

CW3E Event Summary: 13-23 Jan 2024

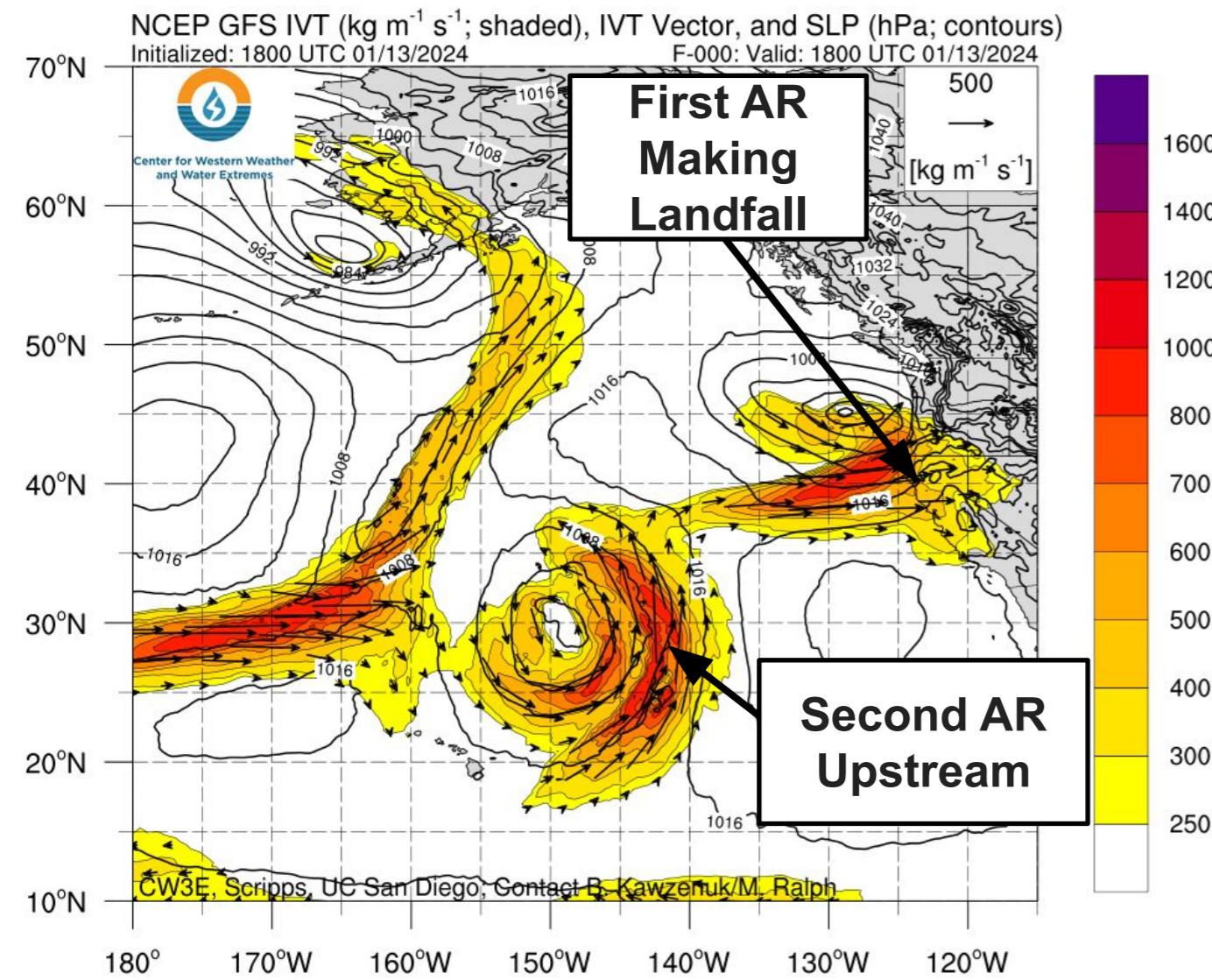
Four Atmospheric Rivers Highlight Active Weather Period Across US West Coast

- A series of four distinct atmospheric rivers made landfall along the US West Coast between Jan 13 and Jan 23 2024
- This prolonged period of active weather for the region resulted in a variety of liquid and frozen precipitation impacts
- The **first** AR made landfall along the OR/CA border early on Sat 13 Jan alongside a low pressure system, bringing heavy precipitation to the OR/CA border and the Southern Cascades.
- A cut-off low pressure system brought the **second** AR to the USWC. The burst of IVT with the AR alongside the persistence of the low pressure system resulted in heavy precipitation in the PNW, including significant freezing rain in the Portland Metro, and heavy snowfall in the Cascades.
- The **third** AR in the sequence developed as the persistent low pressure system shifted into the Gulf of Alaska, resulting in counterclockwise moisture transport around the cyclone, leading to southerly IVT transport along the US West Coast.
- A **fourth** AR developed over the eastern North Pacific, with a robust corridor of elevated moisture transport extending greater than 2,500 miles from north of Hawaii to the US West Coast
- The highest 10-day precipitation totals (> 10 in.) were observed along CA/OR border and over Northern Sierra Nevada.
- Snowfall accumulations during this period ranged from 2-6 feet in the Cascades, Sierra Nevada, and the higher terrain in the Upper Colorado River Basin.
- Additional impacts during this active period included river level rises due to heavy precipitation and a multi-day freezing rain event in the Pacific Northwest.

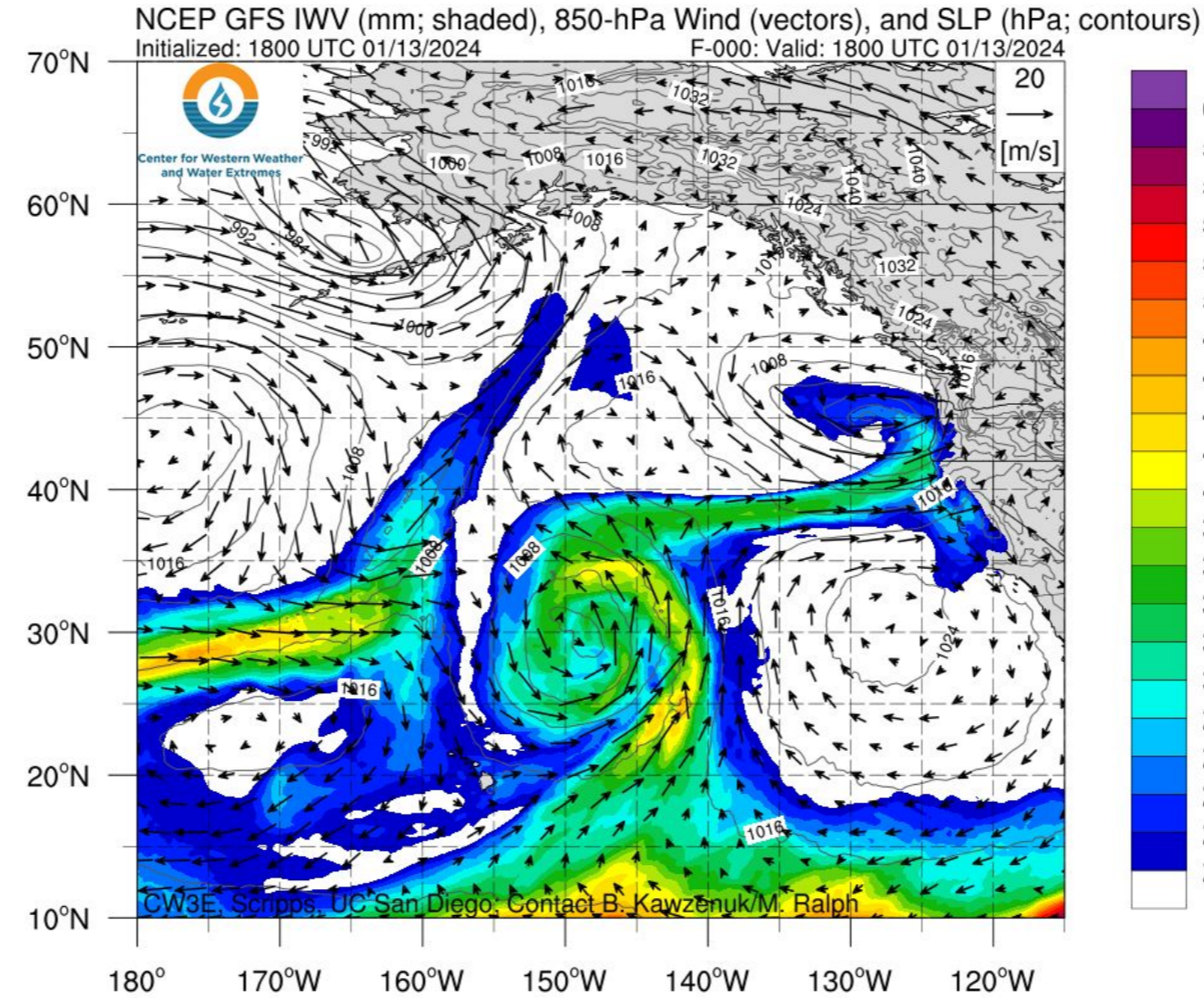
CW3E Event Summary: 13-23 Jan 2024

First AR: Landfall Sat 13 Jan

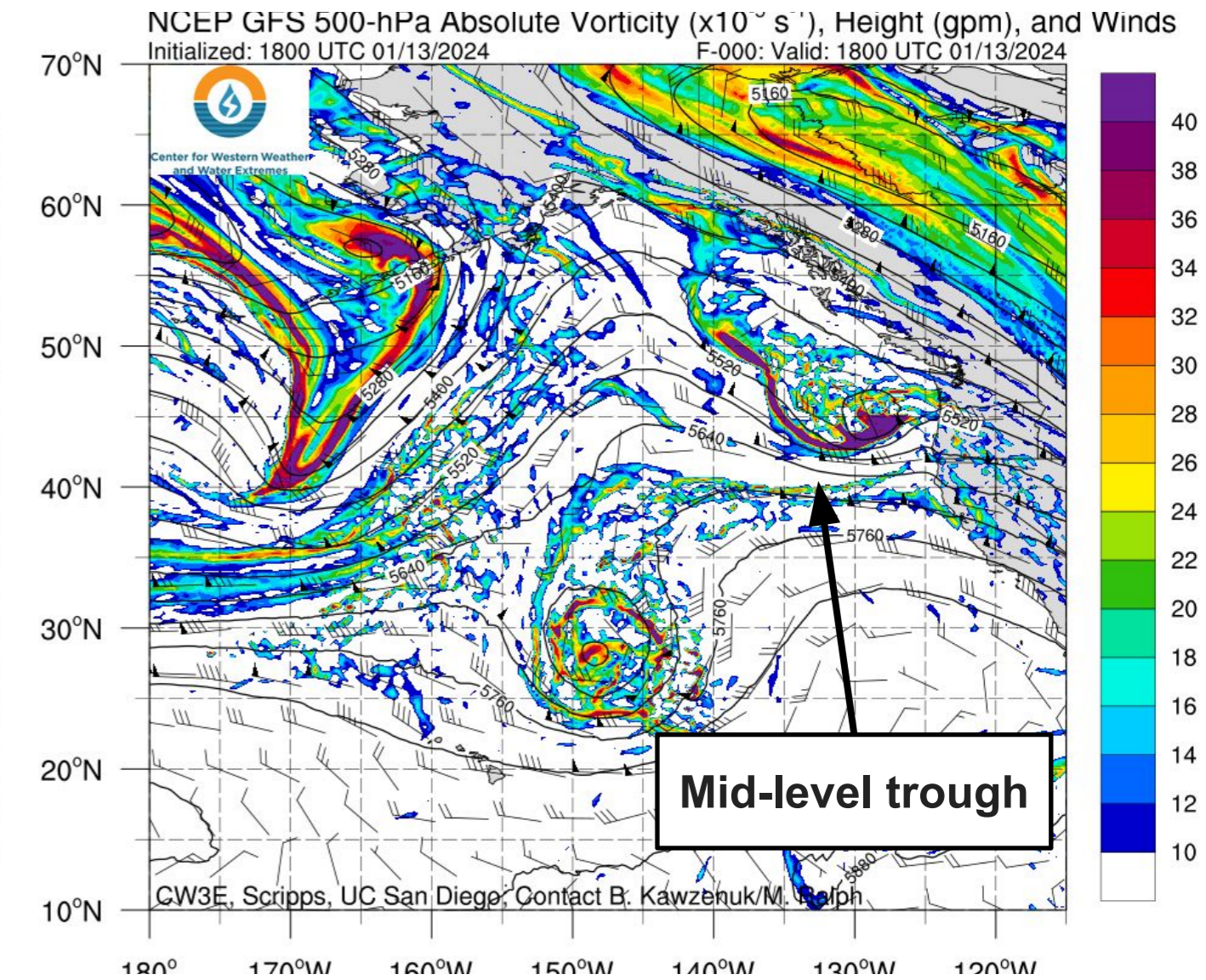
IVT and SLP



IWV and 850-hPa Winds



GFS 500-hPa Abs. Vorticity, Heights and Winds



- The **first** AR during this active period made landfall early in the day on Saturday 13 Jan. AR conditions were present along the coast of Oregon and Northern California for a period of ~24 hours. This AR was associated with a strong surface cyclone in the Gulf of Alaska
- Moisture fueling this storm was provided by a long, narrow corridor of tropical moisture that was transported up and over a ridge positioned off the coast of California,
- A mid-level trough positioned off the coast of the Pacific Northwest provided favorable synoptic forcing for ascent over this region

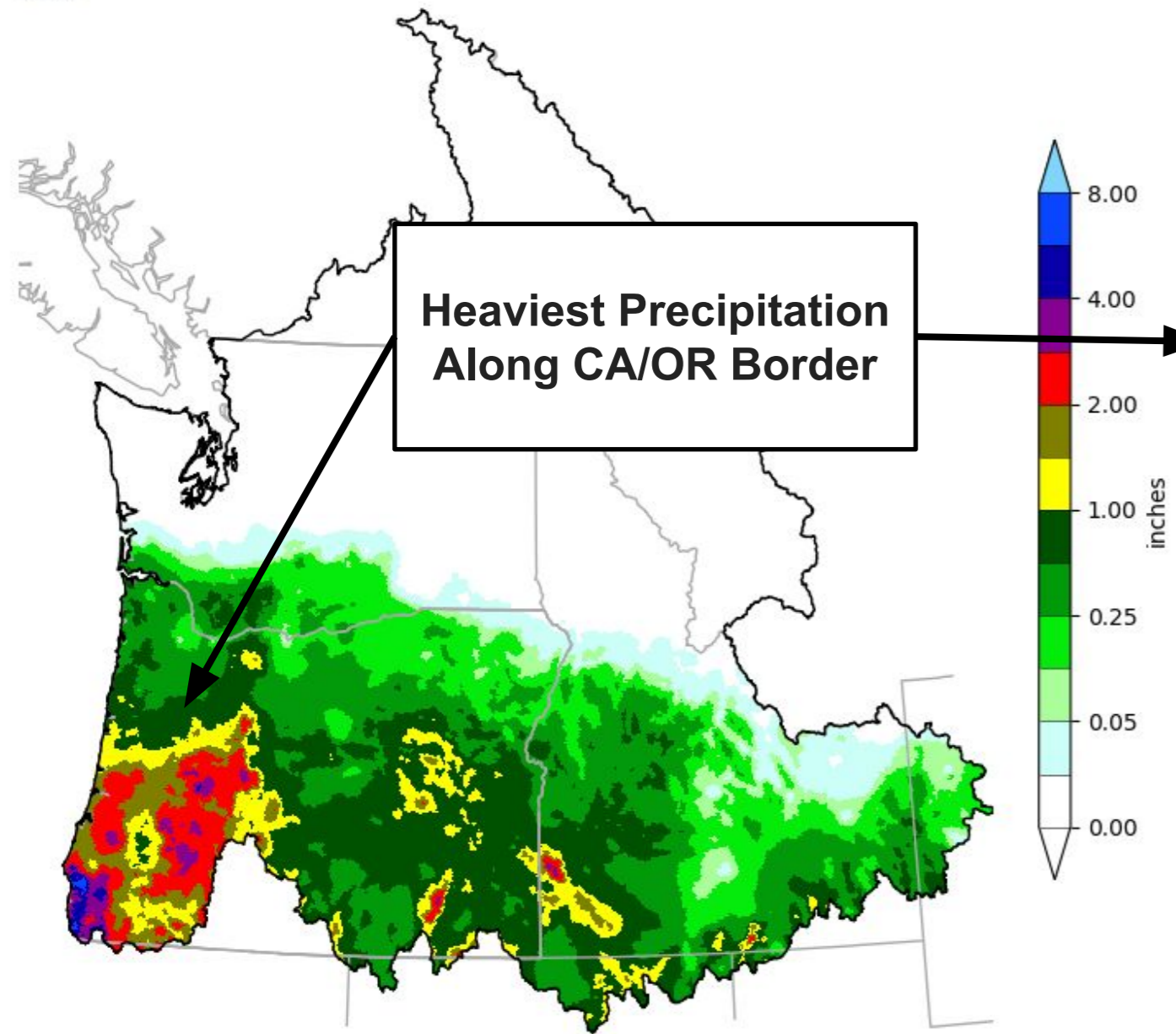
CW3E Event Summary: 13-23 Jan 2024

First AR: Observed Precipitation

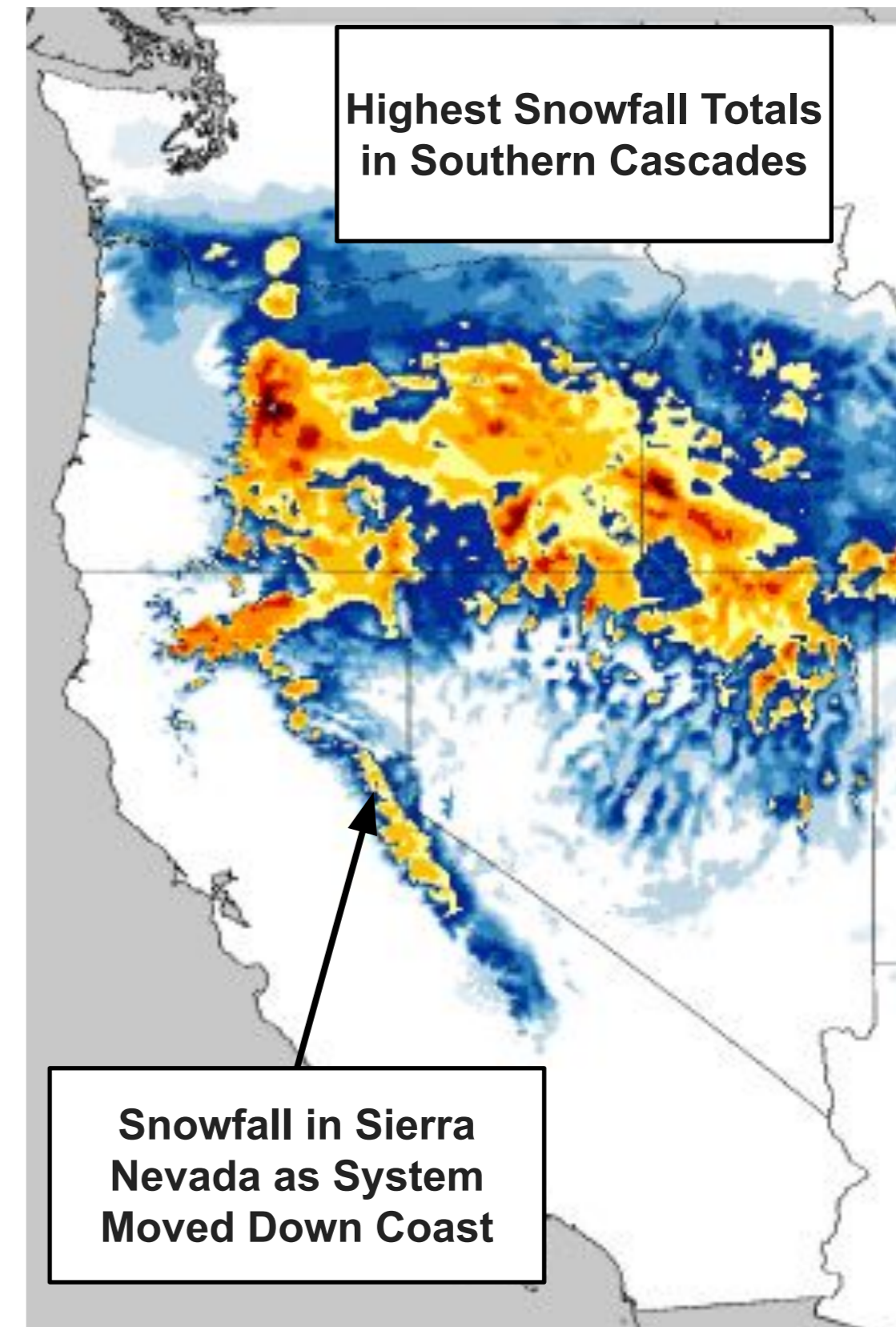
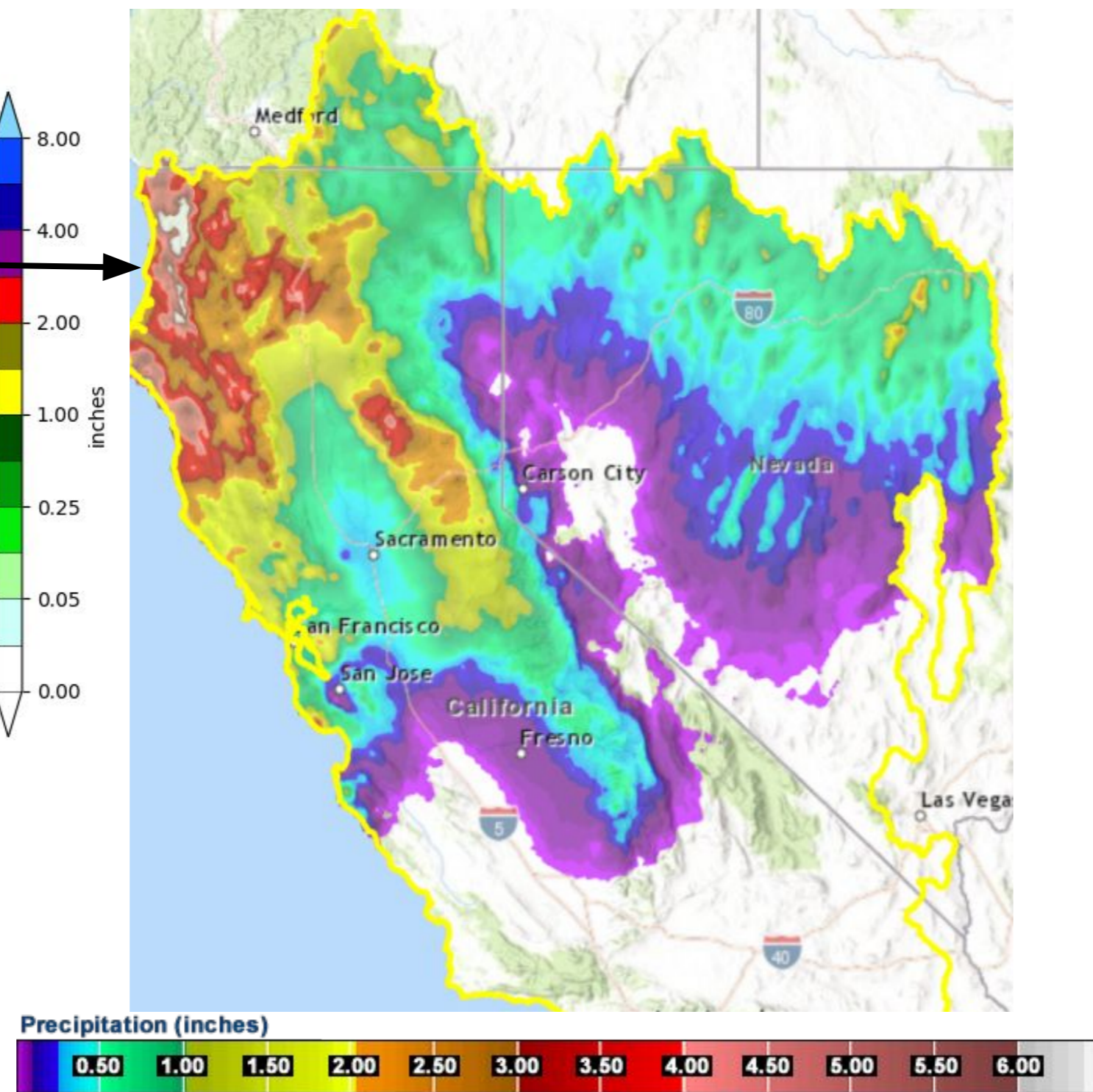
National Snowfall Analysis: 24-hour accumulation ending 2024-01-14 12 UTC
11980 reports; issued 2024-01-19 16:39:01 UTC



