CW3E Event Summary: 22–25 February 2025

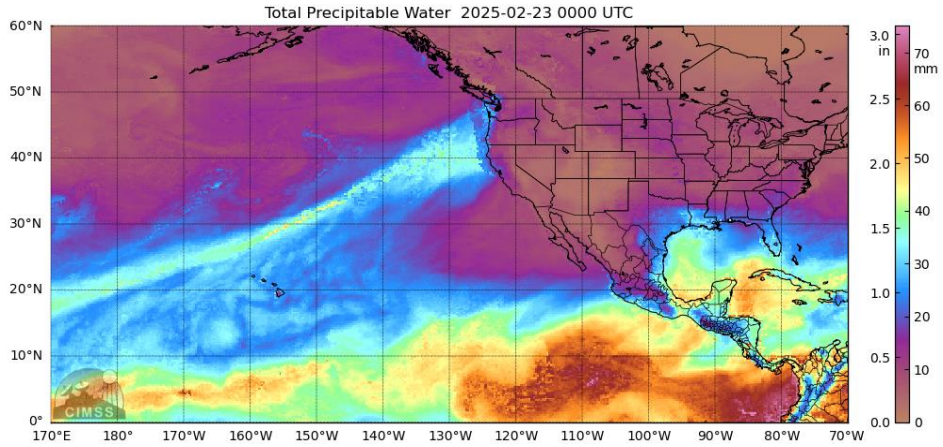
Multiple Atmospheric Rivers Produce Heavy Rain and Flooding in the Pacific Northwest

The ARs:

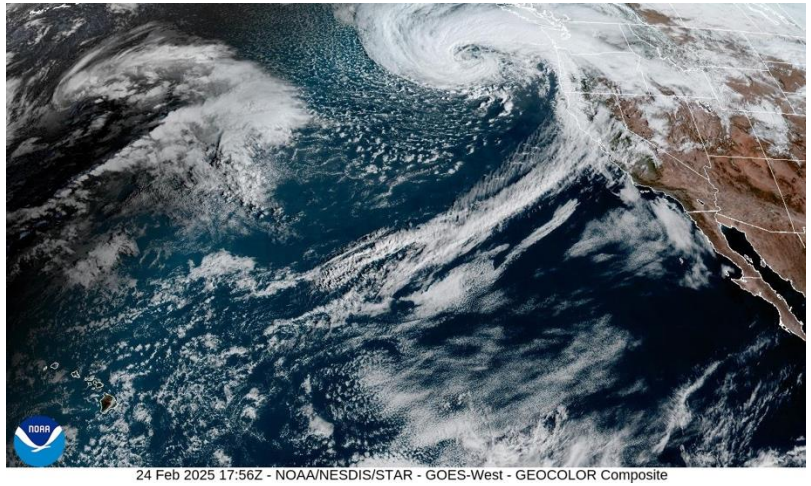
- The first AR made landfall on Sat 22 Feb and produced AR 2–3 conditions (based on the Ralph et al. 2019 AR Scale) in southern coastal Washington and coastal Oregon.
- Significant inland penetration of the first AR also brought AR 2 conditions to interior portions of the northwestern US.
- The second AR made landfall on Mon 24 Feb in association with a strong low-pressure system and produced AR 1–2 conditions in coastal Washington and Oregon.

Impacts:

- At least 5–10 inches of total precipitation fell over much of coastal Washington and Oregon as well as the Cascades.
- Unusually warm temperatures and high freezing levels created favorable conditions for snowmelt and rain-on-snow during the first AR in the Cascades and interior portions of the Pacific Northwest.
- The combination of snowmelt and heavy rainfall led to significant riverine flooding in eastern Washington, northern Idaho, and eastern Oregon.
- Strong winds during the second storm caused widespread tree damage and power outages in western Washington and northwestern Oregon.



Source: Cooperative Institute for Meteorological Satellite Studies (CIMMS), University of Wisconsin-Madison

