

CW3E Event Summary: 26 January – 2 February 2024

Atmospheric Rivers Produce Heavy Precipitation from Alaska to Southern CA

- A family of atmospheric rivers (ARs) brought heavy precipitation to portions of Alaska, British Columbia, the Pacific Northwest, and California during 26 Jan – 2 Feb.

The ARs:

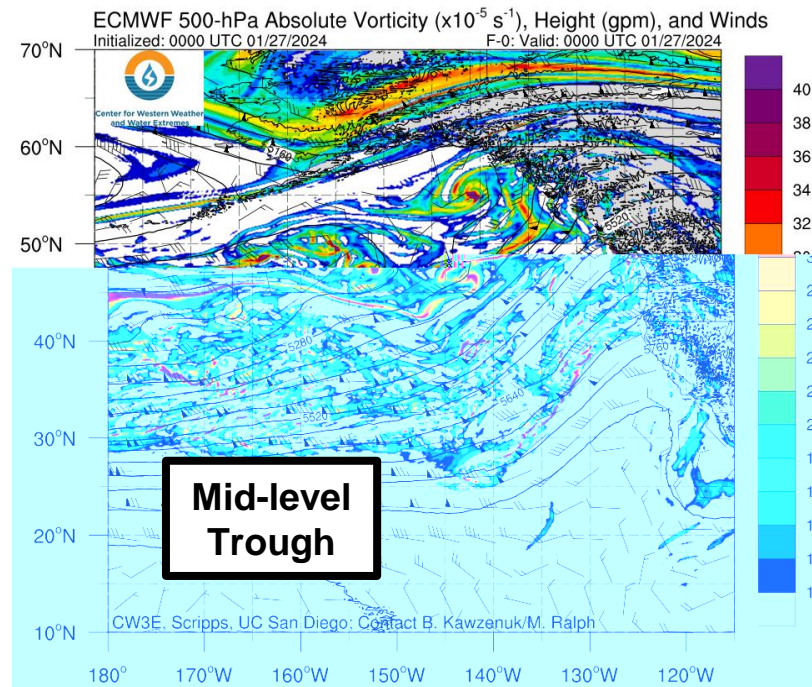
- AR #1 made landfall in Oregon on 26 Jan and produced at least 2–6 inches of precipitation in portions of western Washington and Oregon.
- AR #2 made landfall in British Columbia and southeastern Alaska on 28 Jan and produced 6–12 inches of precipitation over Vancouver Island, the Coast Mountains, the Alaska Panhandle, and the St. Elias Mountains.
- AR #3 produced AR4 conditions (based on the Ralph et al. 2019 AR Scale) along the southern Oregon coast and AR3 conditions in coastal Northern California.
- AR #3 brought widespread precipitation to California, including 4–8 inches of rain in the Northern California Coast Ranges and western Transverse Ranges, and 1–3 feet of snow in the Sierra Nevada.
- All three ARs were fed from a tropical moisture source referred to as a **Tropical Moisture Export (TME)**.

Impacts:

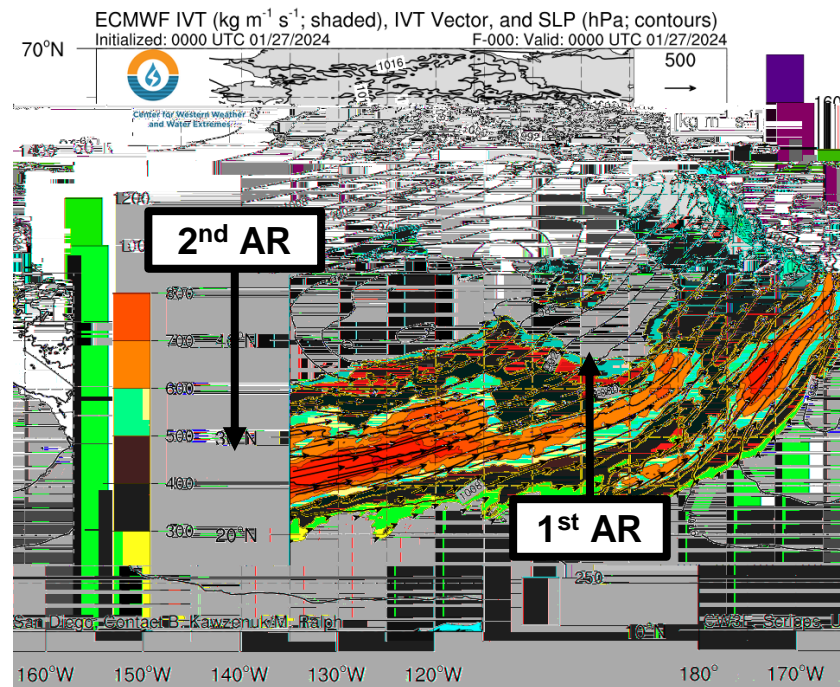
- Rain falling on moist soils caused minor-to-moderate riverine flooding in western Washington during the first AR.
- The greatest hydrologic impacts occurred in British Columbia during the second AR, with significant flooding near Pemberton, BC.
- Minor flooding and several landslides were reported in Northern California during the third AR.
- This family of ARs and nearby essential atmospheric features were sampled by the NOAA and the 53rd Weather Reconnaissance Squadron as part of the AR Recon field campaign.