Northwest River Forecast Center
Observed 24hr Precipitation, Ending 12Z, 01/14/24



CNRFC Observed 24 hr Precipitation, Ending 12Z 14 Jan



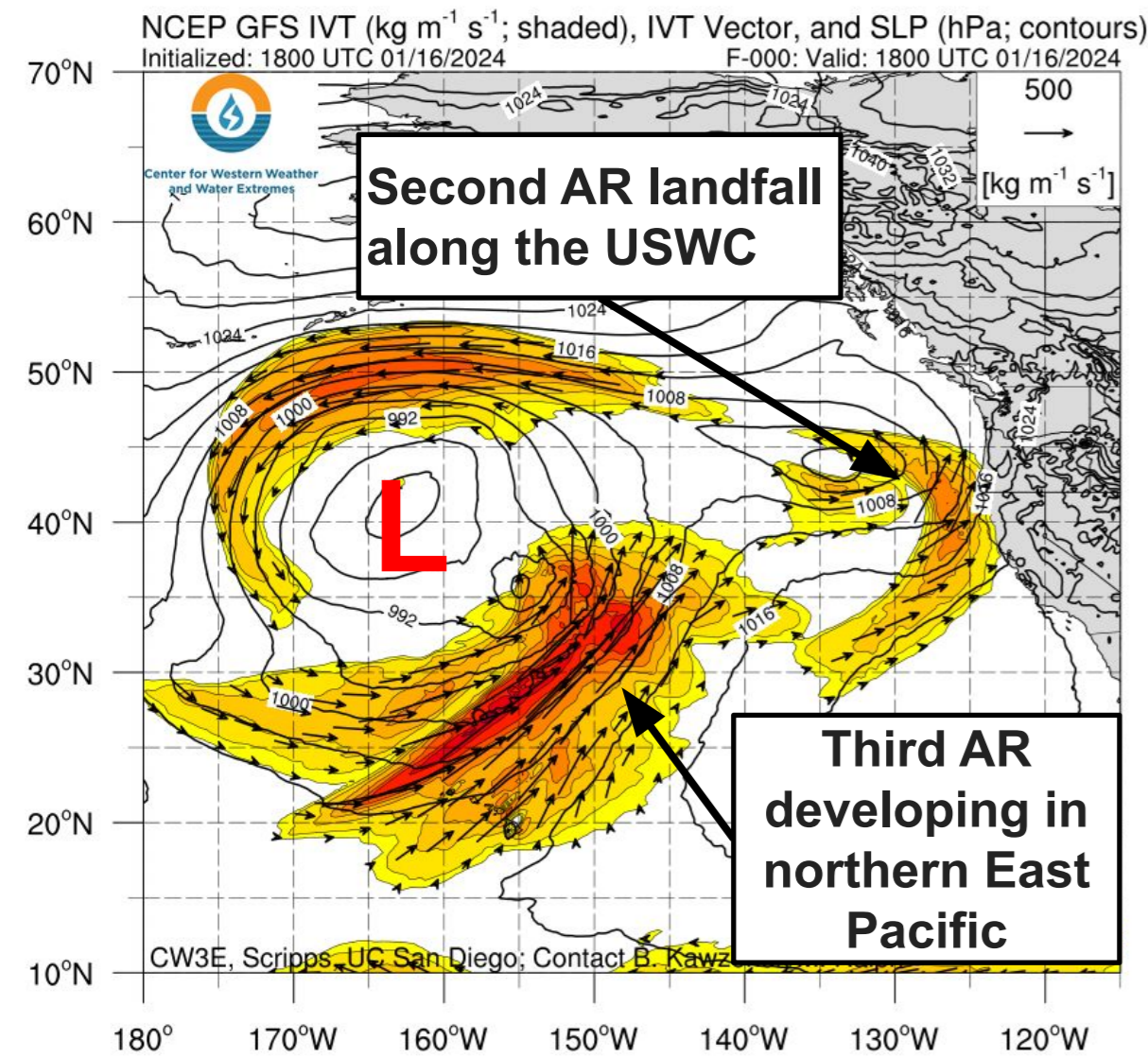
Creation Time: Sun Jan 14 15:30:16 UTC 2024

Source: National Gridded Snowfall Analysis https://www.nohrsc.noaa.gov/snowfall_v2/

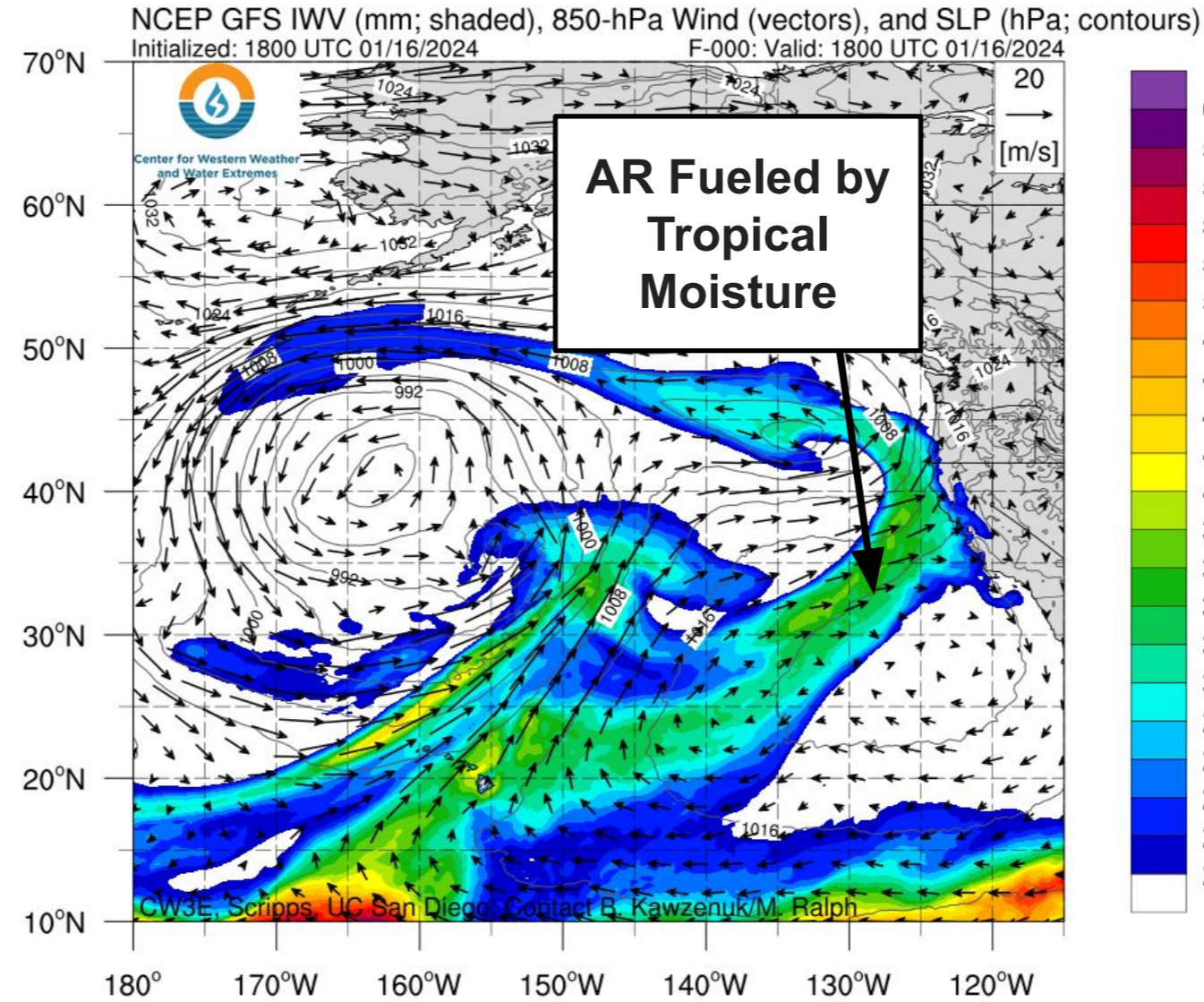
CW3E Event Summary: 13-23 Jan 2024

Second AR: Landfall Tue 16 Jan

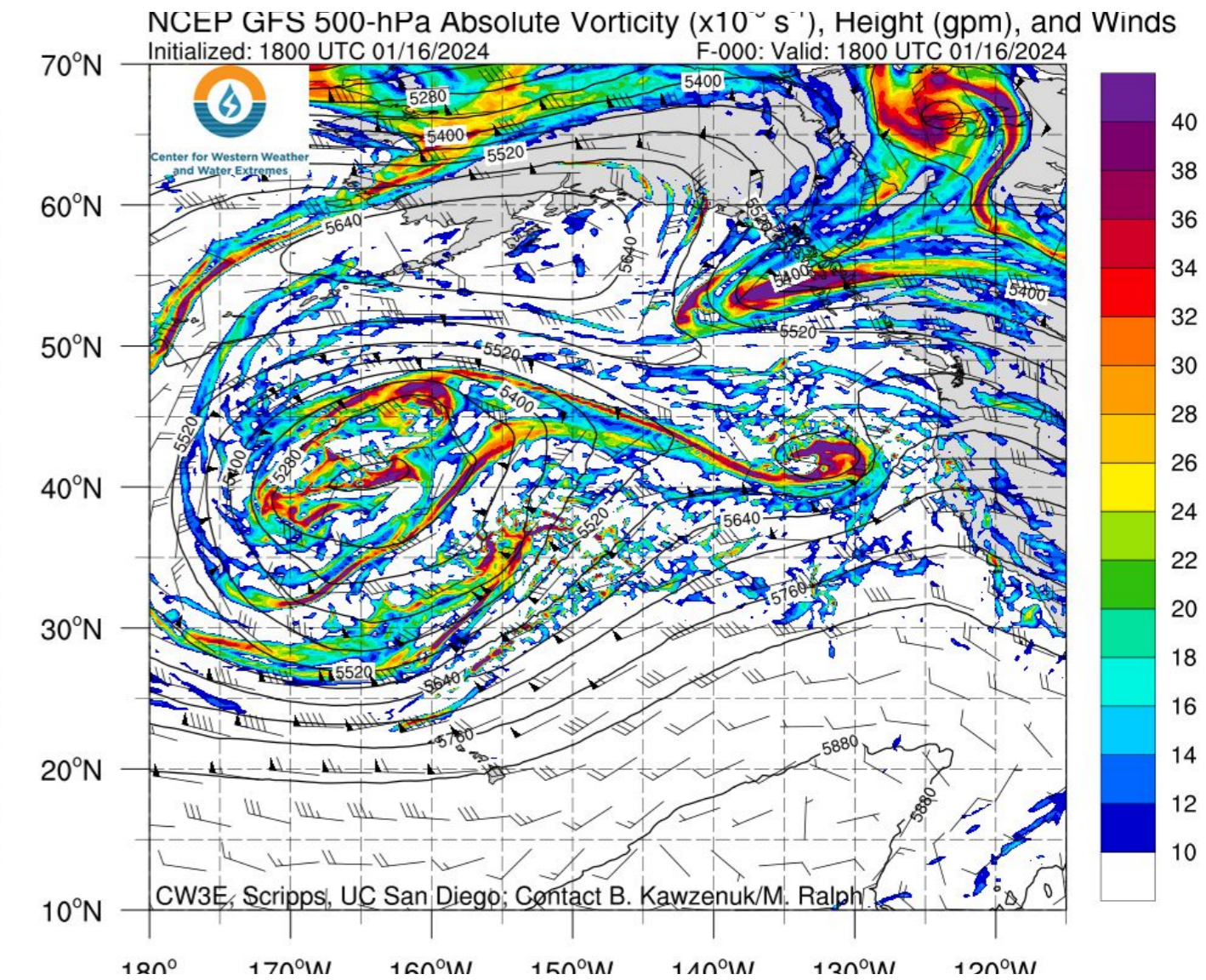
IVT and SLP



IWV and 850-hPa Winds



GFS 500-hPa Abs. Vorticity, Heights and Winds



- A robust surface low pressure system developed in the eastern North Pacific on 14 Jan and remained relatively stationary over the region for approximately 5 days until 19 Jan, playing a role in AR development along the western US.
- The **second AR** made landfall along the border of OR/CA on 16 Jan. The storm developed in association with a surface low-pressure system that broke off the more broad area of low pressure, with moisture support from a robust TME from the tropics.
- A cut off strip of vorticity developed into a shortwave trough in the mid-levels, providing additional forcing for ascent in the region

