (IVT)
- Arrows are drawn on map where IVT was strongest over US West Coast
- Several characteristics and statistics of each AR logged in a database, providing additional information on each AR (e.g., locations impacted, orientation, etc.)

Summary

- 31 ARs impacted California between October 2022 and March 2023, ~2 fewer than a typical WY (Fig. 1)
- While the total number of ARs was less than the average for years back to WY 2012, a larger majority of those ARs were of strong or greater magnitude (7 compared to an average of ~5; Tables 1 & 2)
- California experienced strong or greater magnitude AR conditions 8 times during WYs 2020, 2021, & 2022, combined, leading to a multi-year drought (Figs. 2 & 3)
- CA's central coast, where precipitation was most anomalous, experienced 11 moderate and four strong ARs, double the number this region typically sees in a WY (Fig. 4 & Table 2)
- These moderate and strong ARs came during two active stretches, one from late Dec. through mid Jan. and a second from late Feb. through Mar. (Fig. 4)
- These active stretches combined to produce record precipitation through March over the Tulare Basin 6-Station Index, nearing or surpassing the totals from WYs 1969 and 1983, respectively (Fig. 4)

Summary of Water Year 2023 Through March

31 atmospheric rivers impacted California between October 1st 2022 and March 31st 2023
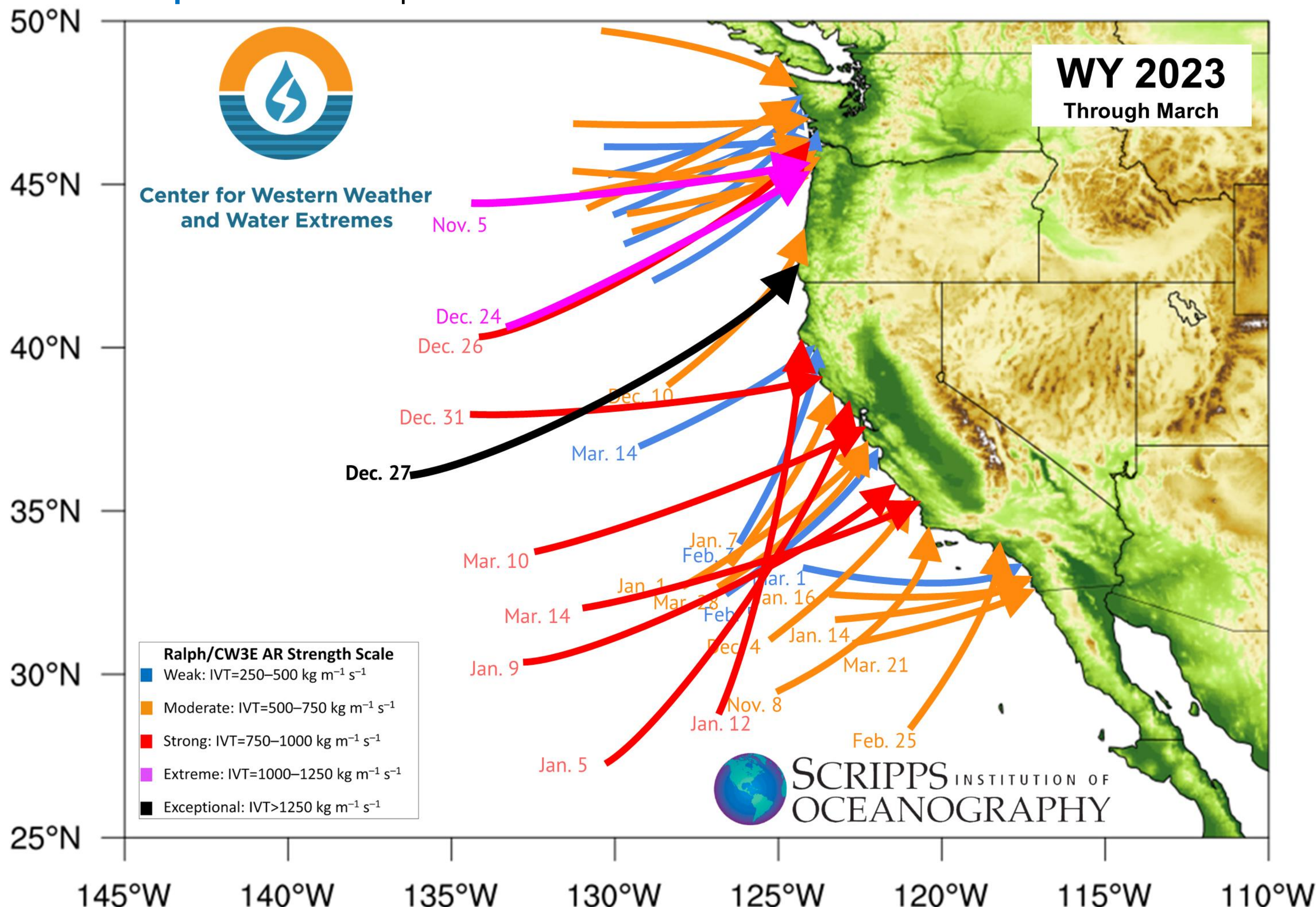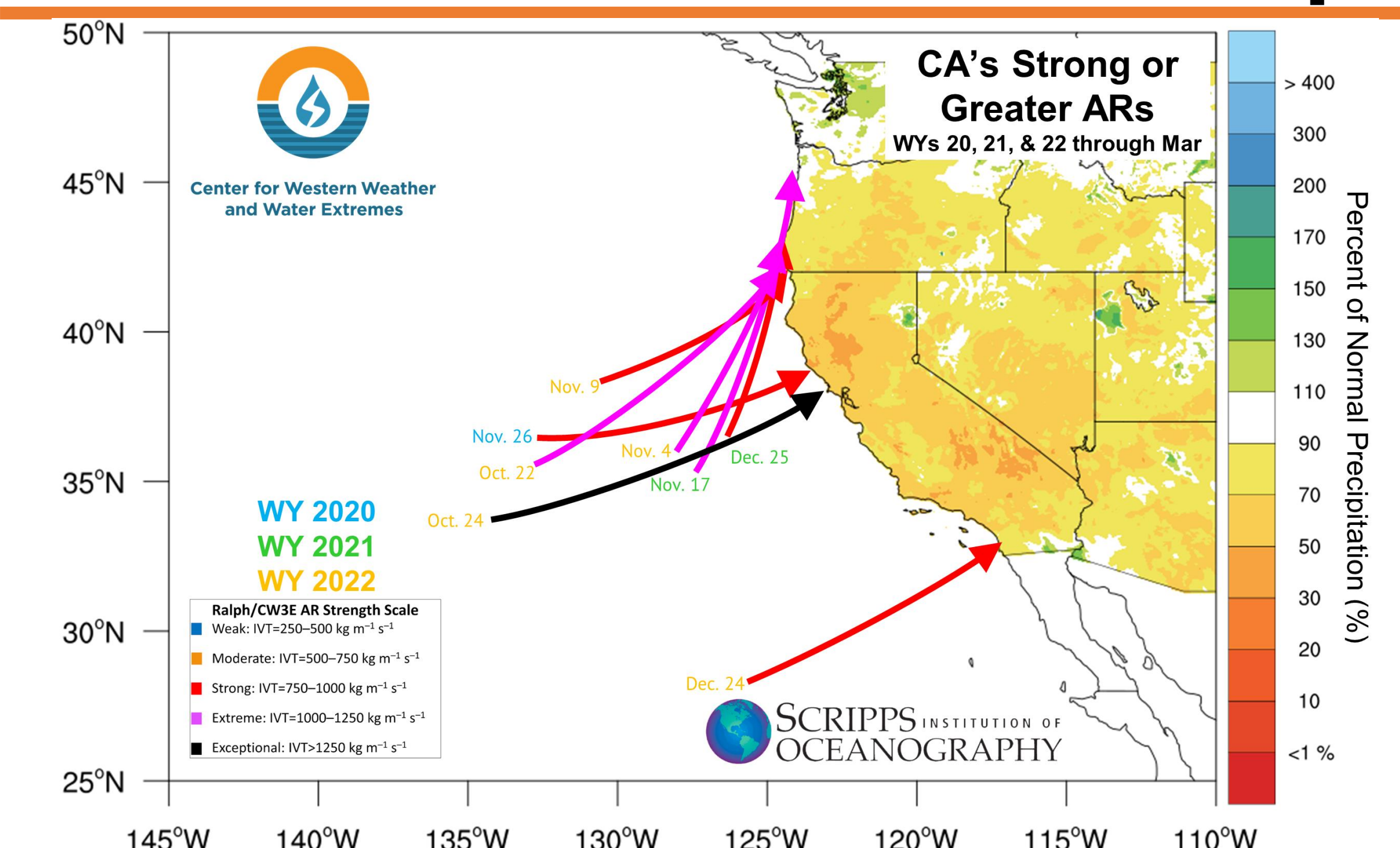