ECMWF Analyses of First AR: Valid 4 PM PT 26 Jan 2024

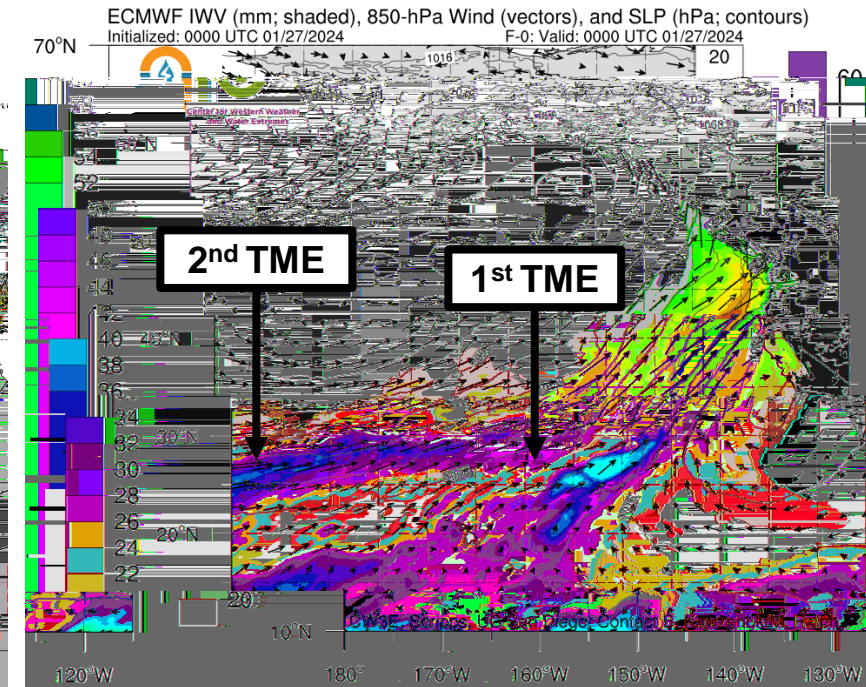
500-hPa Vorticity, Height, and Wind



IVT and SLP



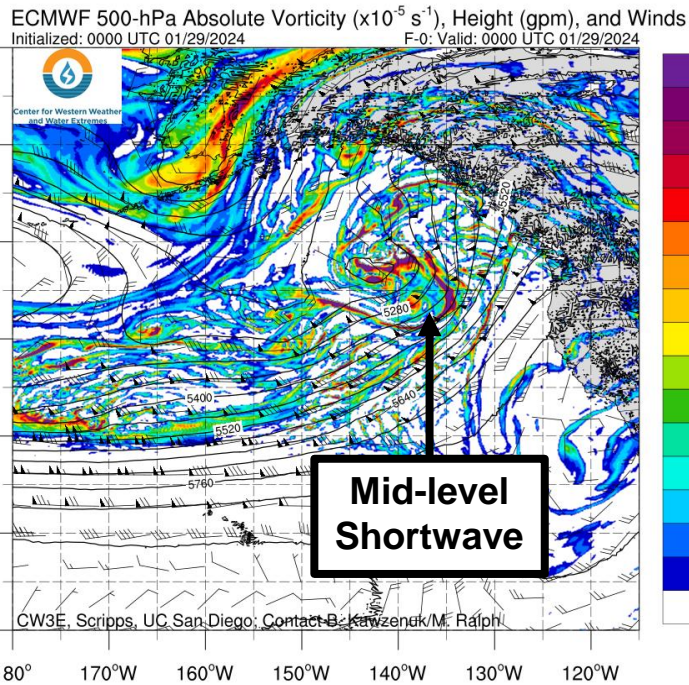
IWV and 850-hPa Wind



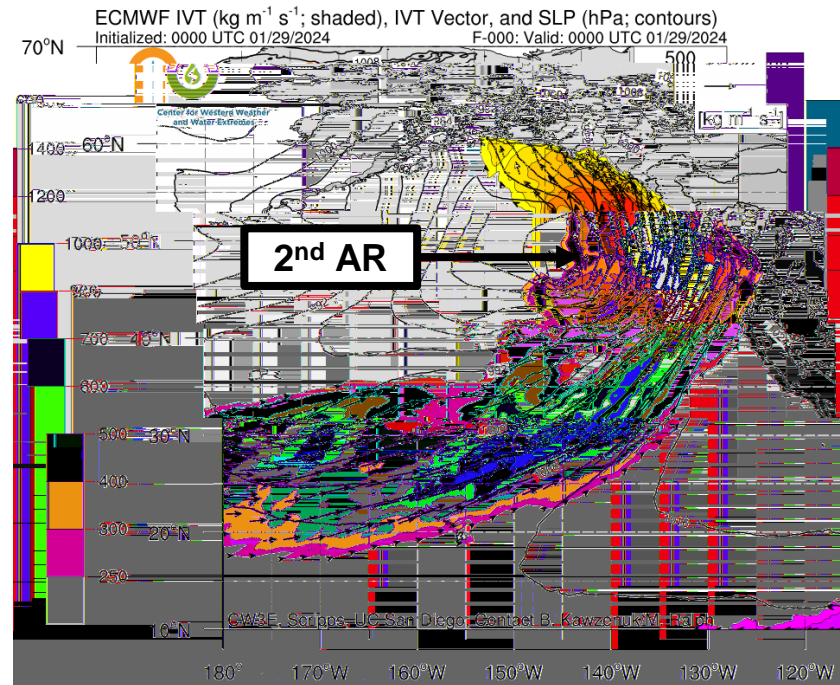
- A persistent mid-level trough over the Northeast Pacific set the stage for multiple landfalling ARs over western North America.
- The first AR developed within a tropical moisture export (TME) originating over the central North Pacific and made landfall over Oregon on 26 Jan.
- This AR brought IWV values $> 30 \text{ mm}$ and IVT magnitudes $> 600 \text{ kg m}^{-1} \text{ s}^{-1}$ to coastal Oregon.
- As the first AR was making landfall, a second AR associated with another TME originating in the western Pacific began to strengthen and move into the Northeast Pacific.

ECMWF Analyses of Second AR: Valid: 4 PM PT 28 Jan 2024

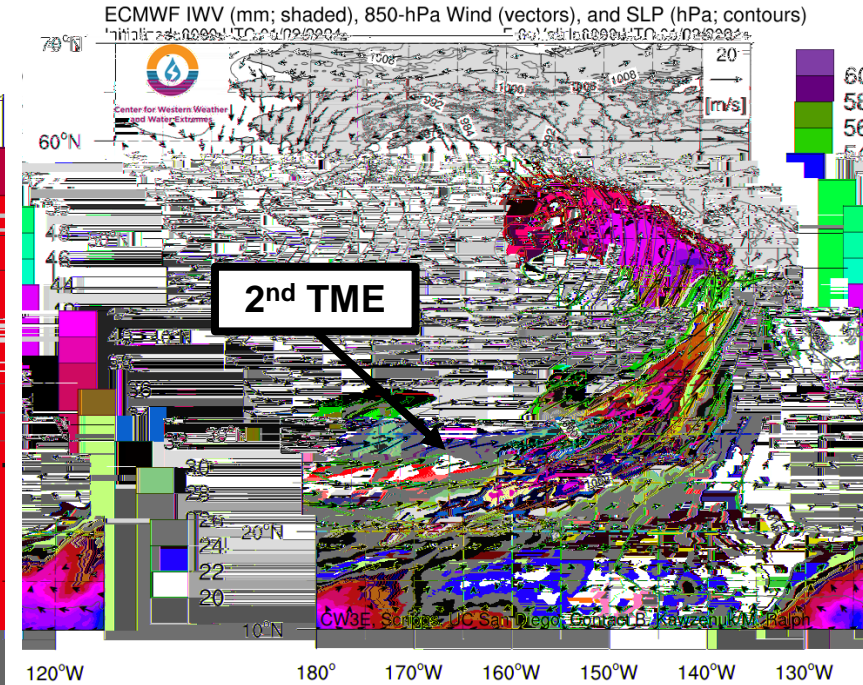
IWV and 850-hPa Wind



IVT and SLP



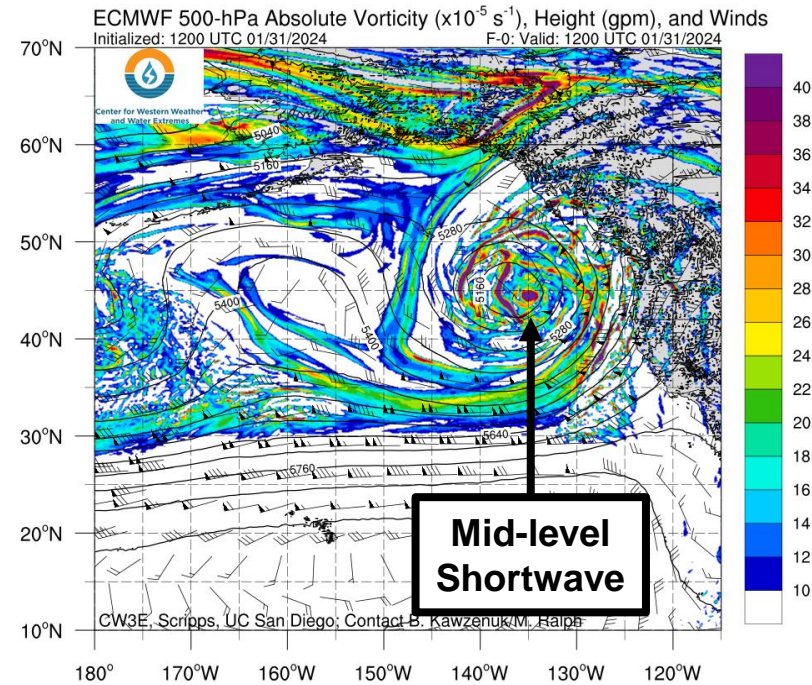
500-hPa Vorticity, Height, and Wind



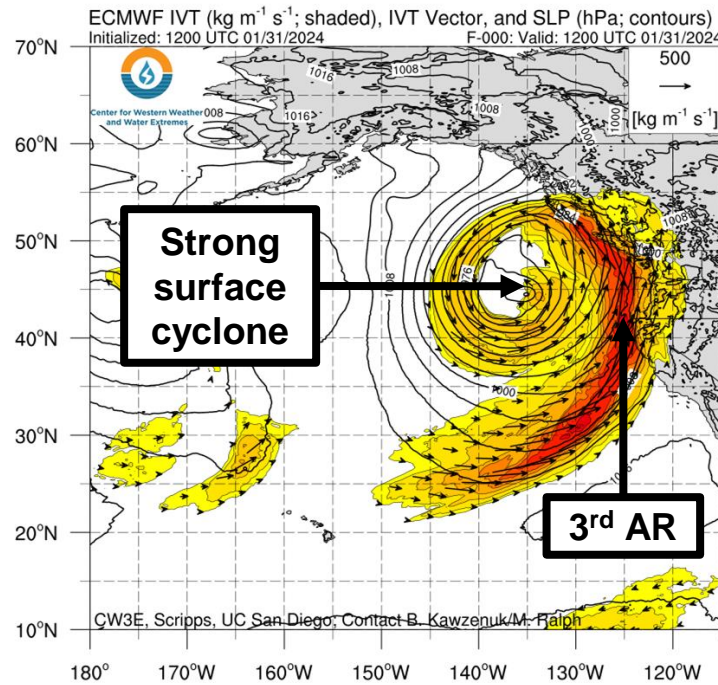
- As time progressed, the second TME and second AR both continued to intensify and move northeastward.
- The second AR made landfall over British Columbia and southeastern Alaska on 28 Jan downstream of a mid-level shortwave in the Gulf of Alaska.
- This AR brought very moist air and strong moisture transport to British Columbia and southeastern Alaska, with IWV values approaching 25 mm and IVT magnitudes approaching $800 \text{ kg m}^{-1} \text{ s}^{-1}$ along the coast.