CW3E Event Summary: 13-23 Jan 2024

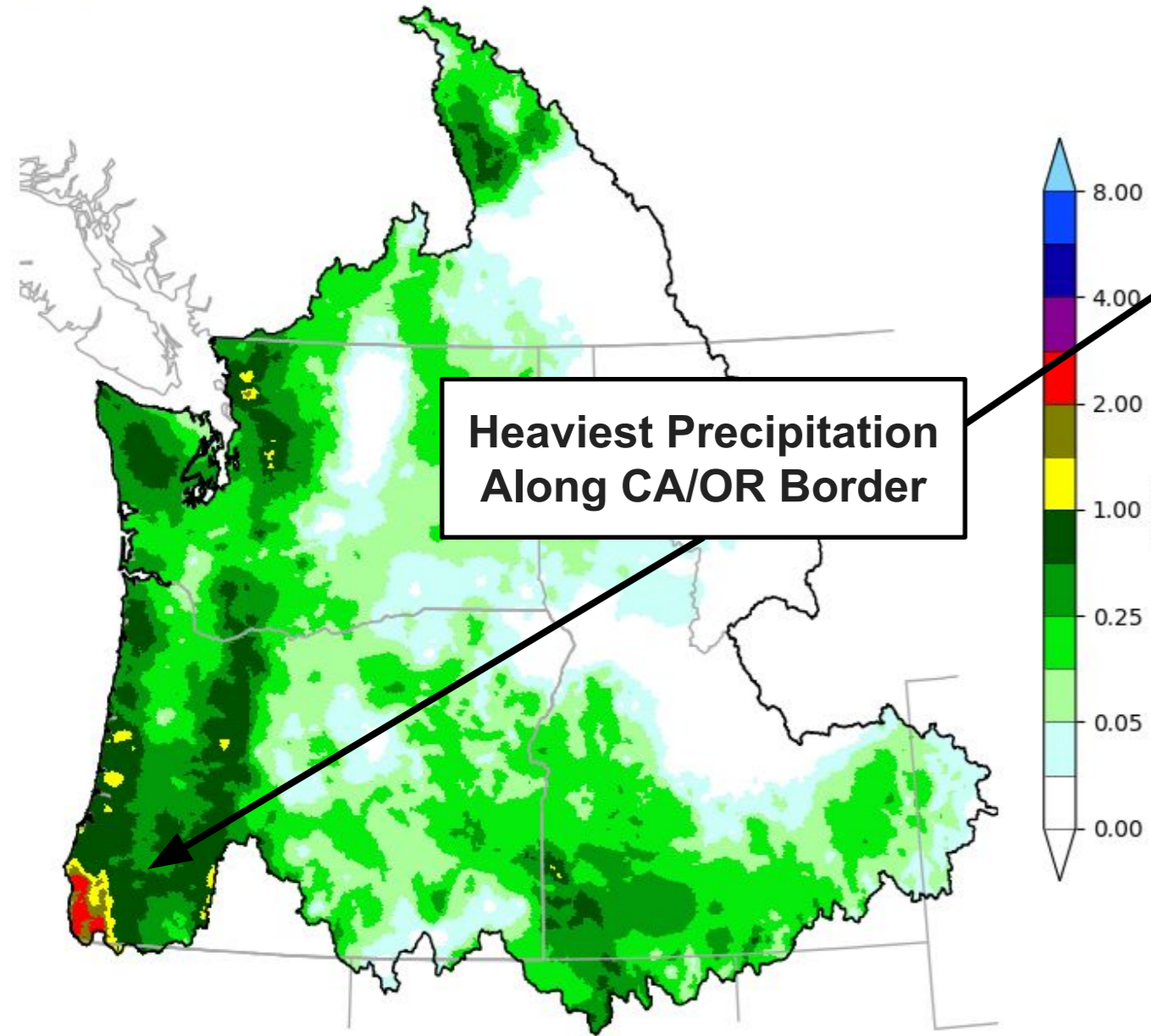
Second AR: Observed Precipitation

National Snowfall Analysis: 24-hour accumulation ending 2024-01-17 12 UTC

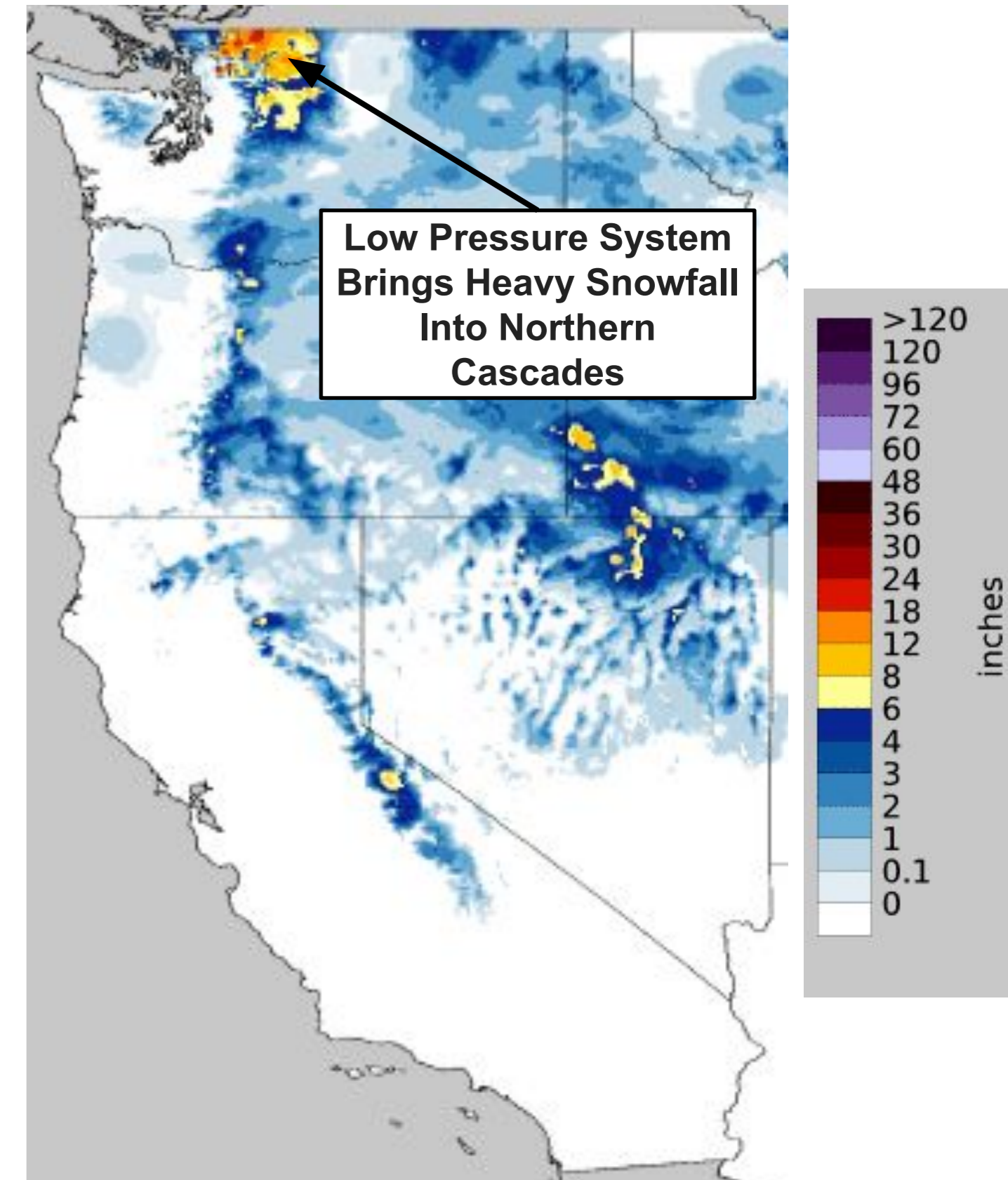
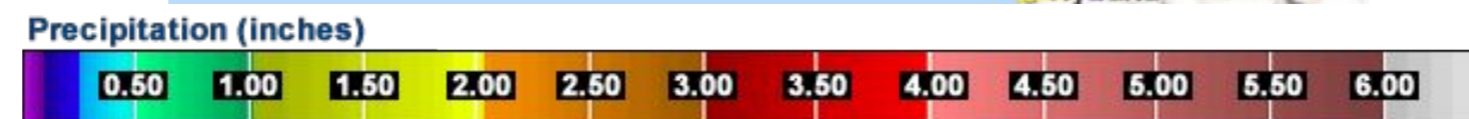
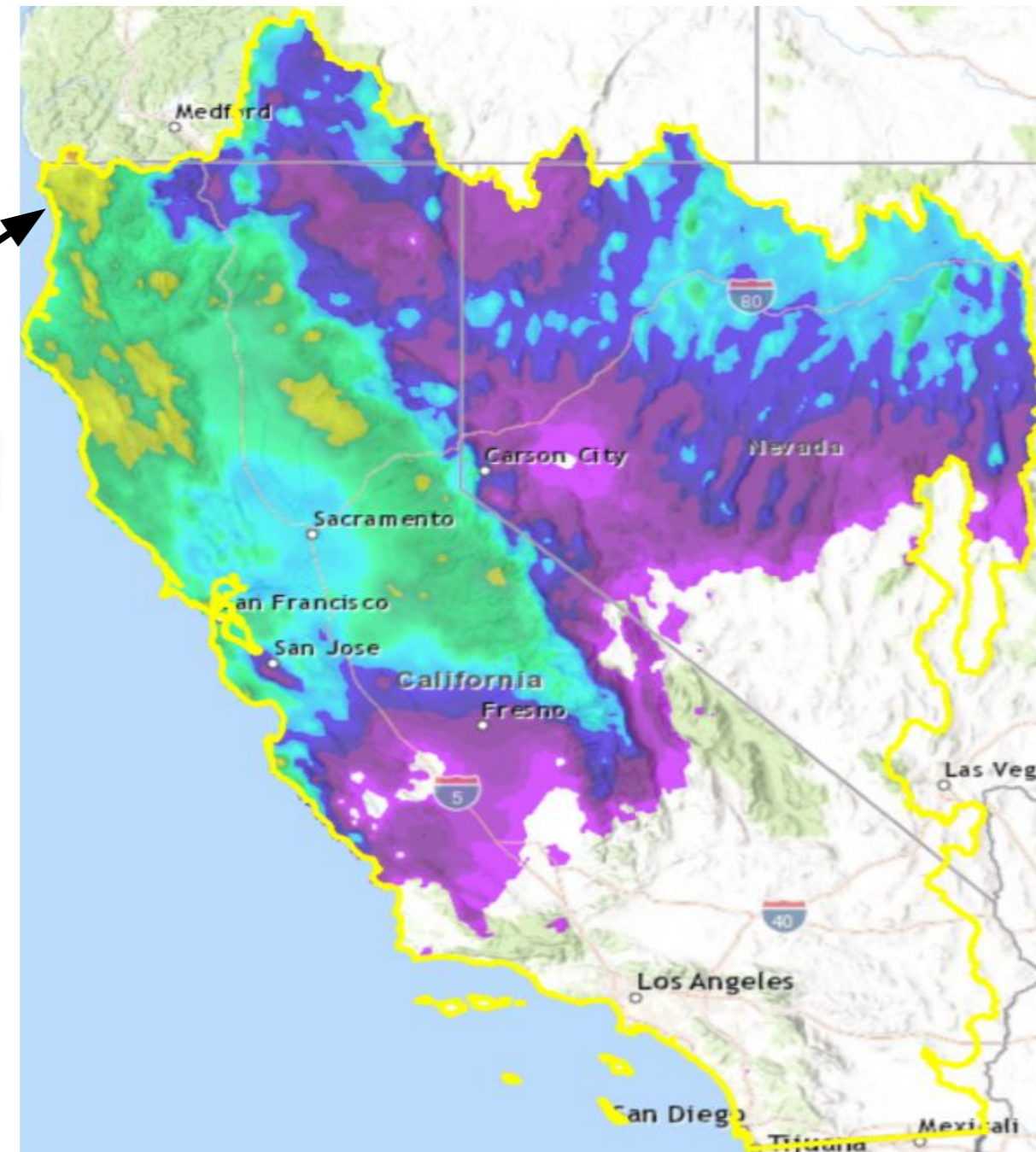
11599 reports; issued 2024-01-22 13:13:55 UTC



Northwest River Forecast Center
Observed 24hr Precipitation, Ending 12Z, 01/17/24



CNRFC Observed 24 hr Precipitation, Ending 12Z 17 Jan



Source: National Gridded Snowfall Analysis https://www.nohrsc.noaa.gov/snowfall_v2/

CW3E Event Summary: 13-23 Jan 2024

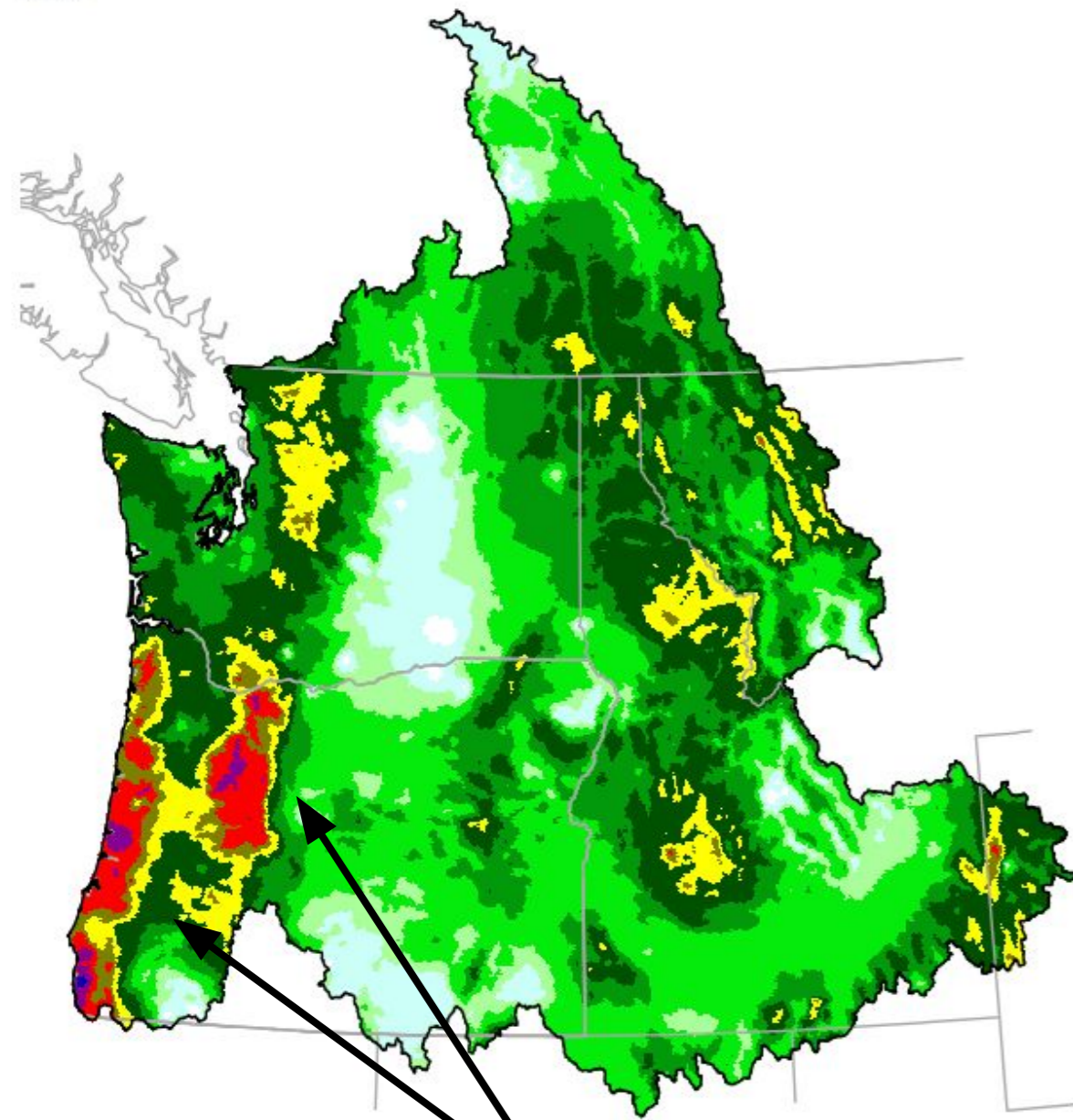
Low Pressure System Observed Precipitation

National Snowfall Analysis: 24-hour accumulation ending 2024-01-18 12 UTC

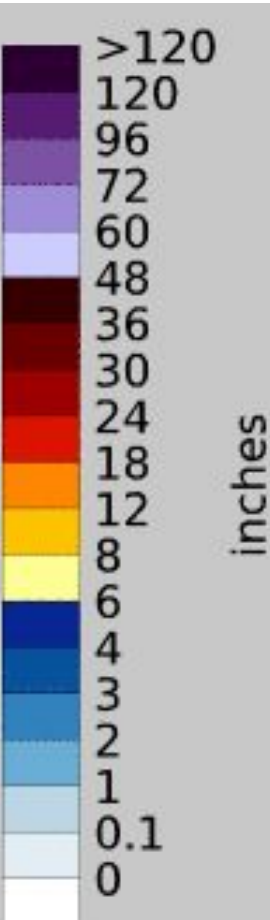
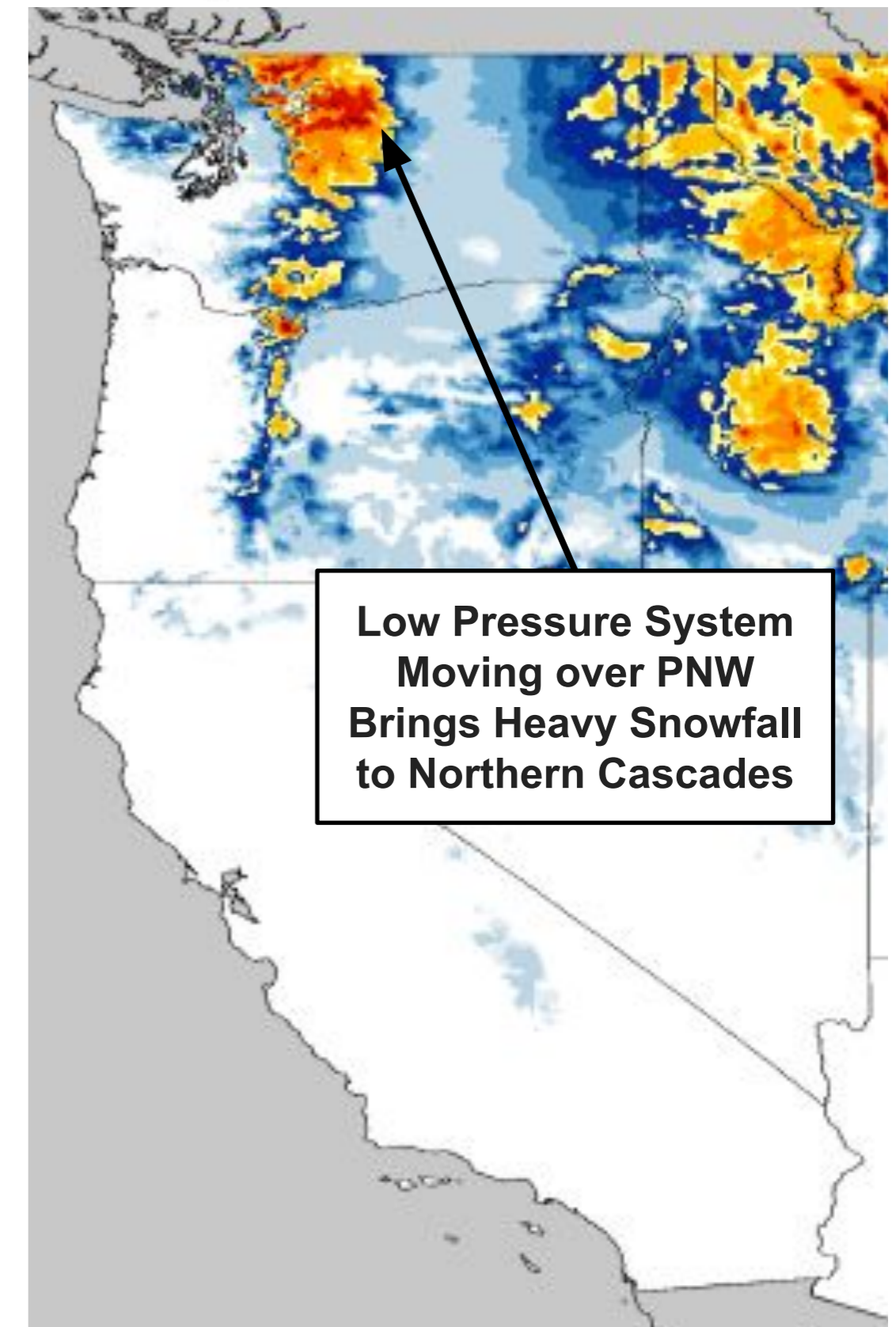
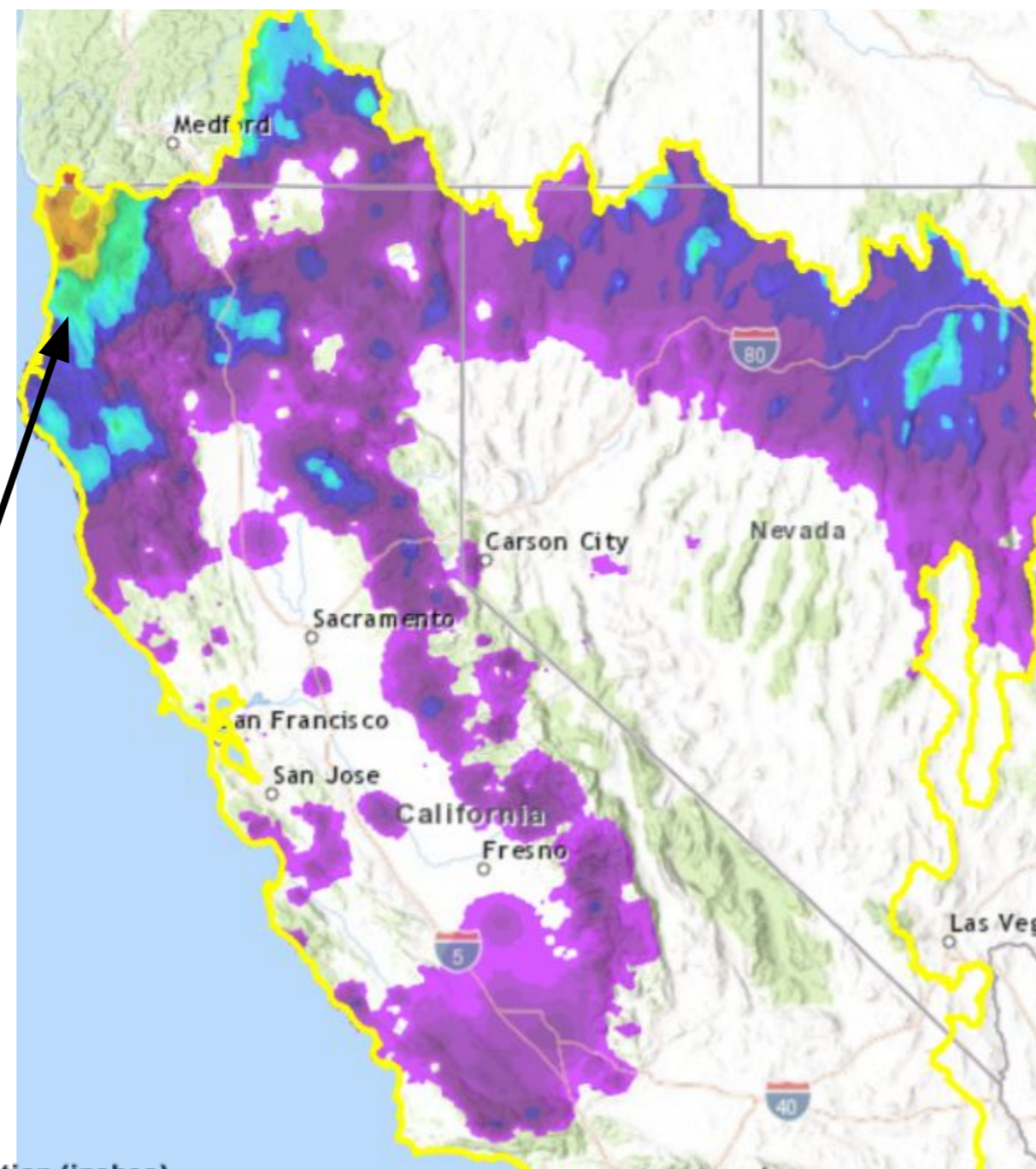
13344 reports; issued 2024-01-23 13:54:54 UTC



Northwest River Forecast Center
Observed 24hr Precipitation, Ending 12Z, 01/18/24