Fig. 1 (Above): The atmospheric rivers of water year 2023 (October through March). Each arrow is placed on the map where integrated vapor transport was strongest over the coast during the event. The color of each arrow corresponds to the maximum instantaneous IVT magnitude (legend on bottom left of graphic).

Table 1 (Below): Breakdown of the atmospheric rivers that impacted California by month and strength. The strength is determined via maximum instantaneous IVT magnitude (legend on bottom right of top image)

Breakdown by Month & Strength							
Strength	Oct	Nov	Dec	Jan	Feb	Mar	Total
Weak	1	1	2	1	4	2	11
Moderate	1	2	4	3	1	2	13
Strong	0	0	1	3	0	2	6
Extreme	0	0	1	0	0	0	1
Total	2	3	8	7	5	6	31

Comparison to Recent Water Years

Figs. 2 & 3: The atmospheric rivers that brought strong or greater magnitude conditions to California during water years 2020–2022 (above) and water year 2023 (below).
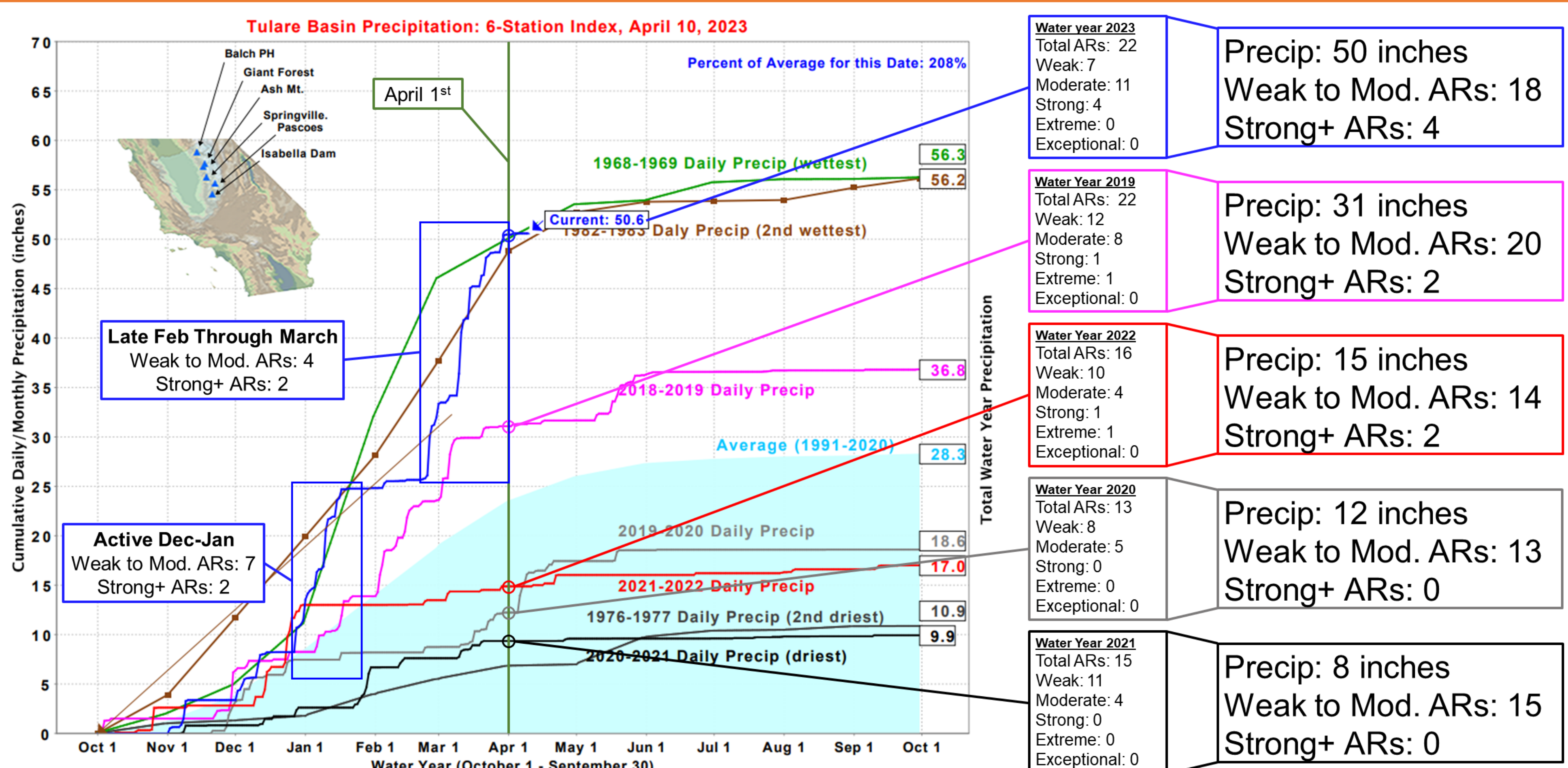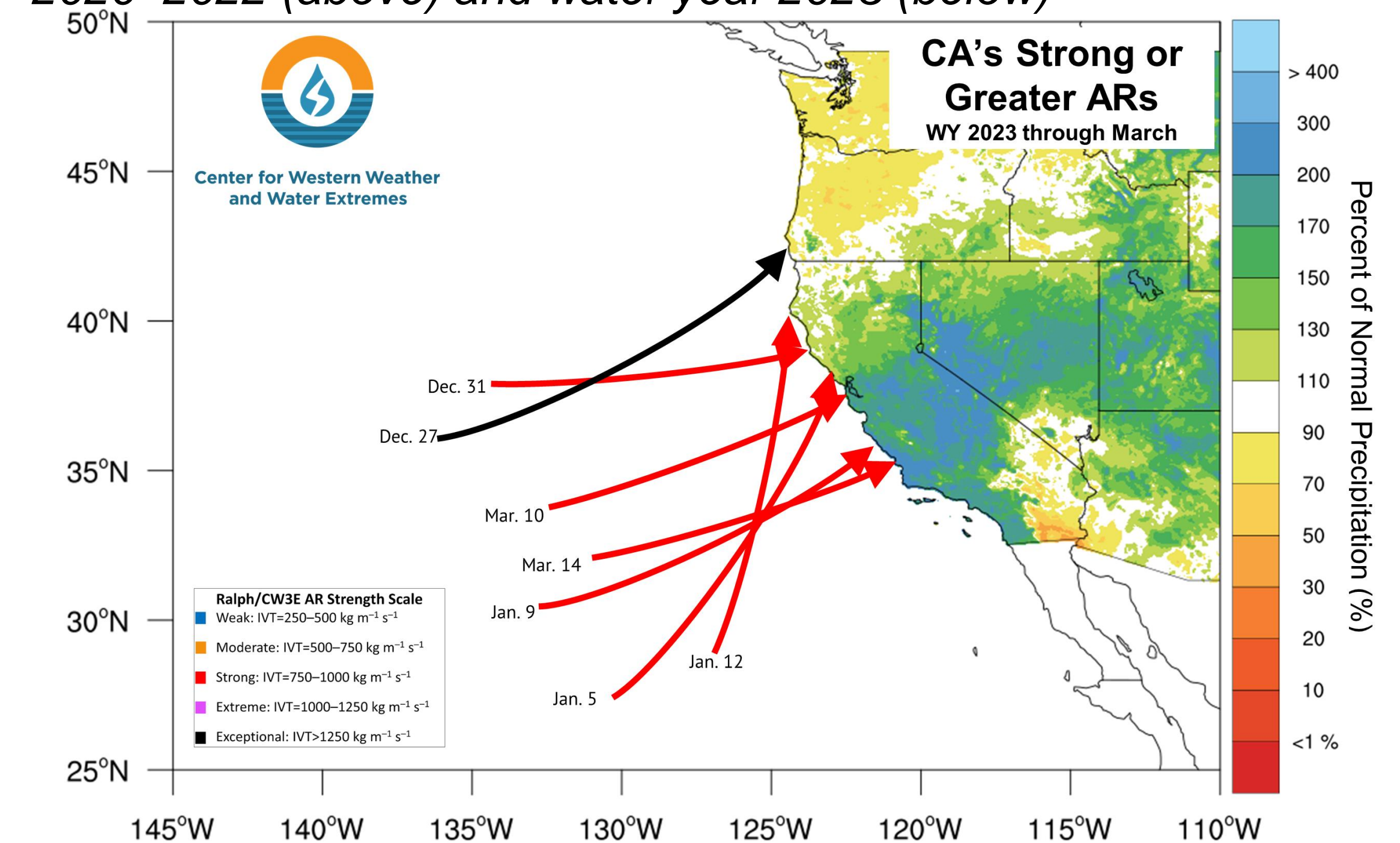