ECMWF Analyses of Third AR: Valid: 4 AM PT 31 Jan 2024

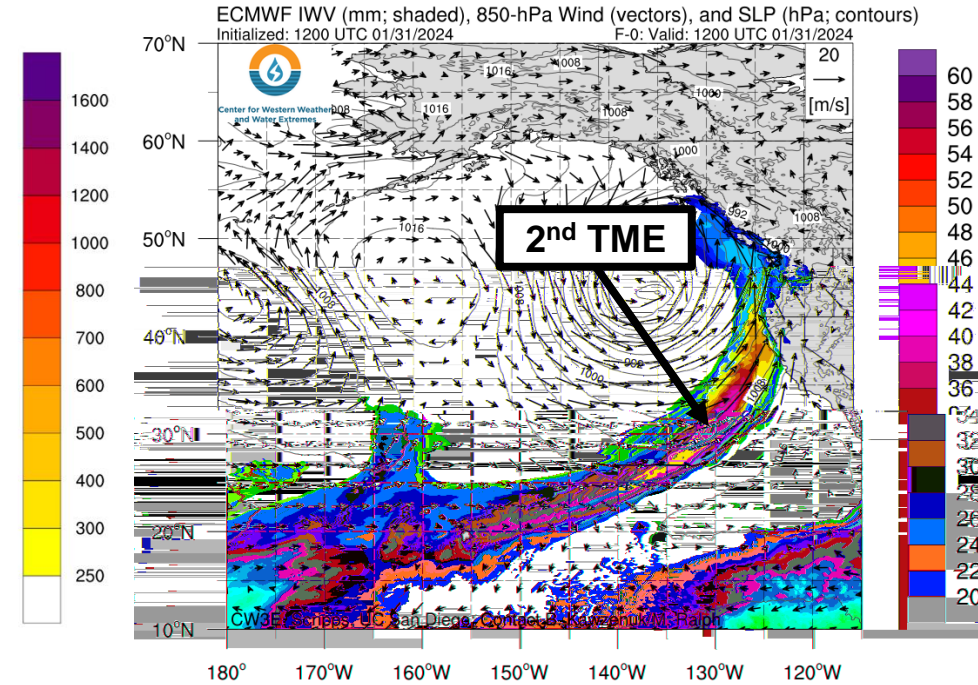
IWV and 850-hPa Wind



IVT and SLP



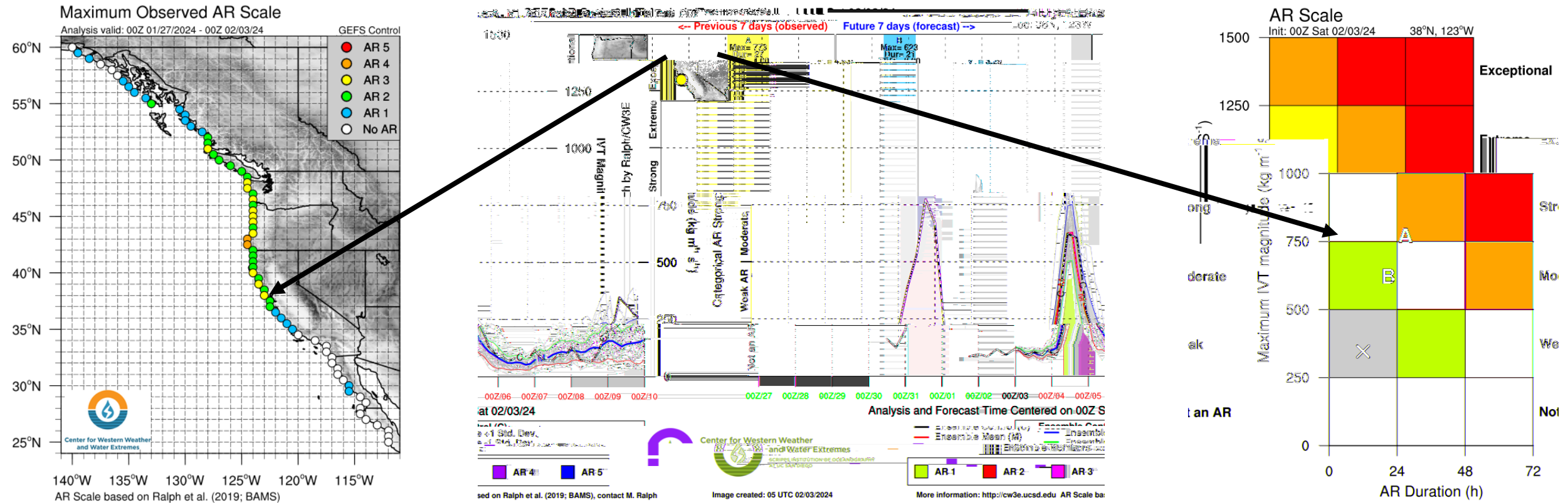
500-hPa Vorticity, Height, and Wind



- The third and strongest AR developed within the same TME in association with a potent mid-level shortwave and a rapidly intensifying surface cyclone.
- This AR made landfall on 30 Jan and produced strong AR conditions ($\text{IVT} > 750 \text{ kg m}^{-1} \text{ s}^{-1}$) in coastal Washington, Oregon, and Northern California.
- As time progressed, the AR gradually moved down the coast, bringing moderate AR conditions ($\text{IVT} > 500 \text{ kg m}^{-1} \text{ s}^{-1}$) to Central California and weak AR conditions ($\text{IVT} > 250 \text{ kg m}^{-1} \text{ s}^{-1}$) to Southern California.