CNRFC Observed 24 hr Precipitation,
Ending 12Z 18 Jan



Low Pressure System
Moving over PNW
Brings Heavy Snowfall
to Northern Cascades

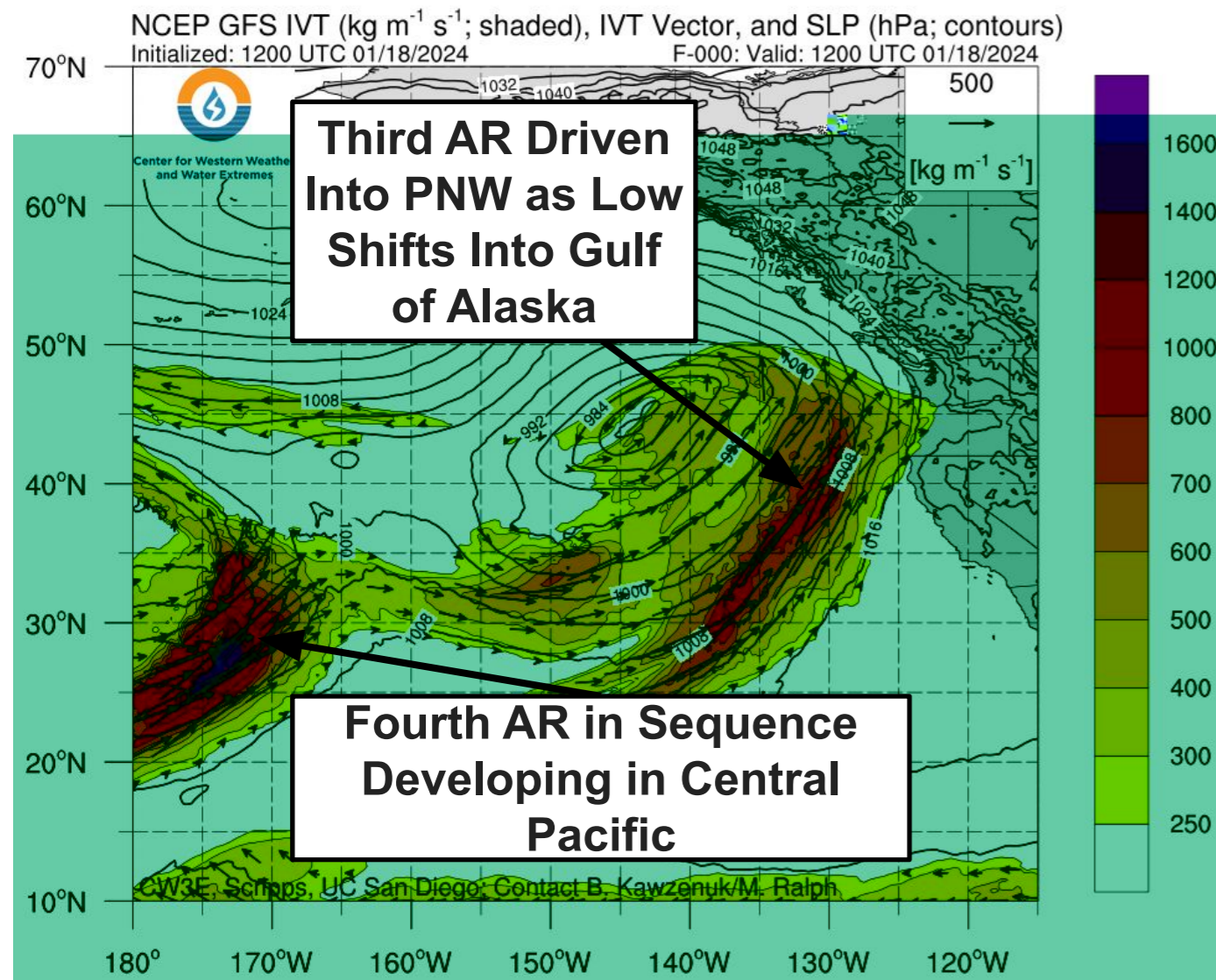
Low Pressure System Brings Significant
Precipitation to OR Cascades, OR Coast
and OR/CA Border

Source: National Gridded Snowfall Analysis https://www.nohrsc.noaa.gov/snowfall_v2/

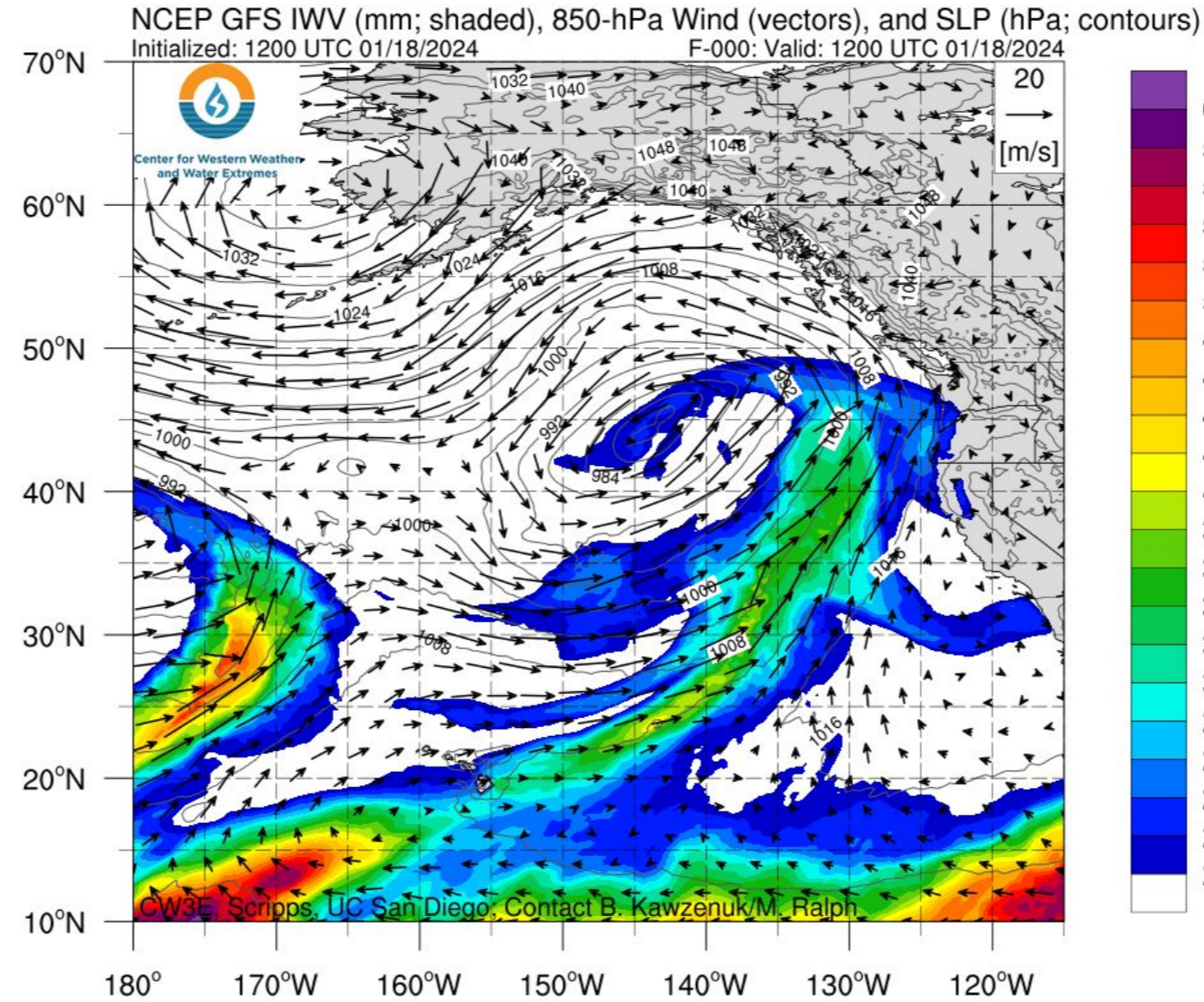
CW3E Event Summary: 13-23 Jan 2024

Third AR: Landfall Thu 18 Jan

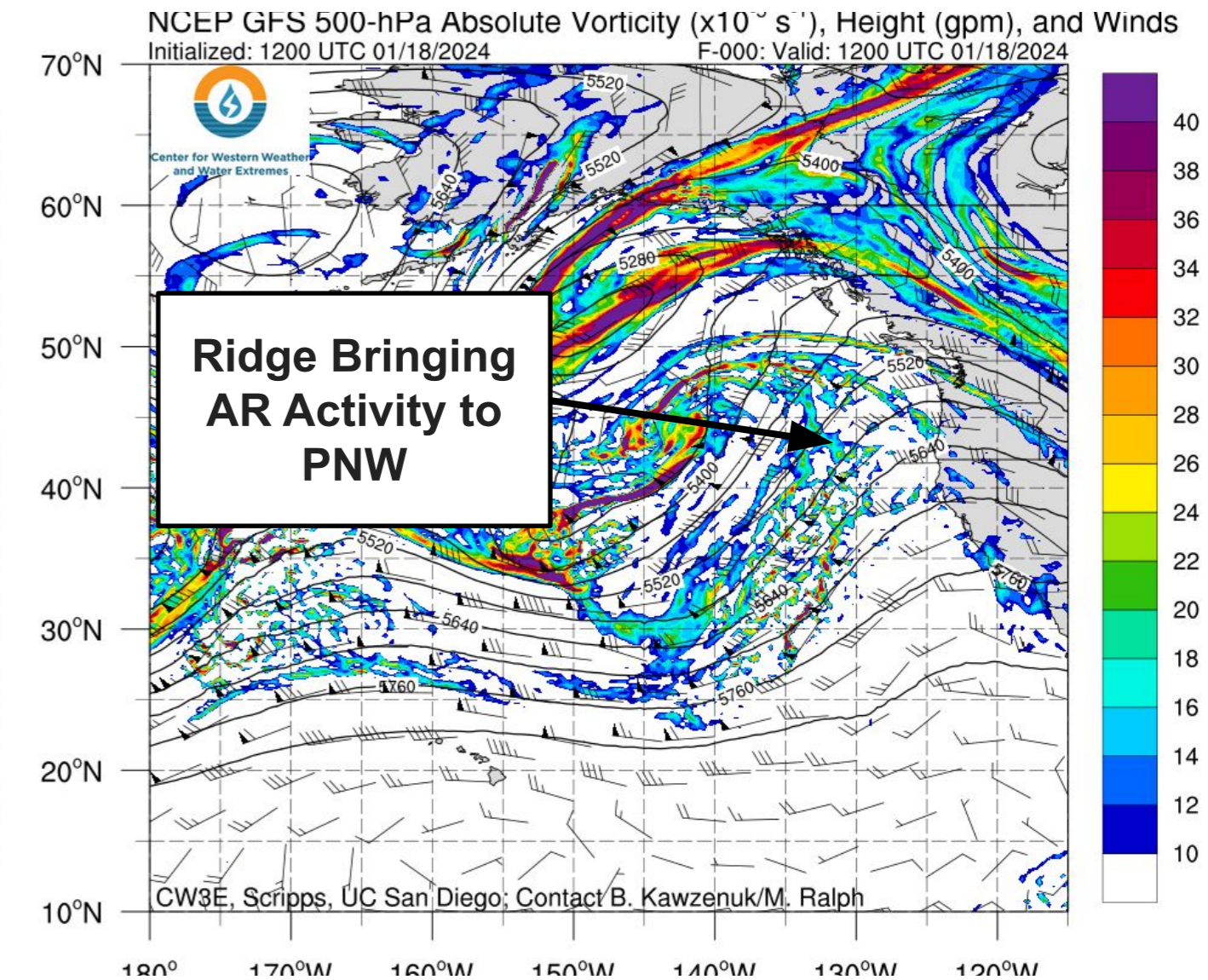
IVT and SLP



IWV and 850-hPa Winds



GFS 500-hPa Abs. Vorticity, Heights and Winds

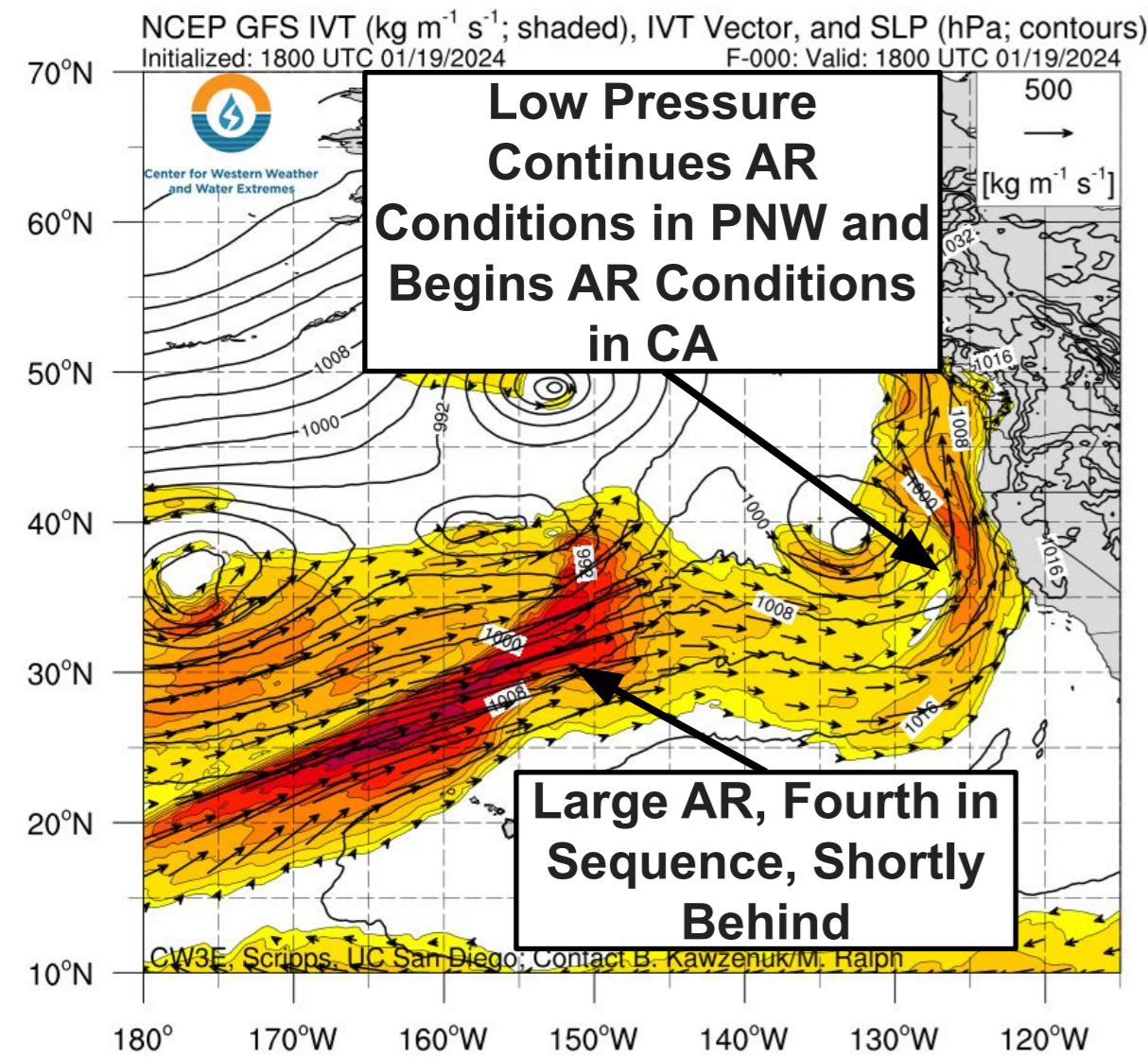


- The **third** AR in the sequence developed in association with the persistent surface low pressure center in the eastern North Pacific and made landfall as the system moved north into the Gulf of Alaska. The AR was fueled by another TME present extending north
- A shortwave trough in the mid-levels provided additional forcing for ascent over the Pacific Northwest during the later period of this AR
- At this time the **fourth** AR of the sequence was developing in the central North Pacific

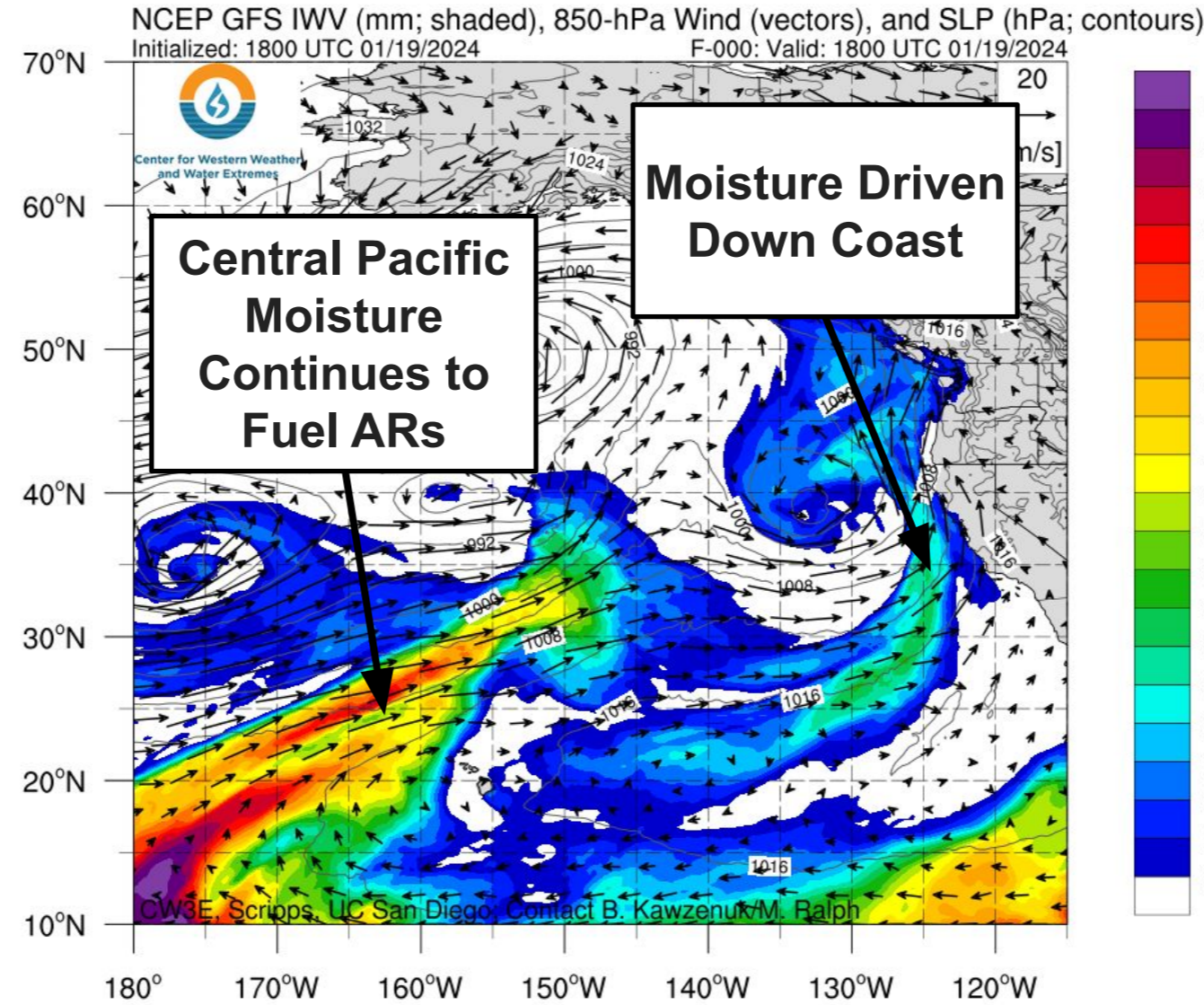
CW3E Event Summary: 13-23 Jan 2024

Third AR: Fri 19 Jan

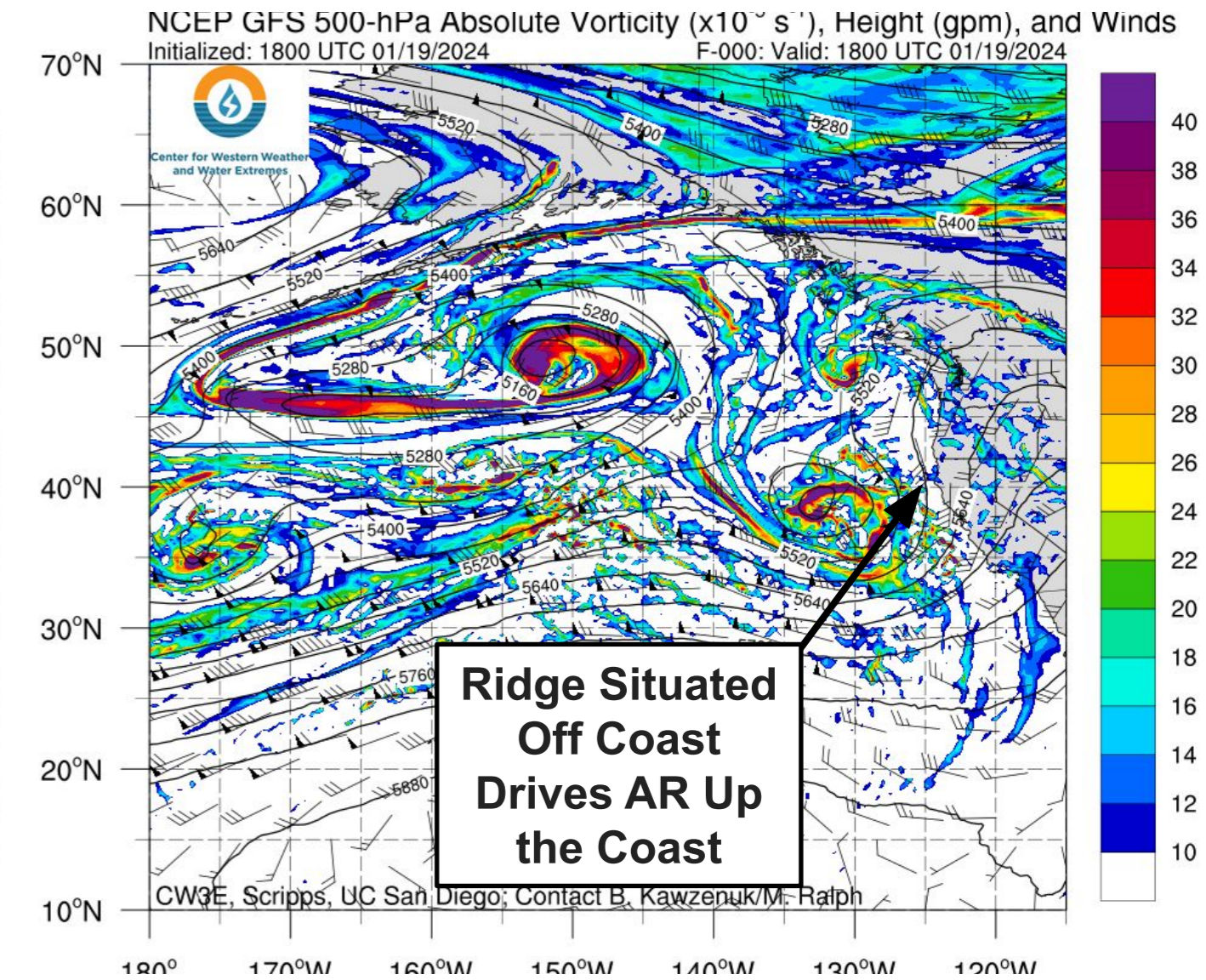
IVT and SLP



IWV and 850-hPa Winds



GFS 500-hPa Abs. Vorticity, Heights and Winds



- A ridge developed along the USWC through Thu Jan 18 as the AR approached the USWC.
- The ridge along the coast along with the low pressure the cut off from the northern region of low pressure drove much of the IVT and moisture along the coast.
- This presented a situation where the moisture transport direction is suboptimal for maximum precipitation in the PNW and therefore limited how much fell over OR and WA on the 19th and 20th.
- However, the moisture driven down the coast by the low pressure system was directed straight into N. CA which provided a moisture source for precipitation.