Fig. 4 (Above): Tulare Basin 6-Station Precipitation Index for the five most recent water years and the number of atmospheric rivers that impacted the central Coast of California during those water years through March (right side of plot).

Water year 2023
Total ARs: 22
Weak: 7
Moderate: 11
Strong: 4
Extreme: 0
Exceptional: 0
Precip: 50 inches
Weak to Mod. ARs: 18
Strong+ ARs: 4

Water Year 2019
Total ARs: 22
Weak: 12
Moderate: 8
Strong: 1
Extreme: 1
Exceptional: 0
Precip: 31 inches
Weak to Mod. ARs: 20
Strong+ ARs: 2

Water Year 2022
Total ARs: 16
Weak: 10
Moderate: 4
Strong: 1
Extreme: 0
Exceptional: 0
Precip: 15 inches
Weak to Mod. ARs: 14
Strong+ ARs: 2

Water Year 2020
Total ARs: 13
Weak: 8
Moderate: 5
Strong: 0
Extreme: 0
Exceptional: 0
Precip: 12 inches
Weak to Mod. ARs: 13
Strong+ ARs: 0

Water Year 2021
Total ARs: 15
Weak: 11
Moderate: 4
Strong: 0
Extreme: 0
Exceptional: 0
Precip: 8 inches
Weak to Mod. ARs: 15
Strong+ ARs: 0

Table 2 (Below): The average number of atmospheric rivers that impact California each year through March, broken down by strength and region. Averages are calculated for years back to water year 2012.

Average ARs through March in California (2012 to Present)					
Region	Weak	Moderate	Strong	Extreme	Total
NorCal	16.4	11.0	4.3	0.7	32.6
Cen/SoCal	11.8	5.5	1.4	0.2	18.8
All of CA	16.2	11.9	4.8	0.8	33.7