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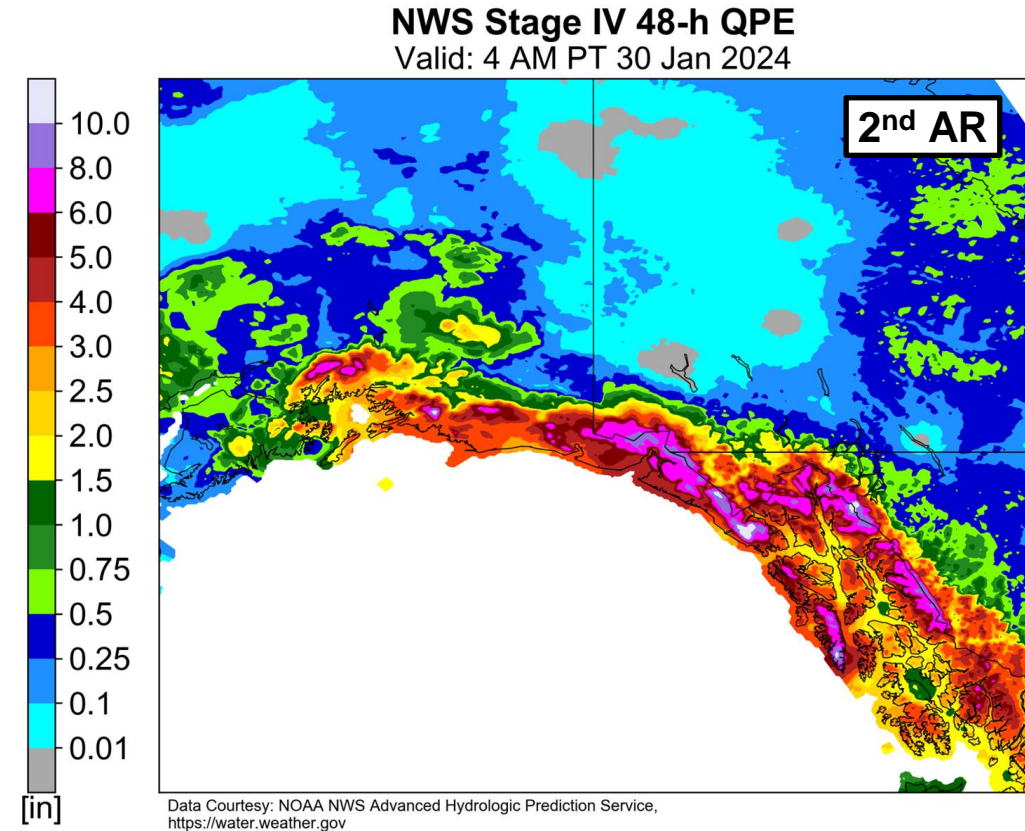
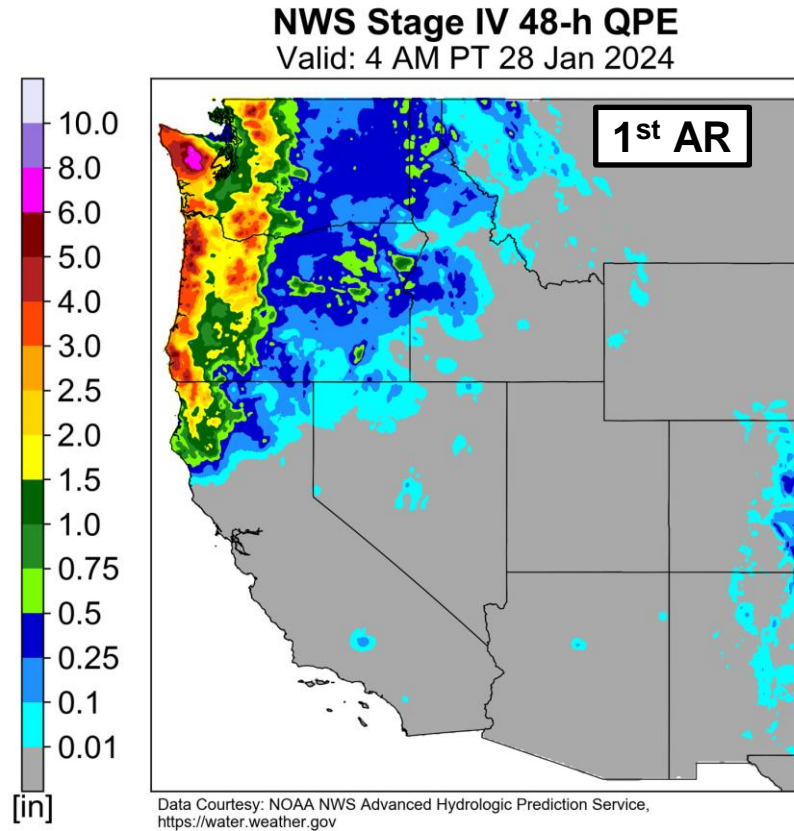
GEFS AR Scale Analysis of Third AR



- Based on the GEFS analysis, the third AR produced AR2–3 conditions from Vancouver Island to the San Francisco Bay Area, with an AR4 observed in coastal southern Oregon.
- An AR duration of 27 hours and a maximum IVT of $773 \text{ kg m}^{-1} \text{ s}^{-1}$ were observed near Point Reyes, CA (i.e., an AR3).
- Note that the AR Scale analysis products were not available during the first or second ARs due to data issues.

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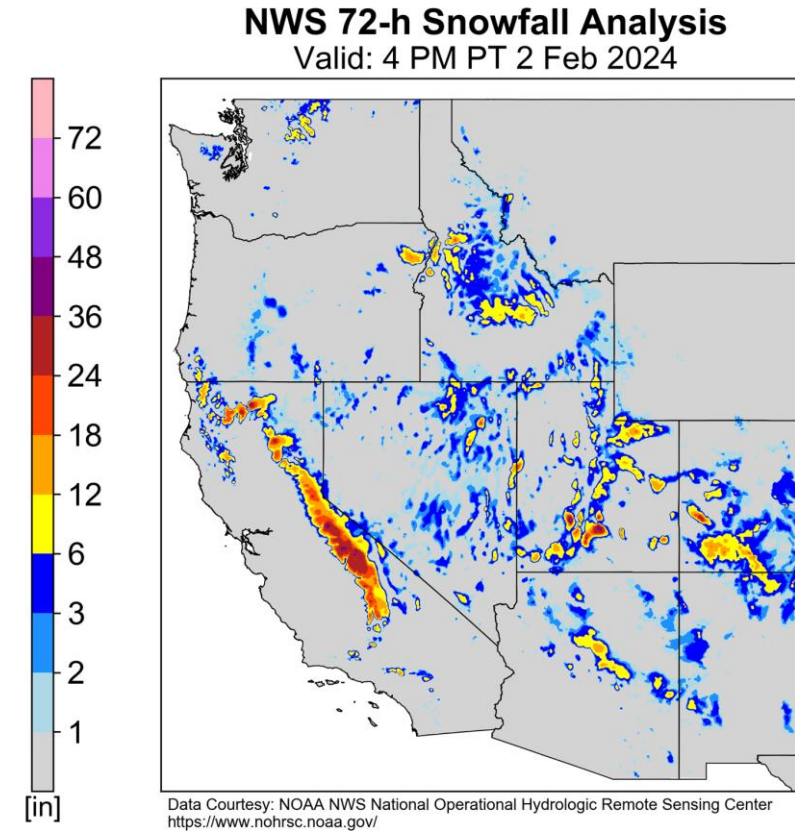
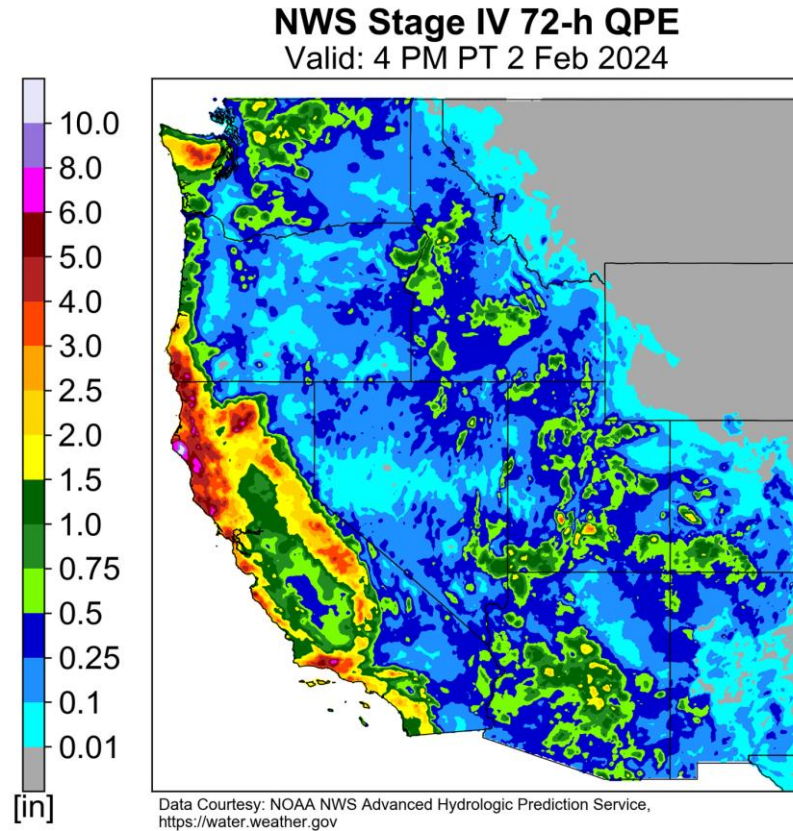
Observed Precipitation: First and Second ARs



- The first AR produced at least 2–6 inches of precipitation in the Coast Ranges and Cascades of Washington and Oregon, with slightly higher amounts in the Olympic Mountains.
- The second AR produced very heavy precipitation (6–12 inches) over Vancouver Island, the British Columbia Coast Mountains, the Alaska Panhandle, and the St. Elias Mountains.