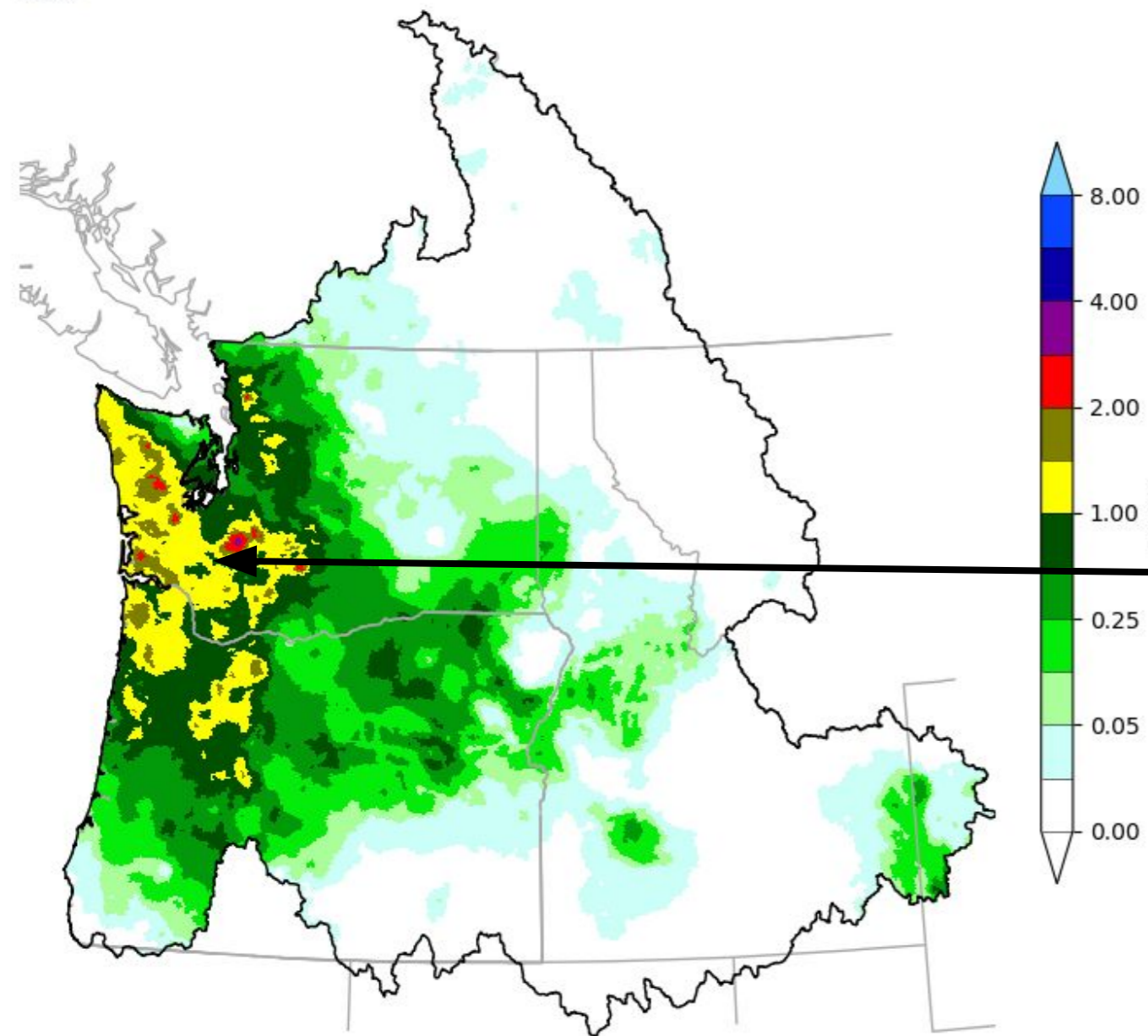
CW3E Event Summary: 13-23 Jan 2024

Third AR: Observed Precipitation

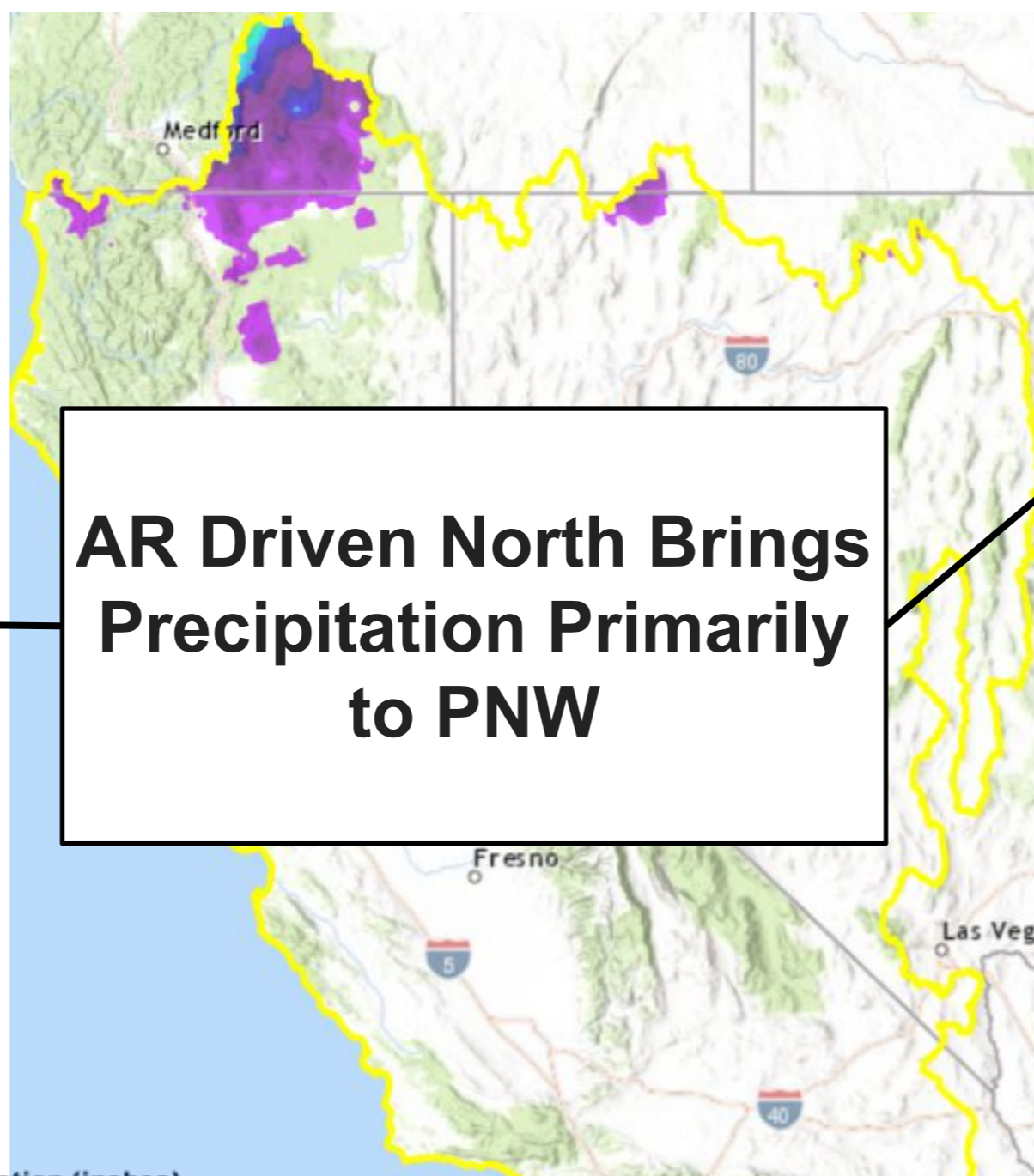
National Snowfall Analysis: 24-hour accumulation ending 2024-01-19 12 UTC
11891 reports; issued 2024-01-24 14:07:24 UTC



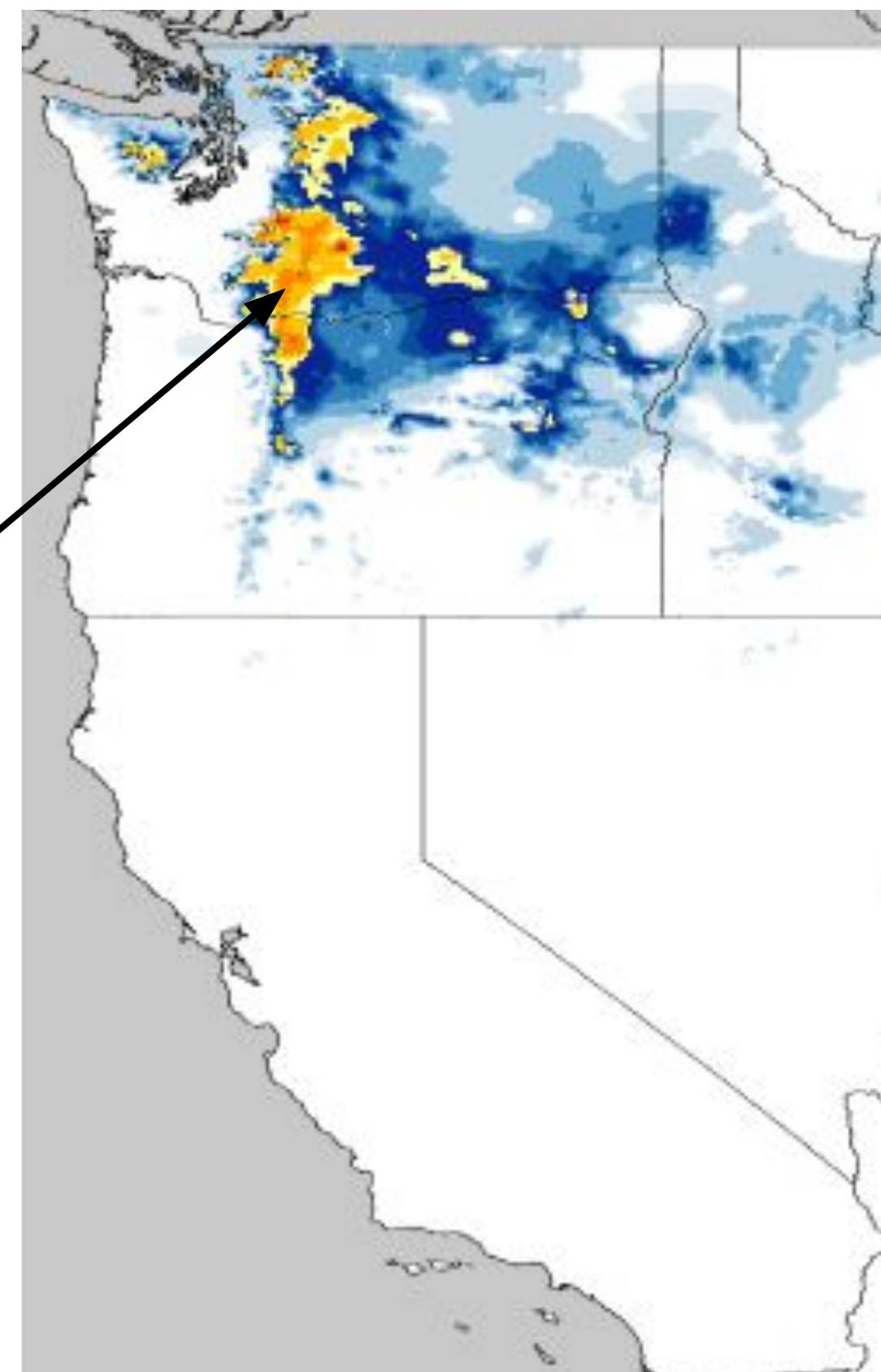
Northwest River Forecast Center
Observed 24hr Precipitation, Ending 12Z, 01/19/24



CNRFC Observed 24 hr Precipitation, Ending 12Z 19 Jan



AR Driven North Brings Precipitation Primarily to PNW



Source: National Gridded Snowfall Analysis https://www.nohrsc.noaa.gov/snowfall_v2/

CW3E Event Summary: 13-23 Jan 2024

National Snowfall Analysis: 24-hour accumulation ending 2024-01-20 12 UTC

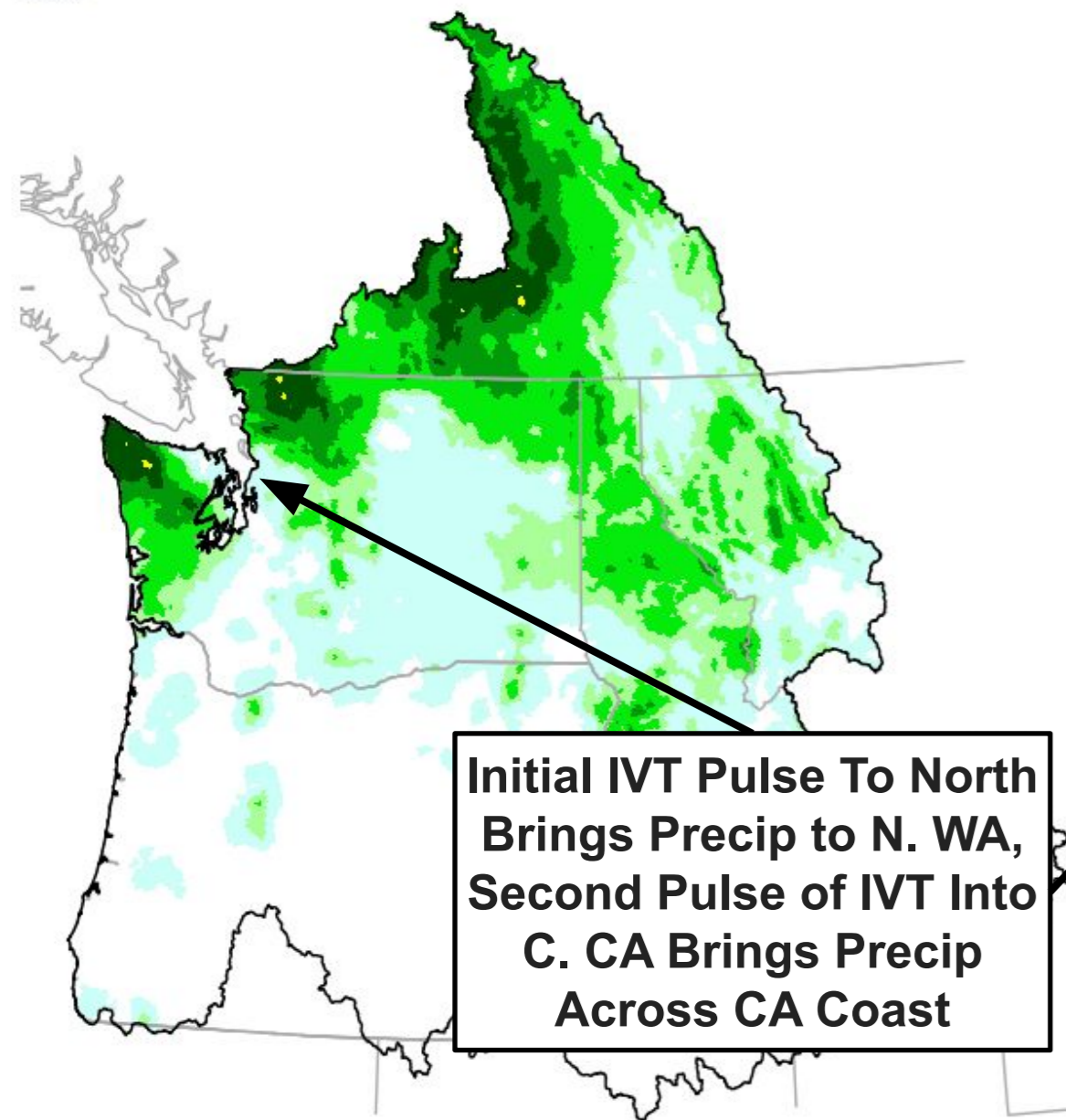
12628 reports; issued 2024-01-25 14:29:46 UTC

Third AR: Observed Precipitation

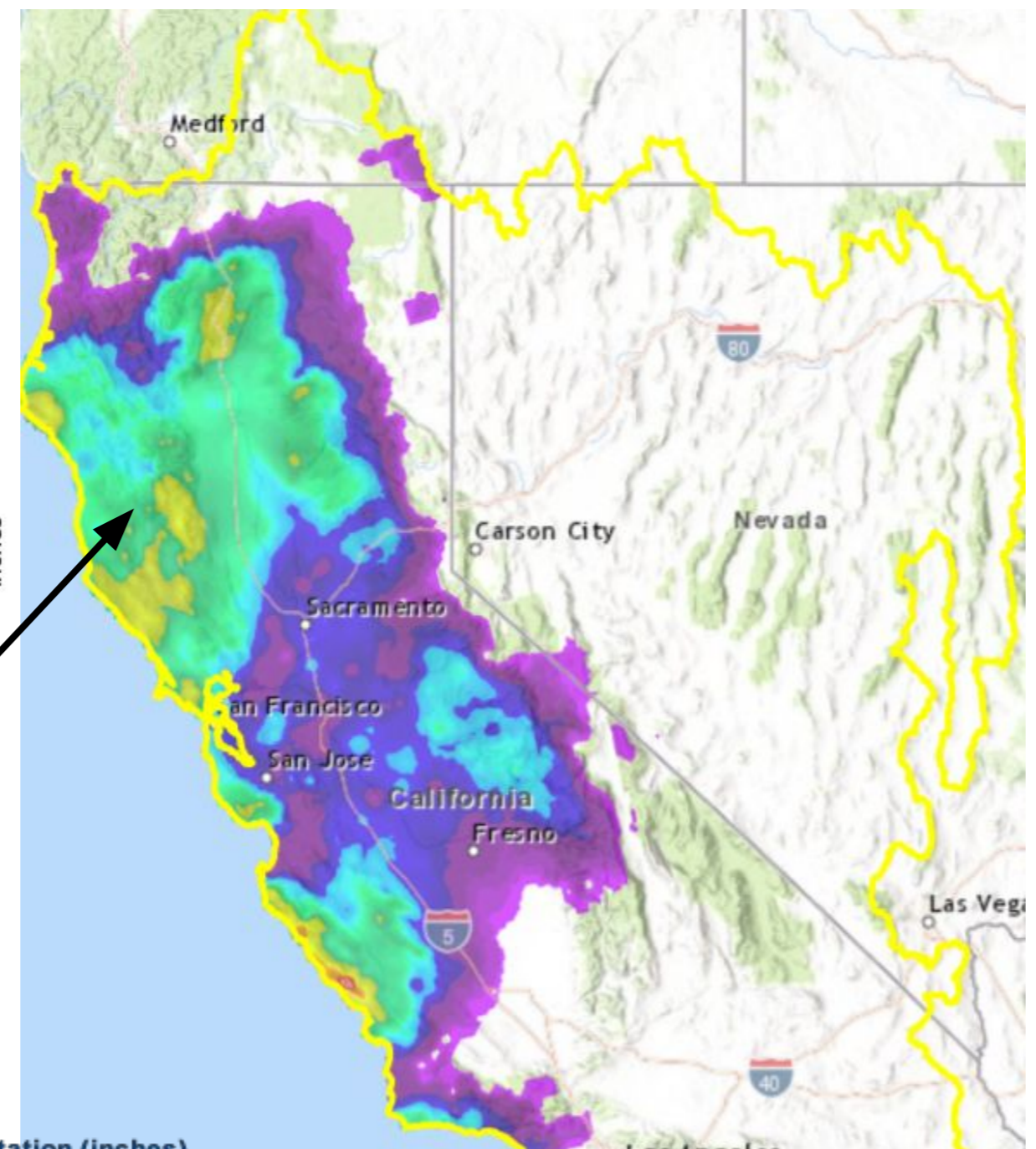
CNRFC Observed 24 hr Precipitation, Ending 12Z 20 Jan