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Observed Precipitation: Third AR

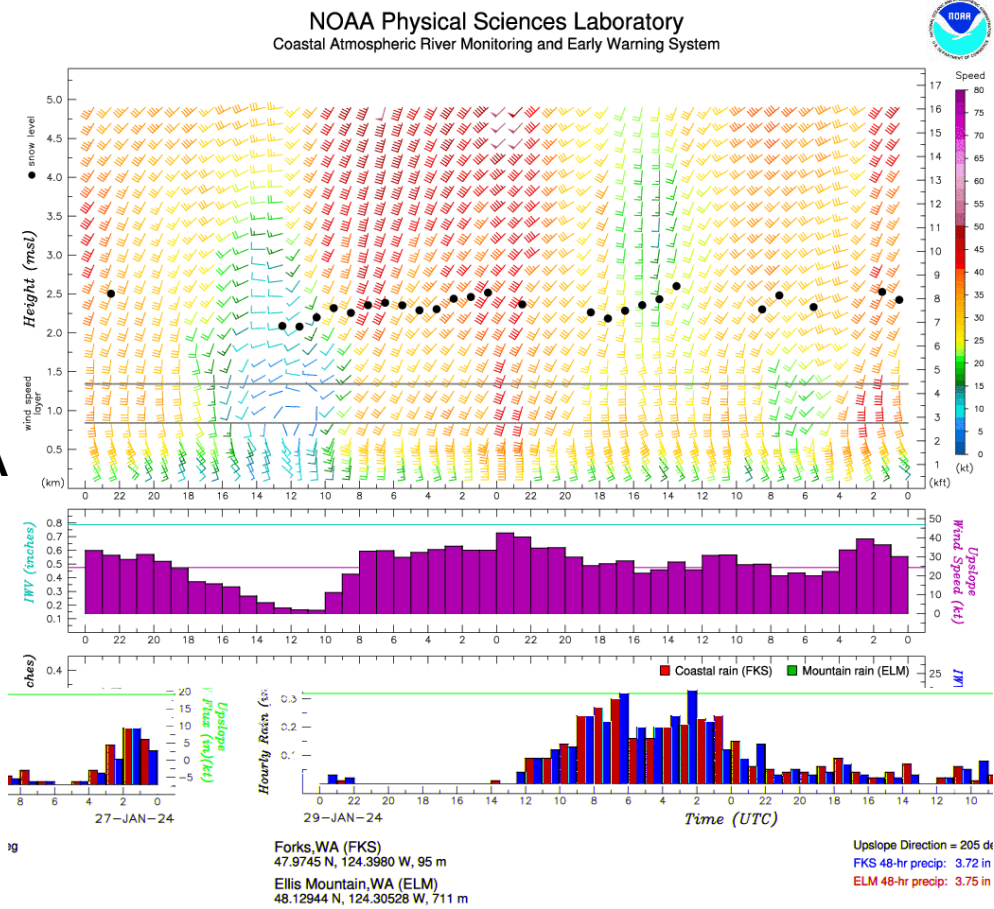


- The third AR produced heavy rainfall in much of coastal California, with the highest amounts (4–8 inches) in the Northern California Coast Ranges and western Transverse Ranges.
- Snowfall was limited over the Cascades during this period, but the third AR produced 1–3 feet of snow in the higher terrain in the Sierra Nevada.

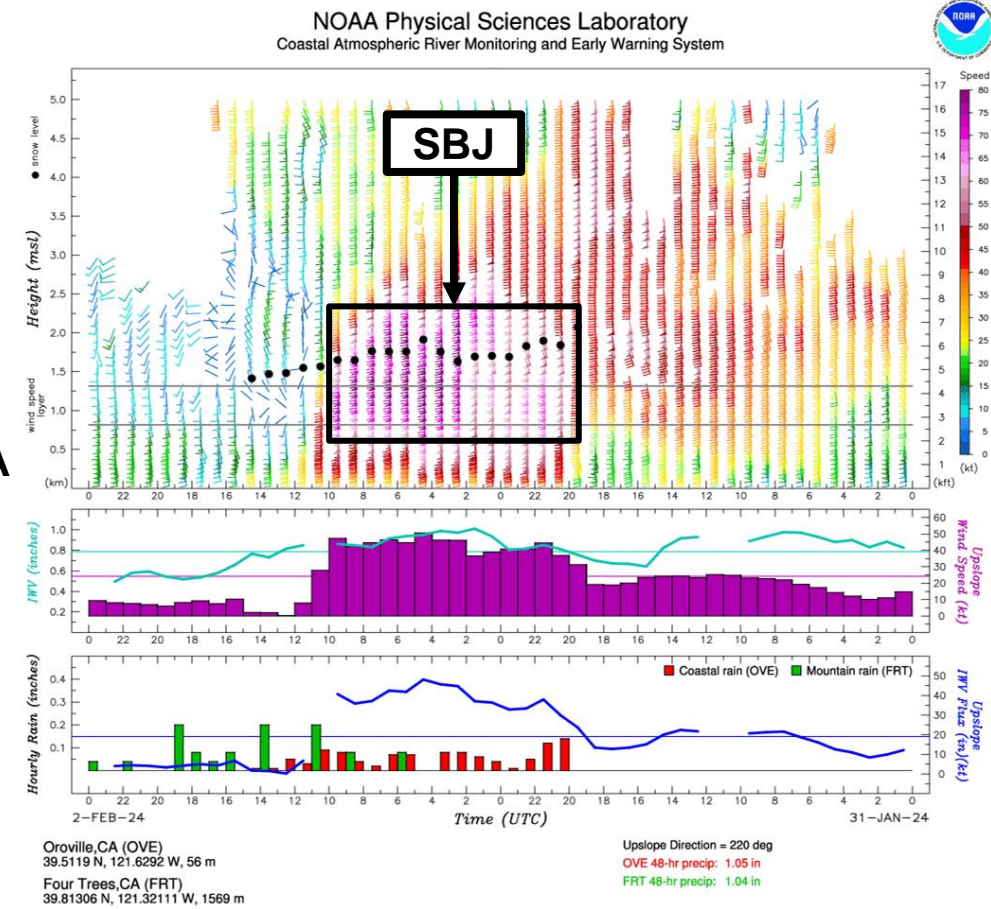
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Wind Profiler Integrated Water Vapor Flux & Snow Level

First AR: Forks, WA (FKS)



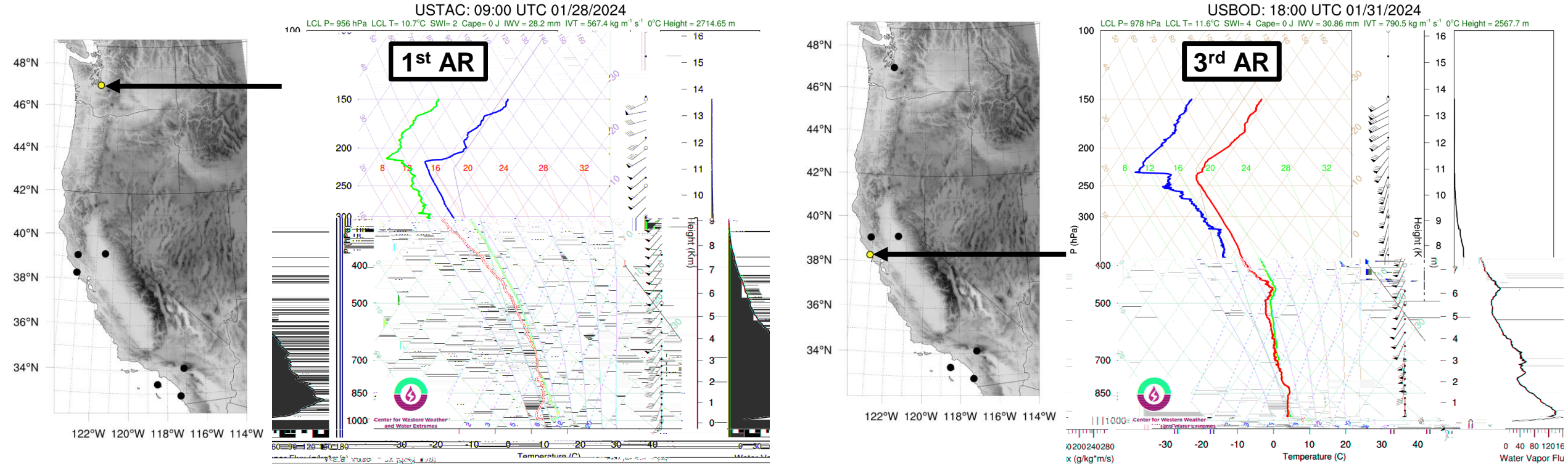
Third AR: Oroville, CA (OVE)



- Snowfall accumulations were limited during the first AR due to high freezing levels.
- The wind profiler at Forks, WA, measured snow levels between 6,800 and 8,600 feet during the first AR.
- Snow levels in the Northern Sierra Nevada dropped below 6,000 feet after the third AR made landfall.
- A Sierra barrier jet (SBJ) also developed during the third AR, with south-southeasterly winds reaching ~90 knots at 4,500 feet.