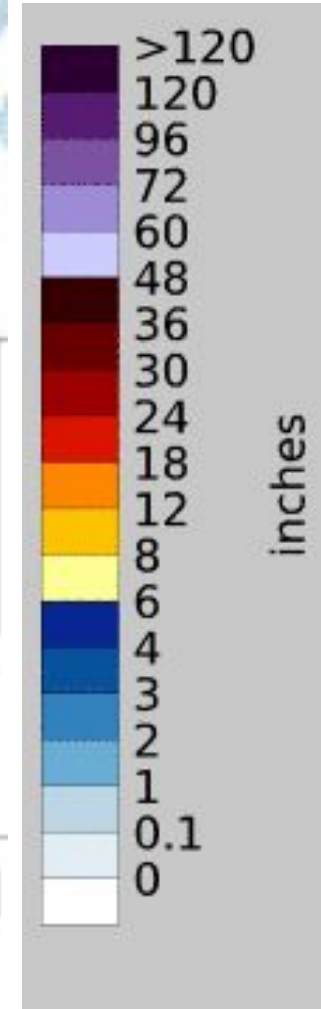
Northwest River Forecast Center
Observed 24hr Precipitation, Ending 12Z, 01/20/24



Initial IVT Pulse To North Brings Precip to N. WA, Second Pulse of IVT Into C. CA Brings Precip Across CA Coast



Light Mountain Snowfall Associated with Each IVT Pulse



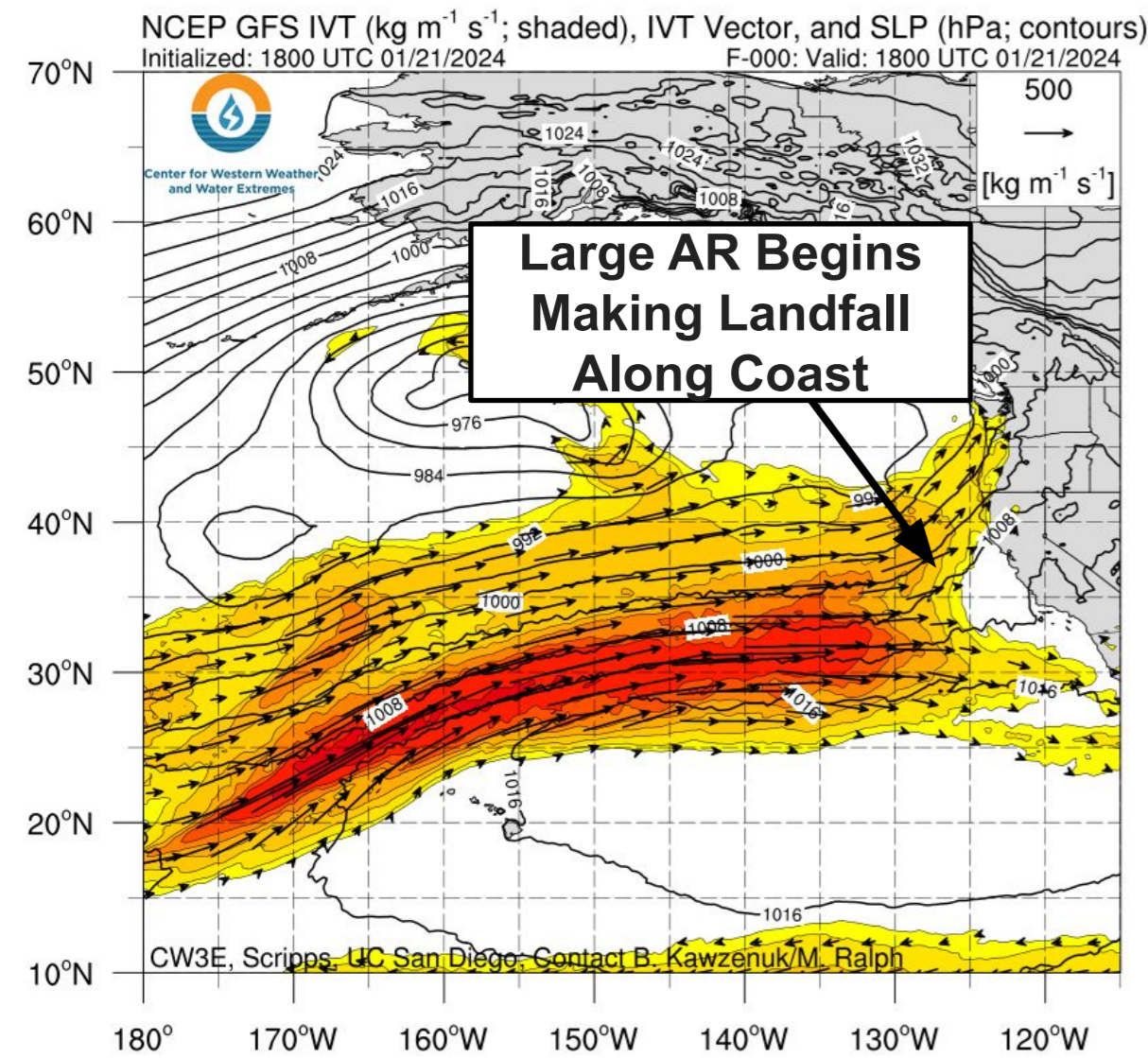
Creation Time: Sat Jan 20 15:38:42 UTC 2024

Source: National Gridded Snowfall Analysis https://www.nohrsc.noaa.gov/snowfall_v2/

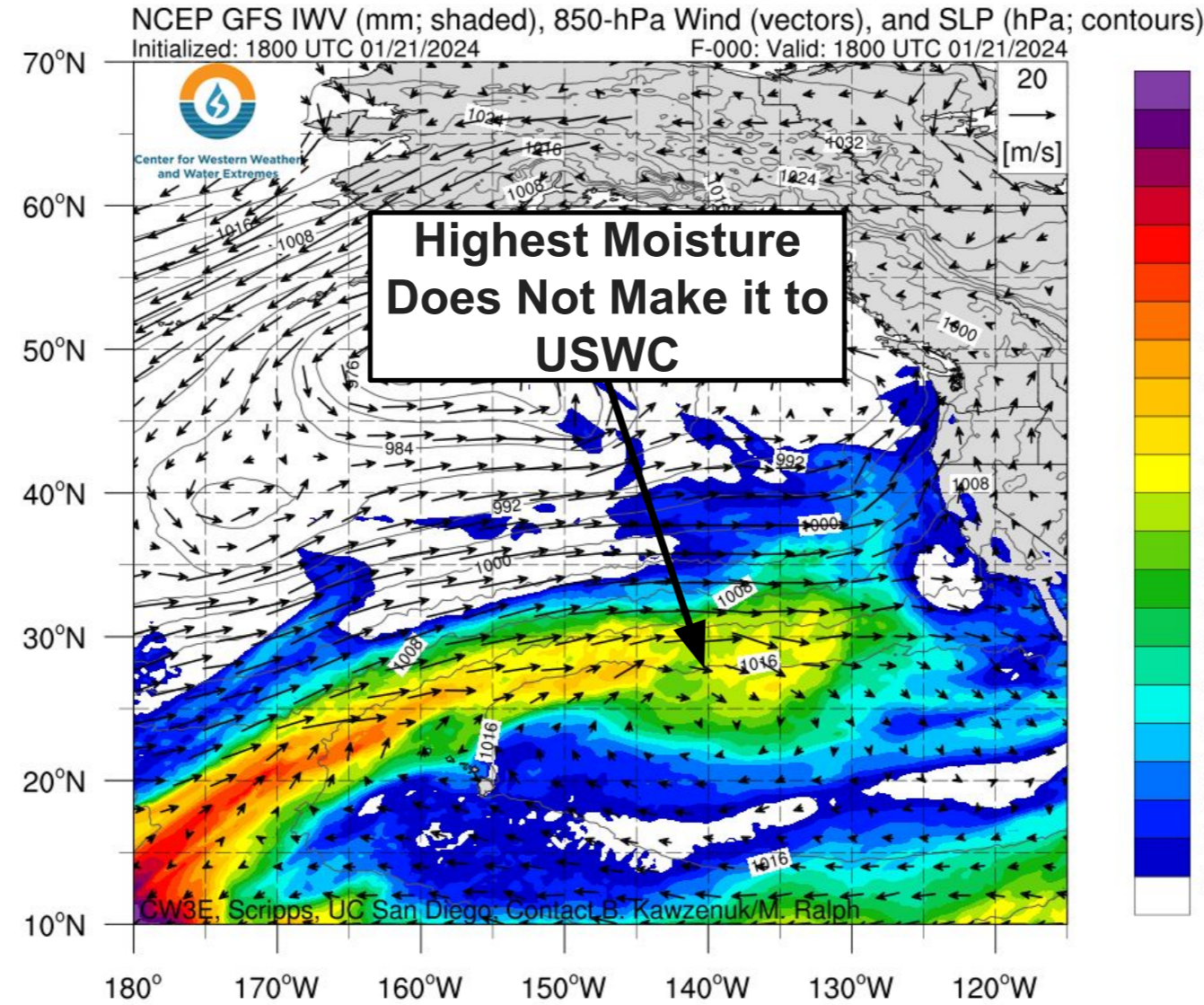
CW3E Event Summary: 13-23 Jan 2024

Fourth AR: Landfall Sun 21 Jan

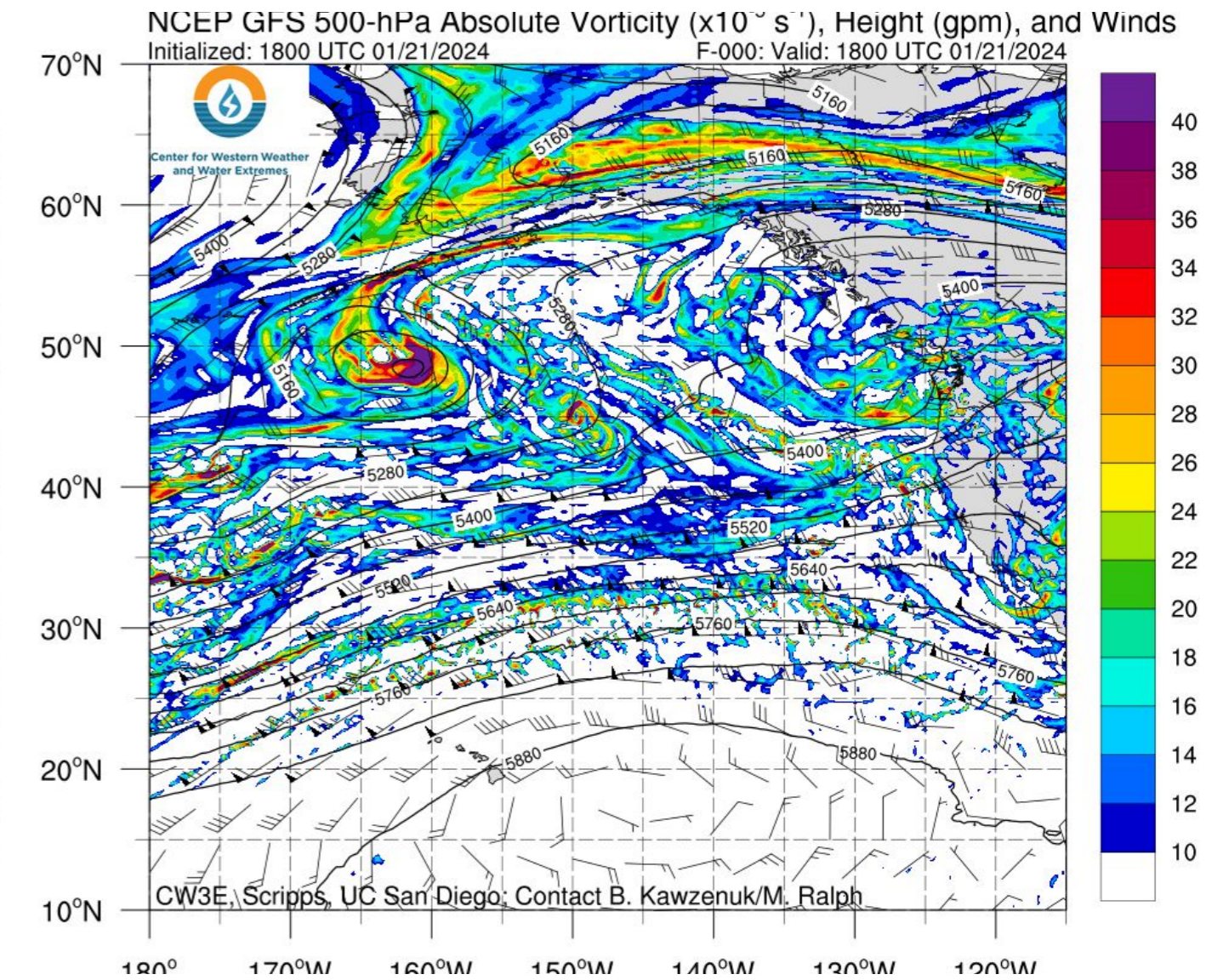
IVT and SLP



IWV and 850-hPa Winds



GFS 500-hPa Abs. Vorticity, Heights and Winds



- The **fourth** AR developed in the central North Pacific during the week leading up to Jan 21 and was positioned horizontally to the north of Hawaii, with an area of IVT $> 800 \text{ kg m}^{-1} \text{ s}^{-1}$ extending greater than 2,500 miles. This AR was associated with a significant TME that contained IWV values $> 50 \text{ mm}$.
- This large AR split prior to reaching the USWC which resulted in the highest IVT and IWV not making it to the USWC. Despite this, tropical moisture was still brought inland across the coast, resulting in more than an inch of precipitation in coastal WA, OR and CA.

CW3E Event Summary: 13-23 Jan 2024

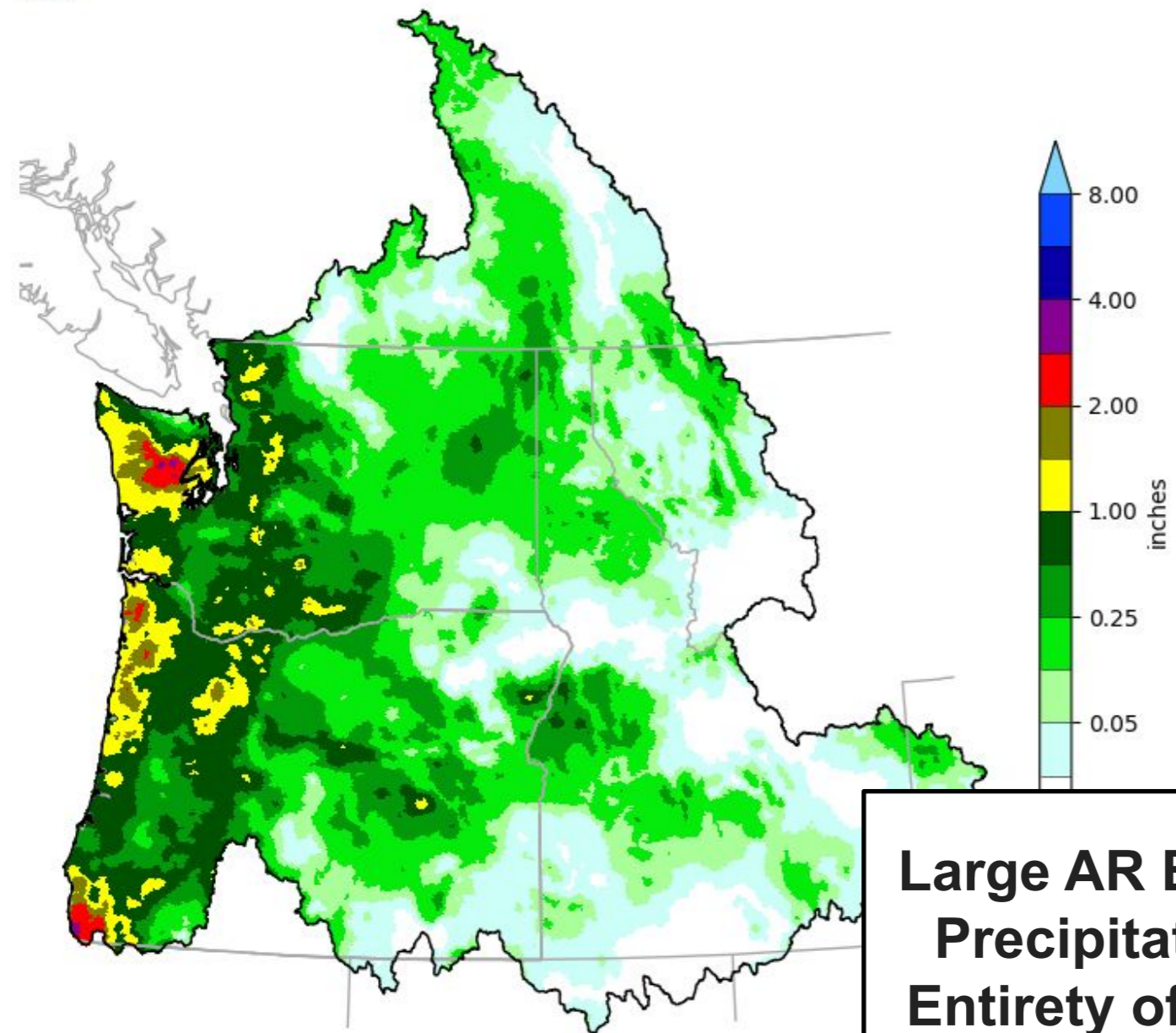
National Snowfall Analysis: 24-hour accumulation ending 2024-01-22 12 UTC

10645 reports; issued 2024-01-25 22:39:37 UTC

Fourth AR: Observed Precipitation

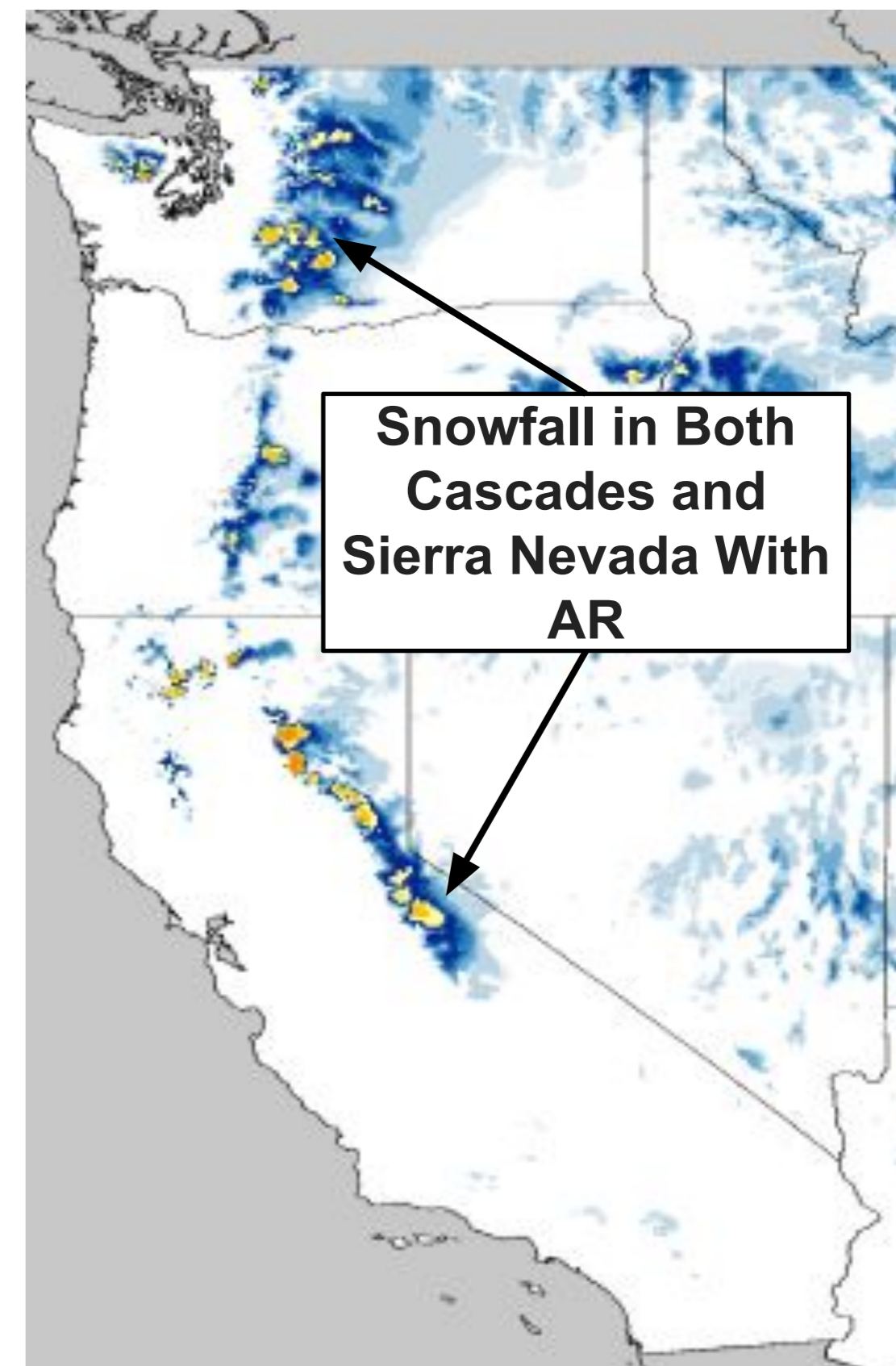
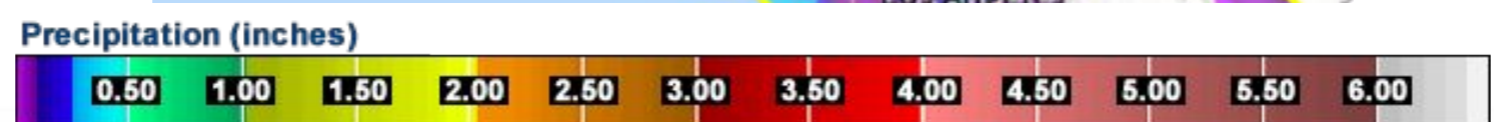
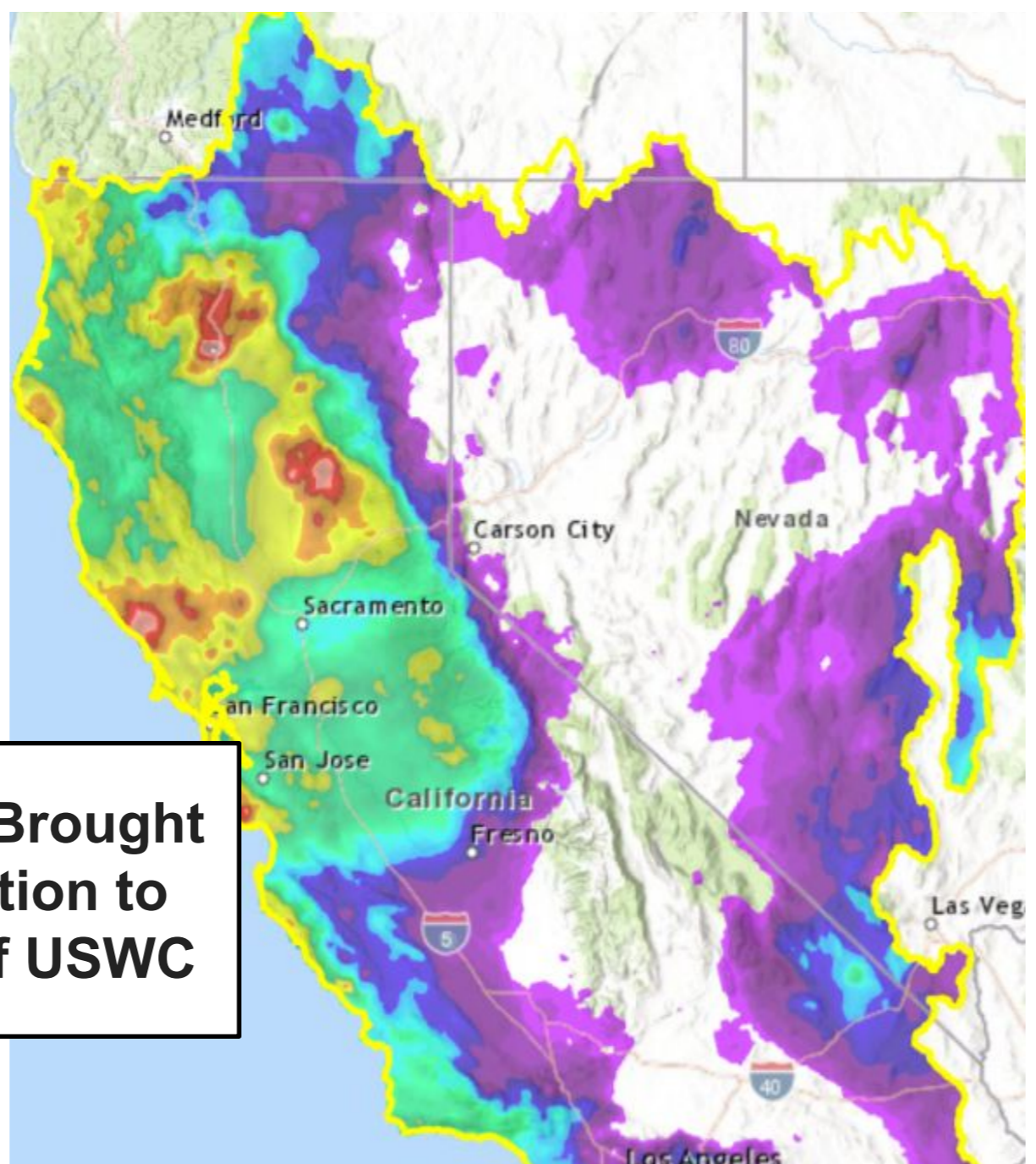


Northwest River Forecast Center
Observed 24hr Precipitation, Ending 12Z, 01/22/24



**Large AR Brought
Precipitation to
Entirety of USWC**

CNRFC Observed 24 hr Precipitation, Ending 12Z 22 Jan



**Snowfall in Both
Cascades and
Sierra Nevada With
AR**

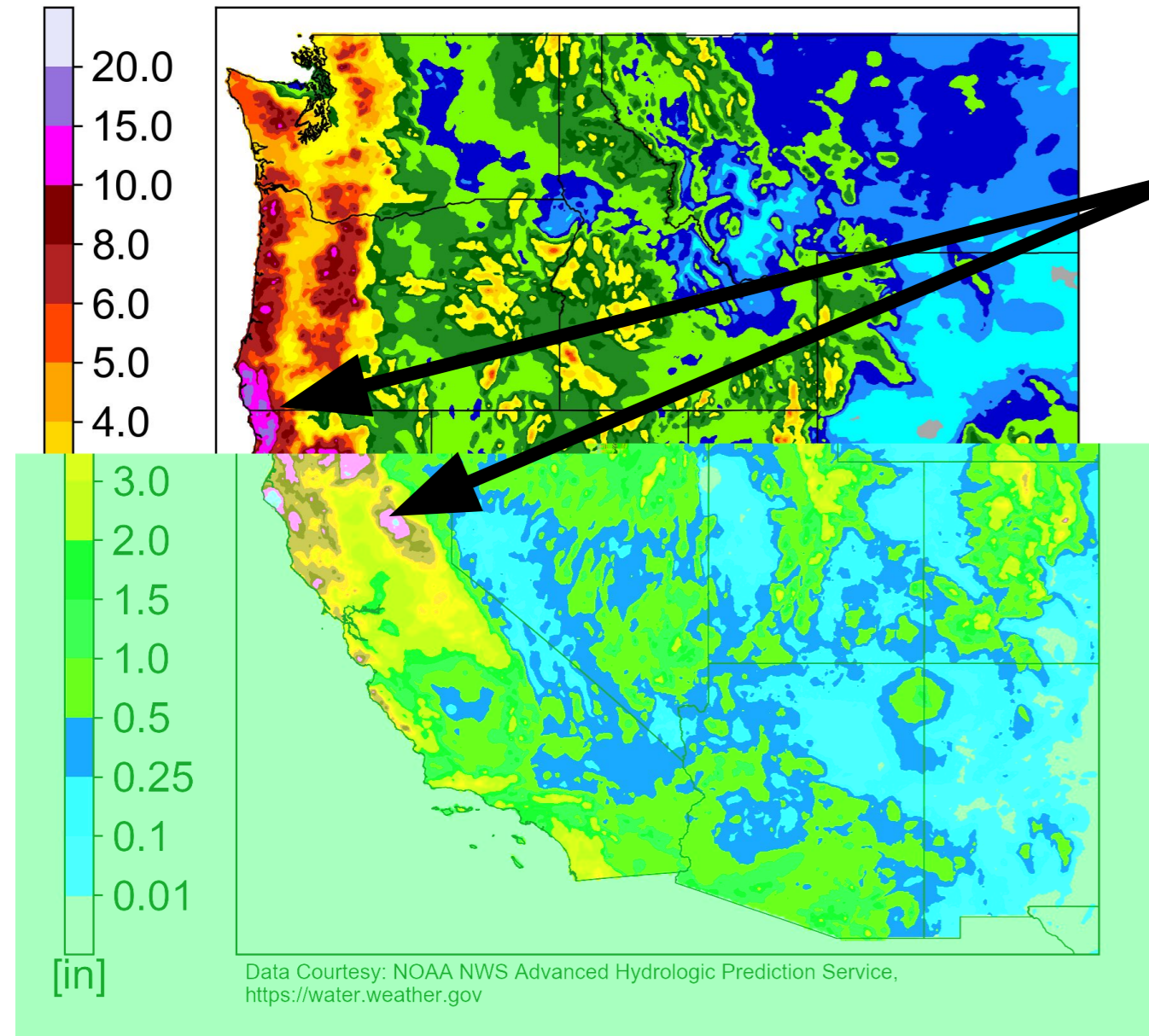
Source: National Gridded Snowfall Analysis https://www.noahrs.noaa.gov/snowfall_v2/

CW3E Event Summary: 13-23 Jan 2024

Total Precipitation/Snowfall for the Sequence

NWS Stage IV 10-day QPE

Valid: 4 AM PT 23 Jan 2024

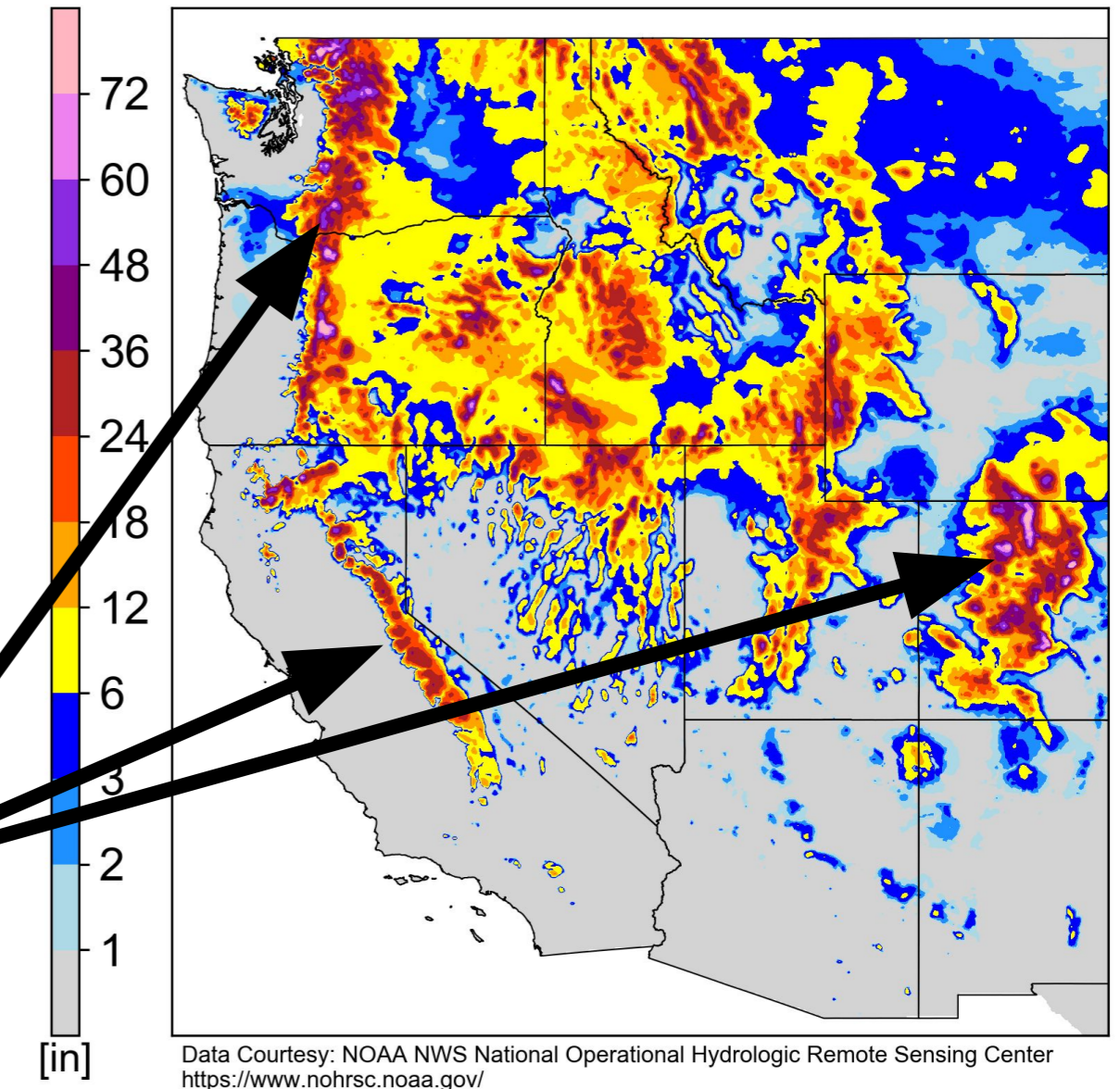


Highest 10-day precipitation totals (> 10 inches) along CA/OR border and over Northern Sierra Nevada

Total snowfall accumulations of 2-6 feet in the Cascades, Sierra Nevada, and the higher terrain in the Upper Colorado River Basin

NWS 10-day Snowfall Analysis

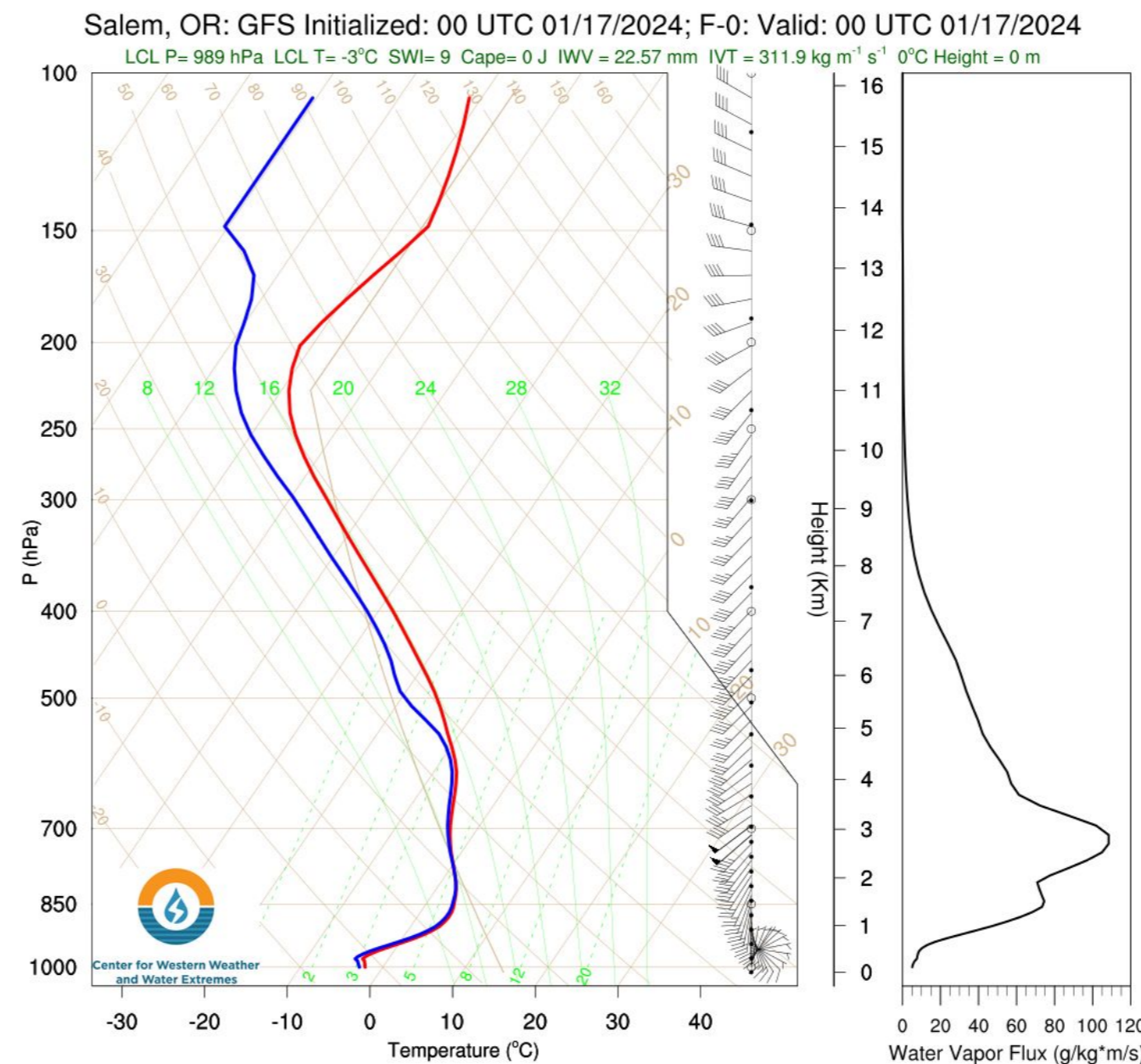
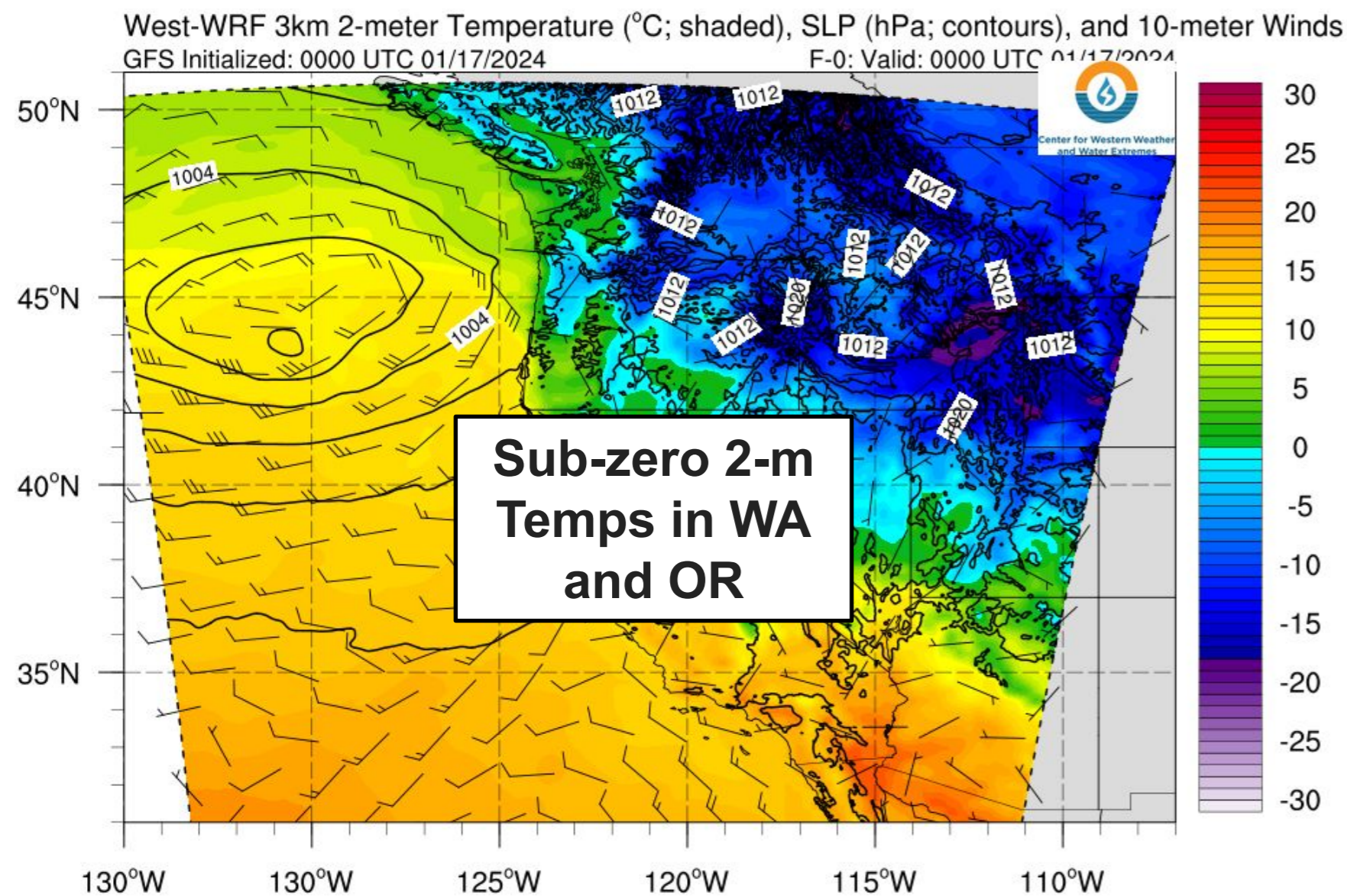
Valid: 4 AM PT 23 Jan 2024