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CW3E Observations: Radiosondes



- The CW3E Field Team launched radiosondes at Tacoma, WA (USTAC), during the first two ARs, and Bodega Bay, CA (USBOD) during the first and third ARs.
- A max IVT of 567.4 kg m⁻¹ s⁻¹ and ~66 hours of continuous AR conditions (i.e., AR3 on the AR Scale) were observed at USTAC during the first and second ARs.
- A max IVT of 790.5 kg m⁻¹ s⁻¹ and ~27 hours of AR conditions (i.e., an AR3 on the AR Scale) were observed at USBOD during the third AR.

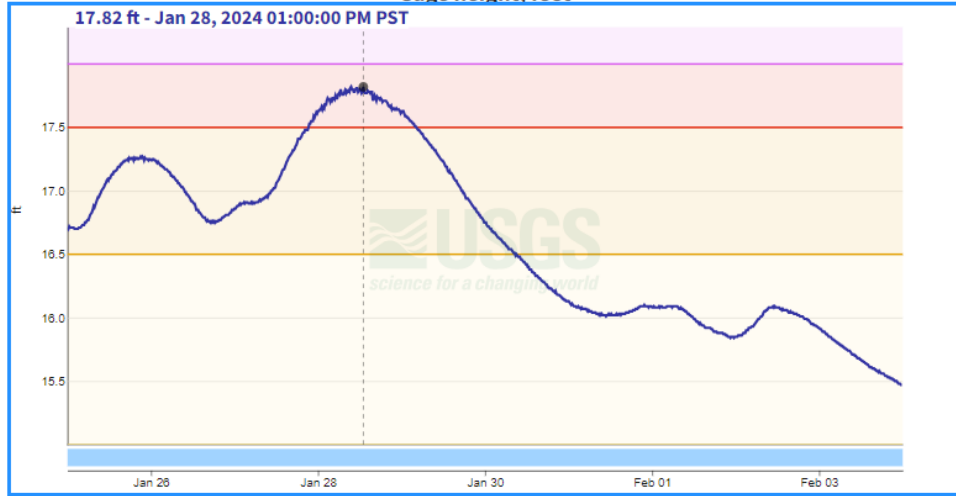
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Hydrologic Impacts of First AR

Skokomish River Near Potlatch, WA - 12061500

January 25, 2024 - February 3, 2024

Gage height, feet



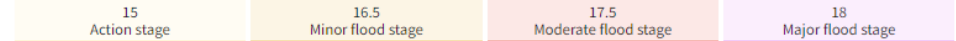
Gage height, feet

— Recorded

Data approval period

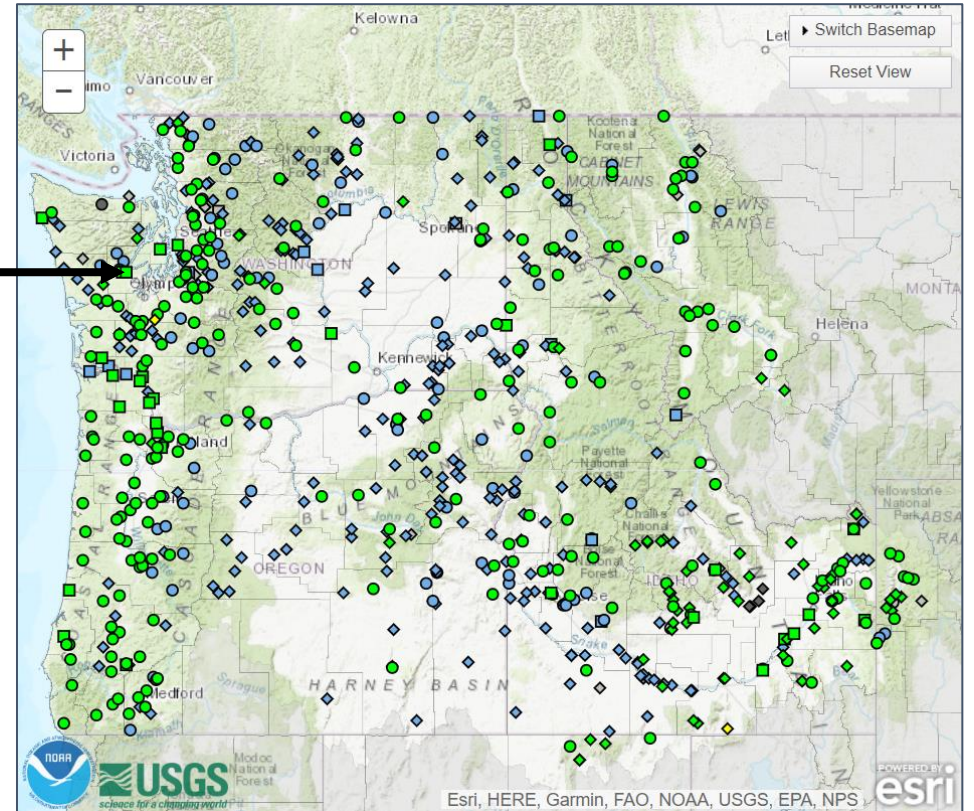
■ Provisional

Flood stages in ft



IMPORTANT Data may be provisional

Source: United States Geological Survey



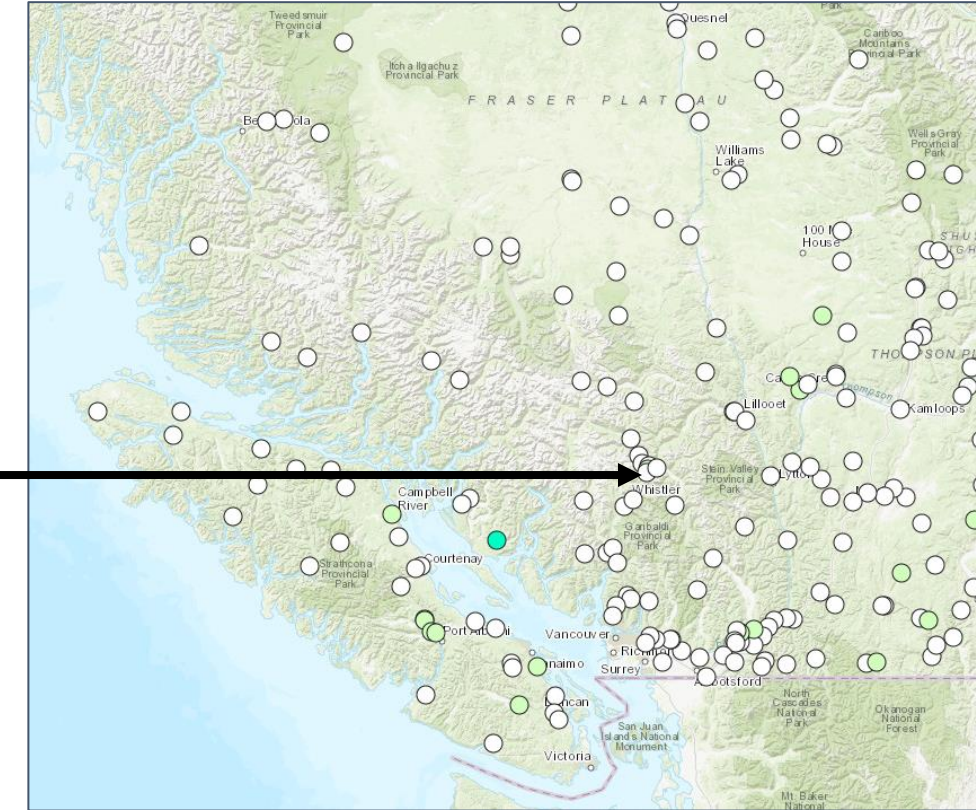
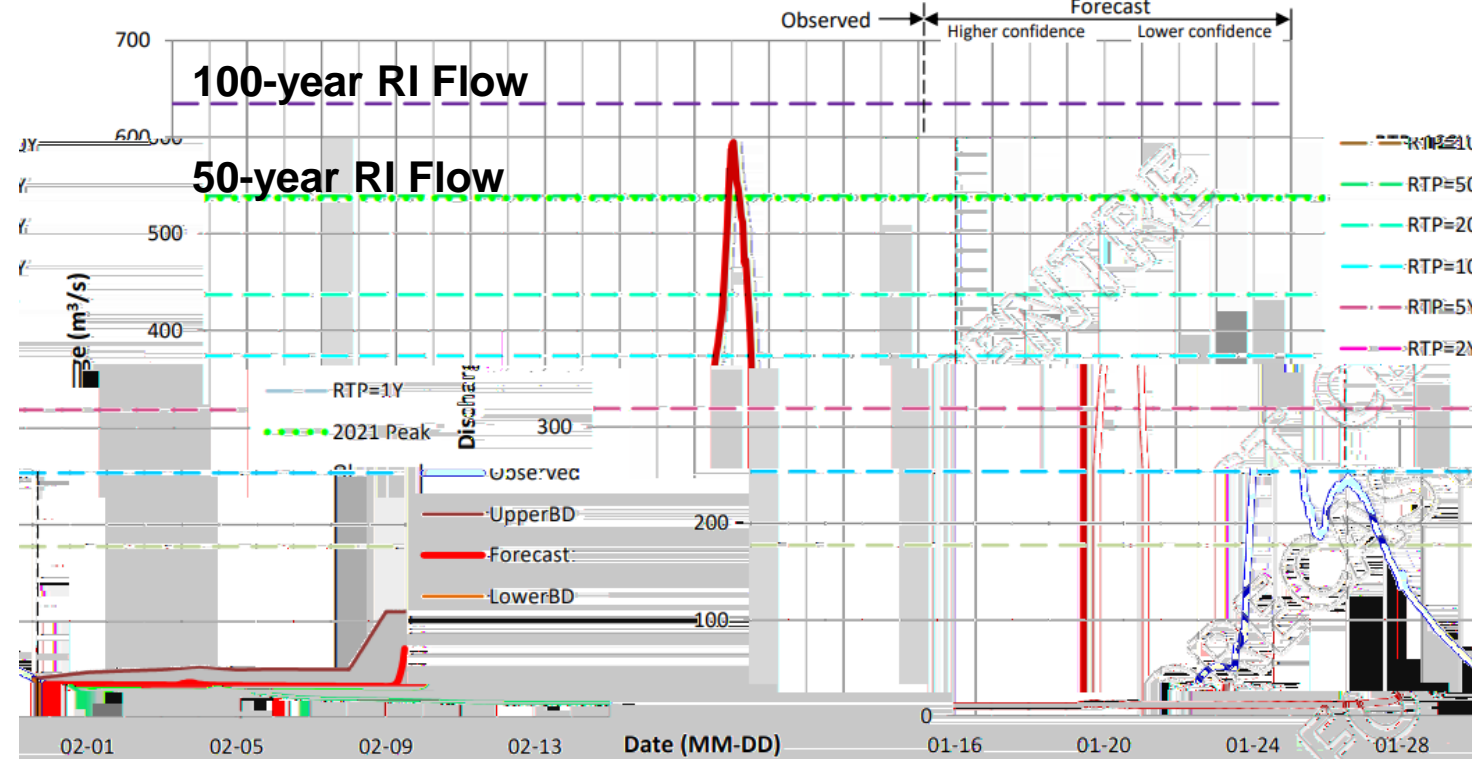
Source: NOAA/NWS Advanced Hydrologic Prediction Service

- Rain falling on saturated soils during the first AR caused minor-to-moderate riverine flooding in western Washington and Oregon.
- The Skokomish River near Potlatch, WA, rose above moderate flood stage (17.5 feet) late on 27 Jan, reaching a peak stage of 17.82 feet around midday 28 Jan.

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Hydrologic Impacts of Second AR

GREEN RIVER AT NAIRN FALLS (BC 08MG0003) (08MG00C)



Source: BC River Forecast Centre

- Heavy rain during the second AR caused flooding in southwestern British Columbia.
- Streamflow on the Green River at Nairn Falls (near Pemberton, BC) exceeded both the 50-year recurrence interval (RI) flow and the peak of the November 2021 event.

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Impacts of Second AR: British Columbia

- Warm temperatures and heavy rains associated with these ARs resulted in flooding in multiple locations in British Columbia due to combined precipitation and snow melt.
- Flooding along the Lillooet River near Pemberton, BC, resulted in evacuations on 30 Jan.
- BC Hydro, a major electric power provider and dam operator in the area, reported numerous power outages due to wind damage and also highlighted significant outflows from the Daisy Lake Reservoir along the Cheakamus River on 1 Feb (*right*).



<https://www.cbc.ca/news/canada/british-columbia/pemberton-evacuation-state-of-local-emergency-1.7099658>



<https://www.facebook.com/VillageOfPemberton>



<https://x.com/bchydro/status/1753210849215516850?s=20>

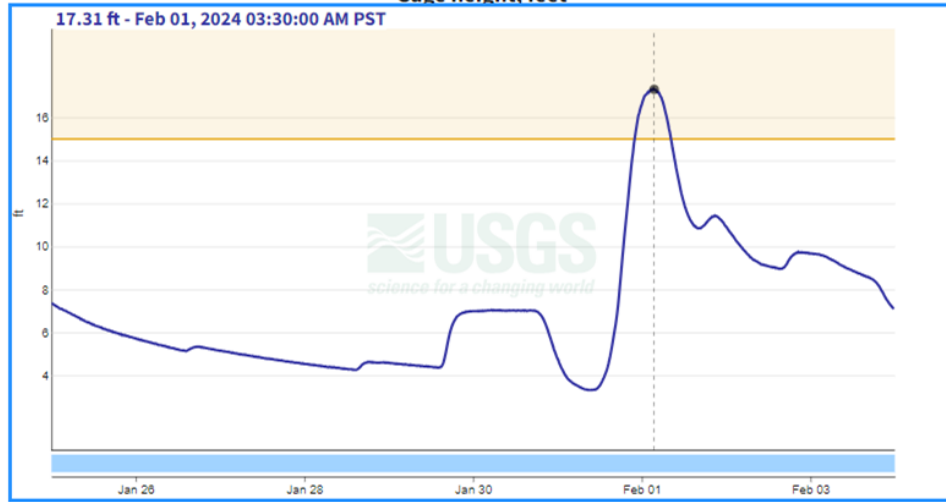
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Hydrologic Impacts of Third AR