CW3E Event Summary: 13-23 Jan 2024

Portland Freezing Rain Events: Synoptic Setup

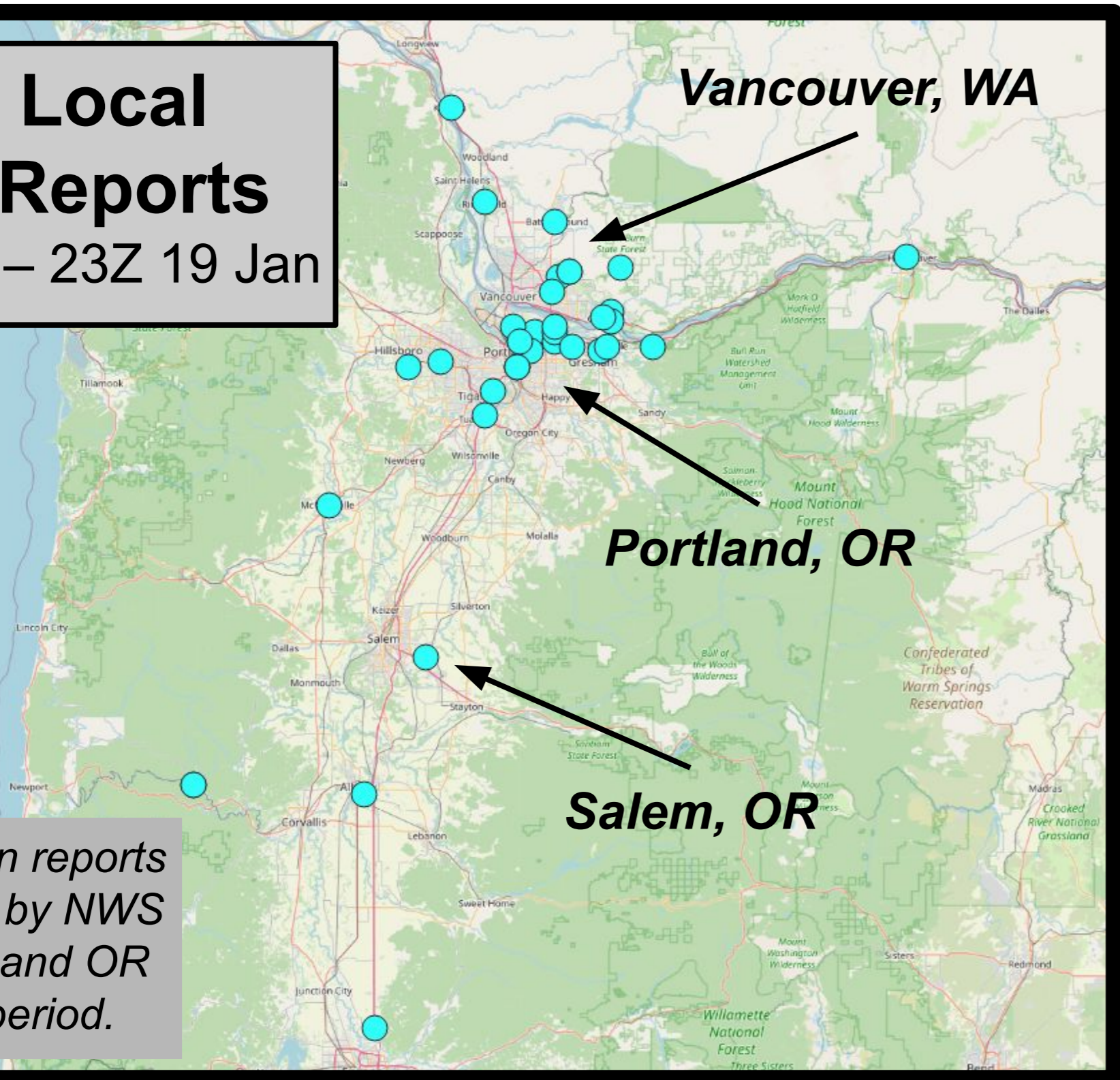
- ARs 2, 3 and 4 combined with an Arctic air mass moving over the PNW to produce significant freezing rain events in northern OR and southern WA.
- West-WRF Skew-T analysis (4 PM PT 16 Jan) at Salem, OR, shows a classical freezing rain signature, with a shallow layer of subfreezing air near the surface, a warm melting layer ($T > 0^{\circ}\text{C}$) aloft, and nearly saturated conditions through much of the troposphere



CW3E Event Summary: 13-23 Jan 2024

Portland Freezing Rain Impacts

NWS Local Storm Reports
00Z 16 Jan – 23Z 19 Jan



36 freezing rain reports were received by NWS offices in WA and OR during this period.

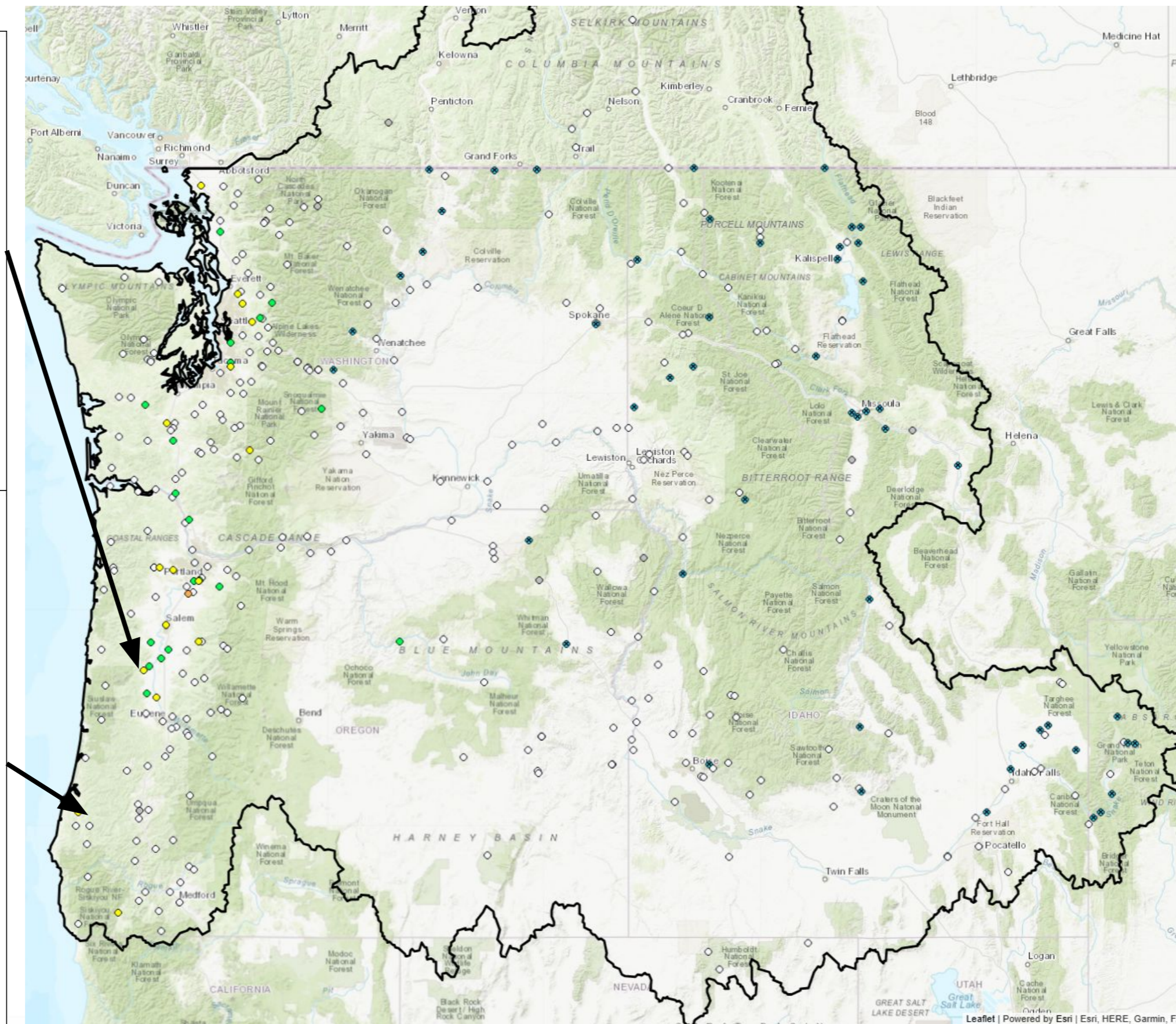
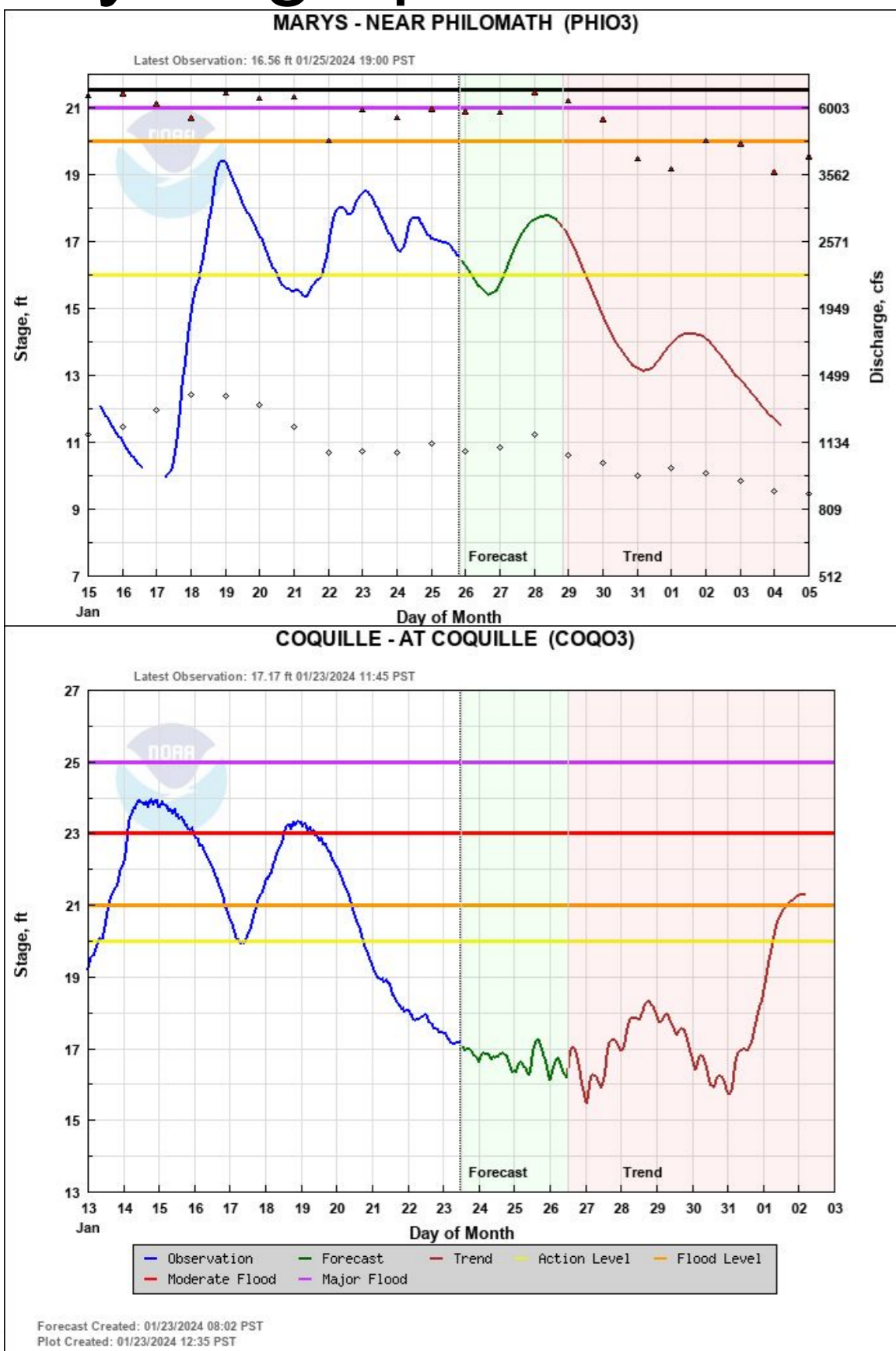


Thick Sheet of Ice Covering I-84 in the Columbia River Gorge in OR (courtesy: Oregon Department of Transportation)

- Freezing Rain accumulations above .75 inches caused major power outages and damages throughout OR and into Southern WA.
- 36 Freezing Rain reports were received by the NWS offices in WA and OR late 15 Jan through 19 Jan.

CW3E Event Summary: 13-23 Jan 2024

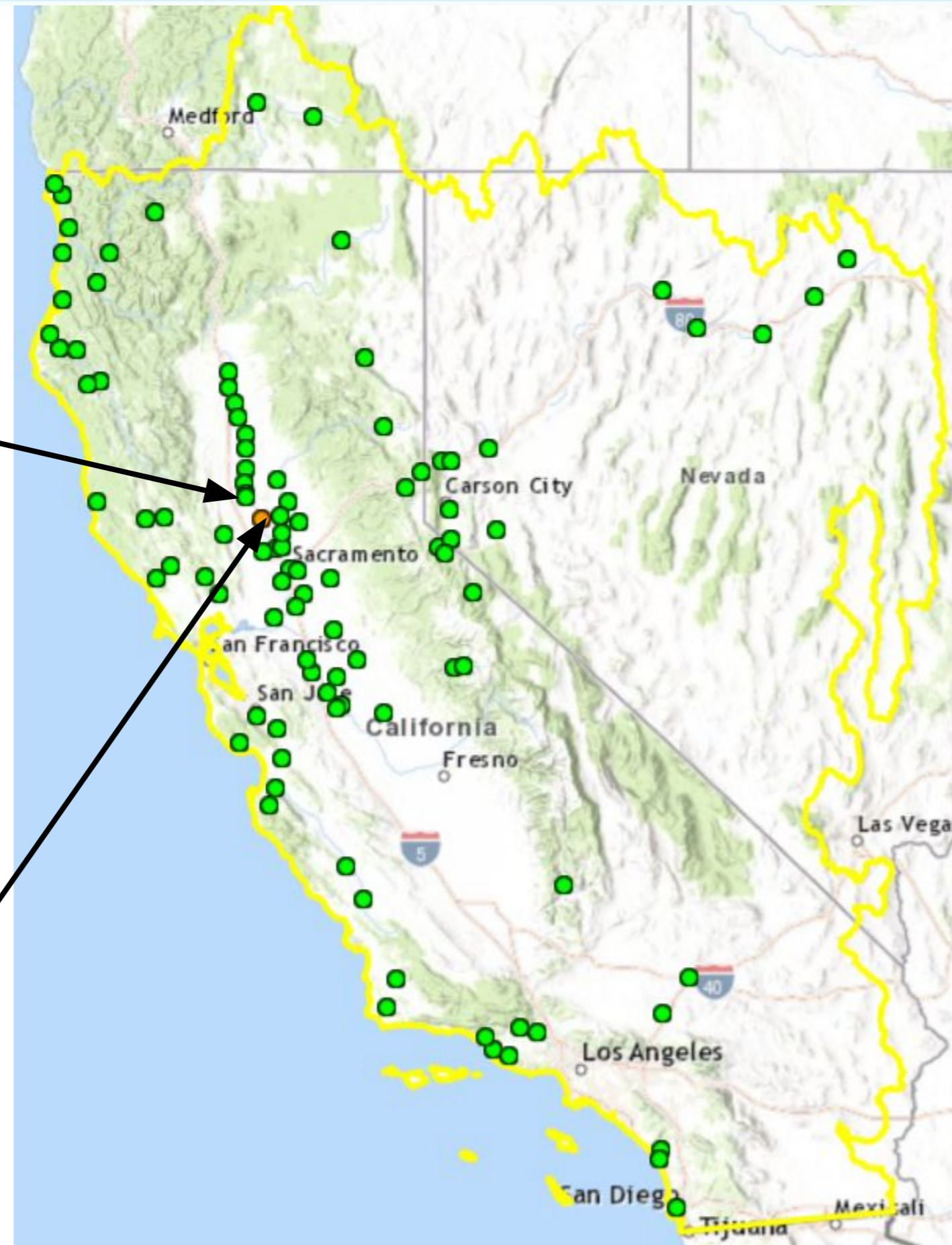
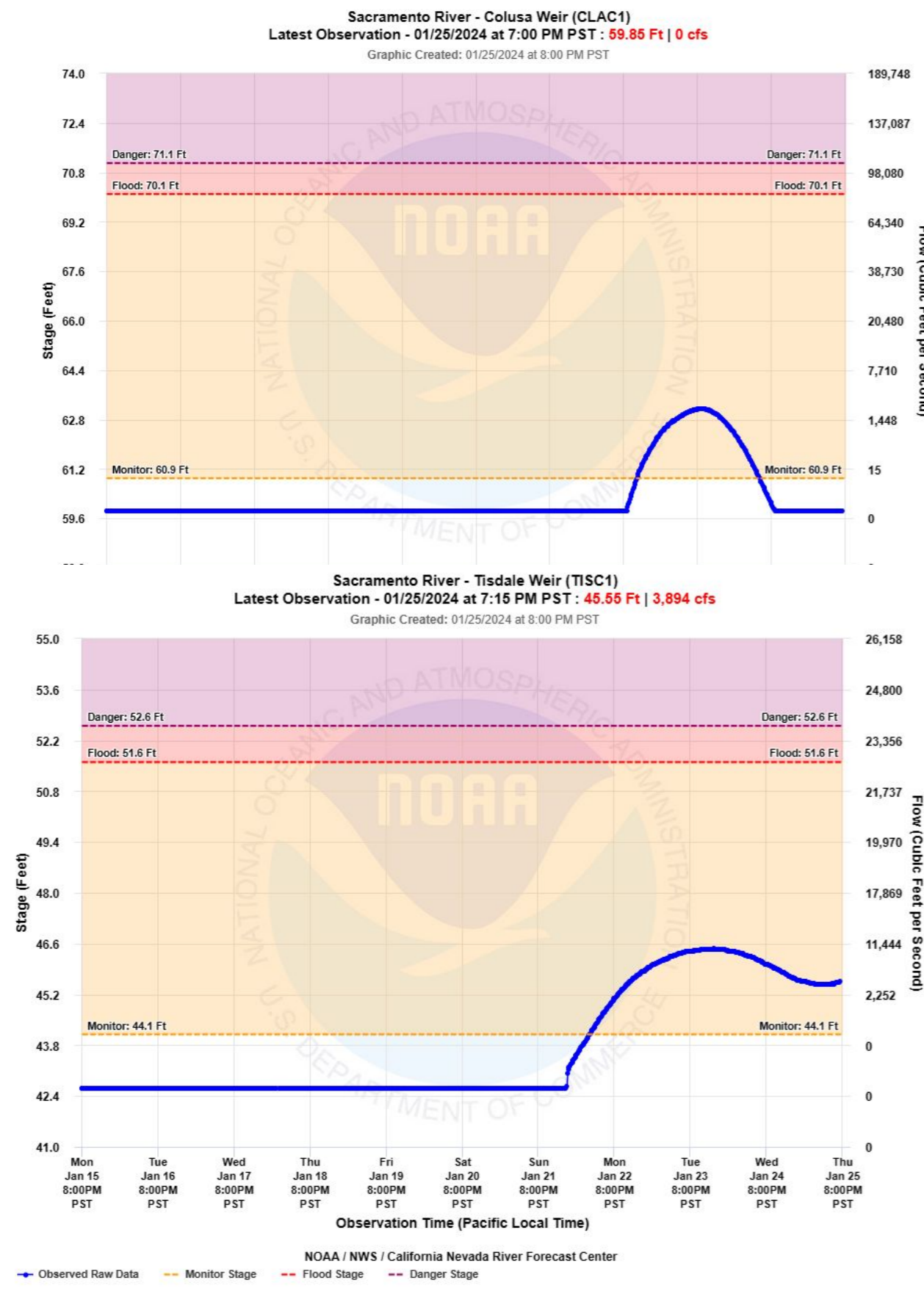
Hydrographs



- Stream level responses were observed in the Pacific Northwest as a result of this period of sustained AR activity and precipitation.
- Multiple stations within the boundaries of the NWRFC rose above “action” level due to these storms, with multiple reaching “flood” stage during this period.
- Marys River near Philomath in Oregon rose nearly 10 feet between 18 Jan to 19 Jan, entering “action” level
- The Coquille river rose roughly 4 feet during both the first and fourth ARs, reaching “flood” stage during each period.

CW3E Event Summary: 13-23 Jan 2024

Hydrographs



- Heavy precipitation associated with the fourth AR resulted in stream gauge responses in California
- Between 21 Jan and 23 Jan resulted in river stage rises of 3-5 feet along the Sacramento River in the northern Central Valley of California
- Some gauges did rise into the “monitor” stage, but stayed well below “flood” stage.
- Both the Colusa Weir and Tisdale Weir along the Sacramento River (pictured to the left) observed their stage rise into “monitor” stage