Russian R NR Hopland CA - 11462500

January 25, 2024 - February 3, 2024

Gage height, feet



Gage height, feet

— Recorded

Data approval period

■ Provisional

Flood stages in ft

15

Minor flood stage

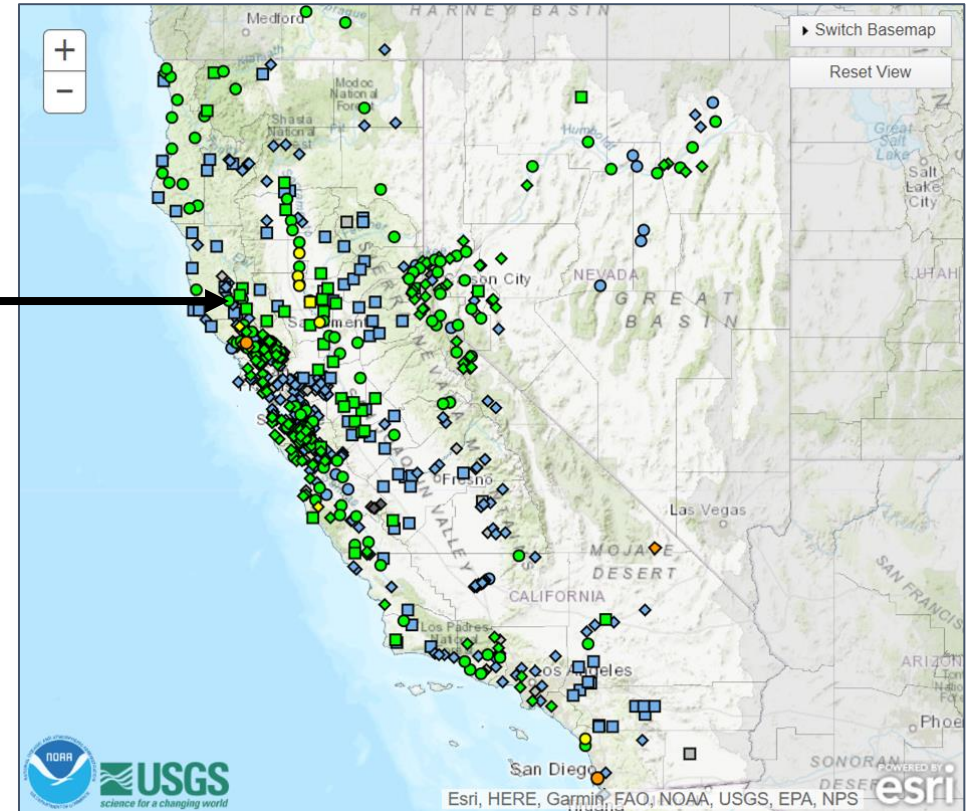
23

Moderate flood stage

26

Major flood stage

Source: United States Geological Survey



Source: NOAA/NWS Advanced Hydrologic Prediction Service

- Heavy rain during the third AR caused minor riverine flooding in Northern California.
- The Russian River near Hopland, CA, rose above minor flood stage (15.0 feet) on 31 Jan, reaching a peak stage of 17.31 feet during the early morning on 1 Feb.

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Impacts of Third AR: California

- Multi-day precipitation led to flooding and roadway closures in Northern and Central California. Pictured is flooding along Main St. in Ferndale - Humboldt County (*upper right*).
- Sustained precipitation increased susceptibility to geological hazards across the state. A significant rockfall was observed along State Route 70 in Butte County, CA (*lower right*).
- A hillslope failure was reported along Tesla Road in Alameda County, CA, in an area that was already being monitored for erosion due to prior storm impacts. (*below*).



<https://x.com/CaltransDist1/status/1752833618425369032>



<https://x.com/CaltransD2/status/1753469019657818223>



<https://twitter.com/CHPDublin/status/1753956623817548135>



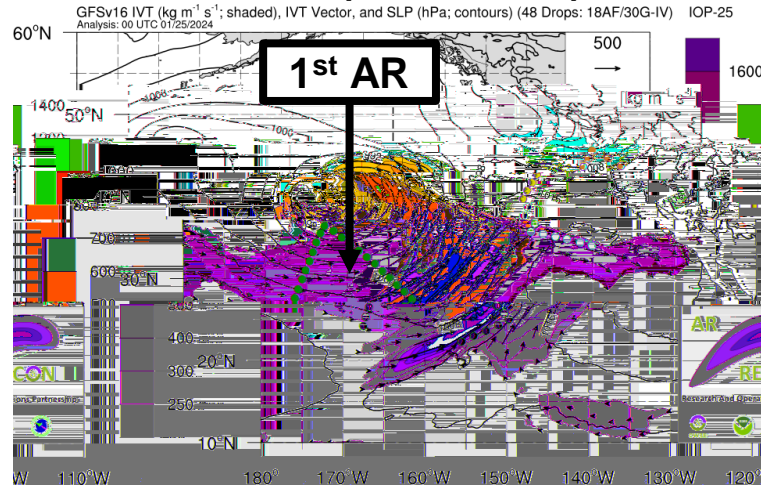
<https://twitter.com/AlamedaCounty/status/1754903298576978337>

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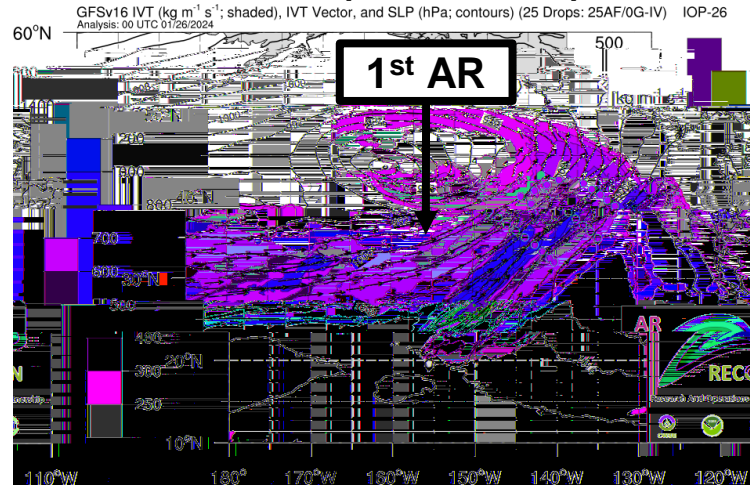


Atmospheric River Reconnaissance Flights

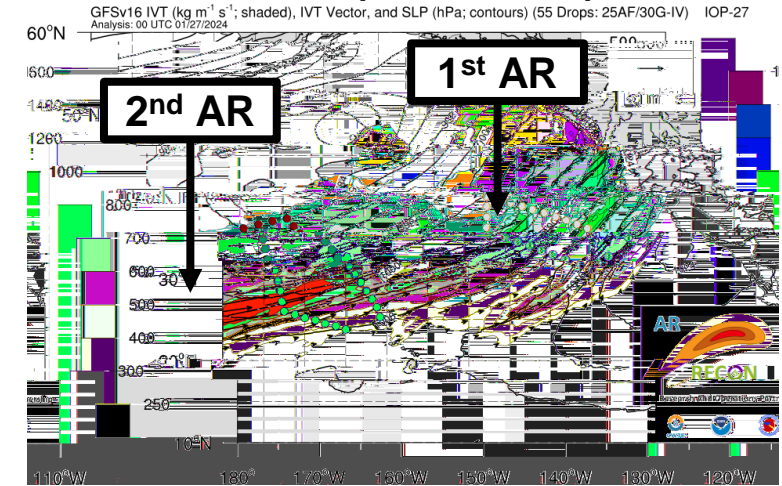
IOP-25 (00Z 25 Jan)



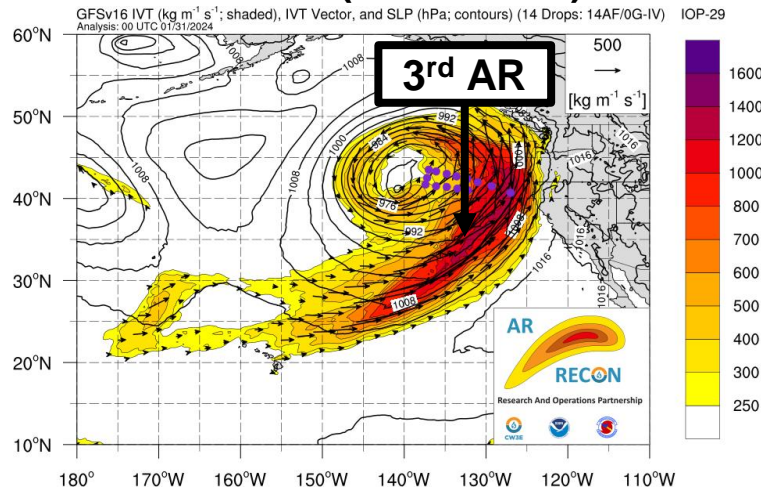
IOP-26 (00Z 26 Jan)



IOP-27 (00Z 27 Jan)



IOP-29 (00Z 31 Jan)



IOP = Intensive observation period

- During this time period, NOAA and the 53rd Weather Reconnaissance Squadron provided observational support over the North Pacific as part of CW3E's AR Recon field campaign.
- 145 successful dropsondes were deployed across 7 missions, providing additional observations for global forecast models and collecting valuable data for future research.
- The Air Force C-130 targeted the first AR and nearby essential atmospheric features during IOPs 26 and IOP-27, as well as the third AR during IOP-29.
- The NOAA-GIV targeted the first/second ARs and nearby essential features during IOP-25 and IOP-27.