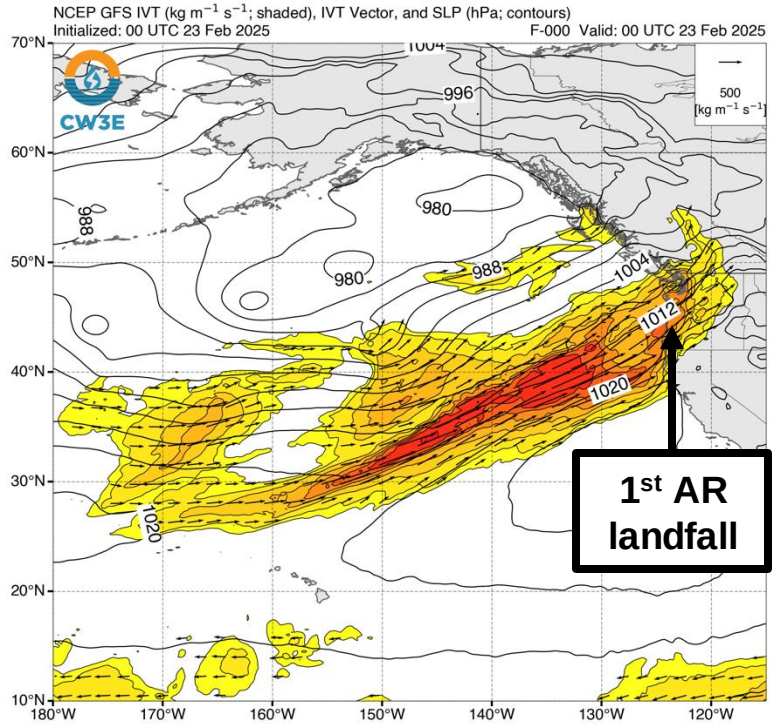


Source: NOAA/NESDIS Center for Satellite Applications and Research

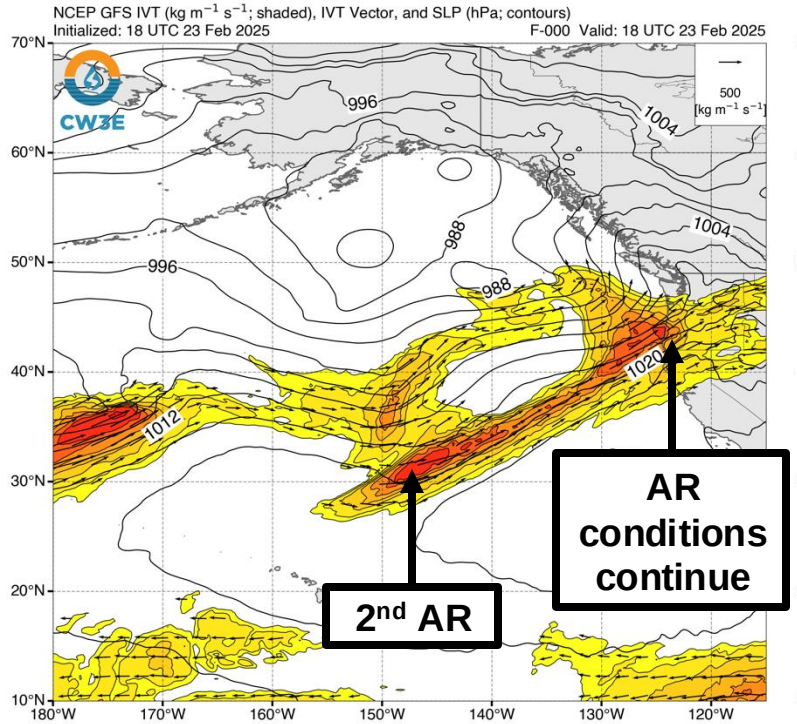
CW3E Event Summary: 22–25 February 2025

GFS IVT & SLP Analyses

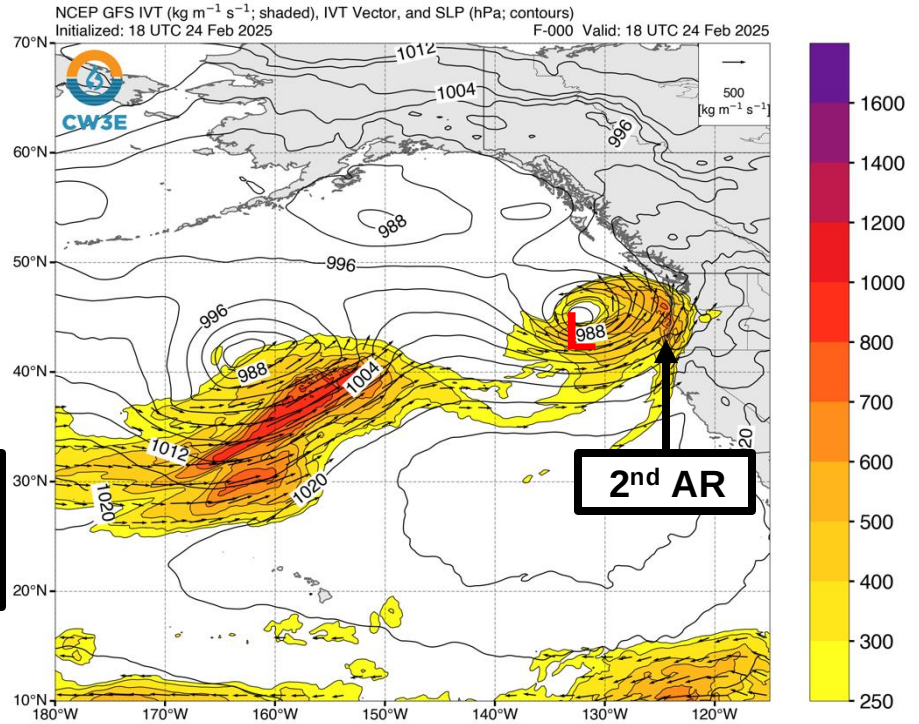
Valid 4 PM PST 22 Feb



Valid 10 AM PST 23 Feb



Valid 10 AM PST 24 Feb



- Both ARs formed within a long plume of subtropical moisture emanating from the central North Pacific.
- The first AR made landfall on Sat 22 Feb, bringing moderate AR conditions (IVT ≥500 kg m^{-1} s^{-1}) to coastal portions of southern Washington, Oregon, and far Northern California.
- As time progressed, a mesoscale wave on the northern periphery of the AR propagated northeastward and helped extend AR conditions in coastal Oregon and Northern California into Sun 23 Feb.
- The second AR formed near the tail of the moisture plume in association with a cyclogenesis event and brought a brief period of moderate AR conditions to coastal Oregon on Mon 24 Feb.

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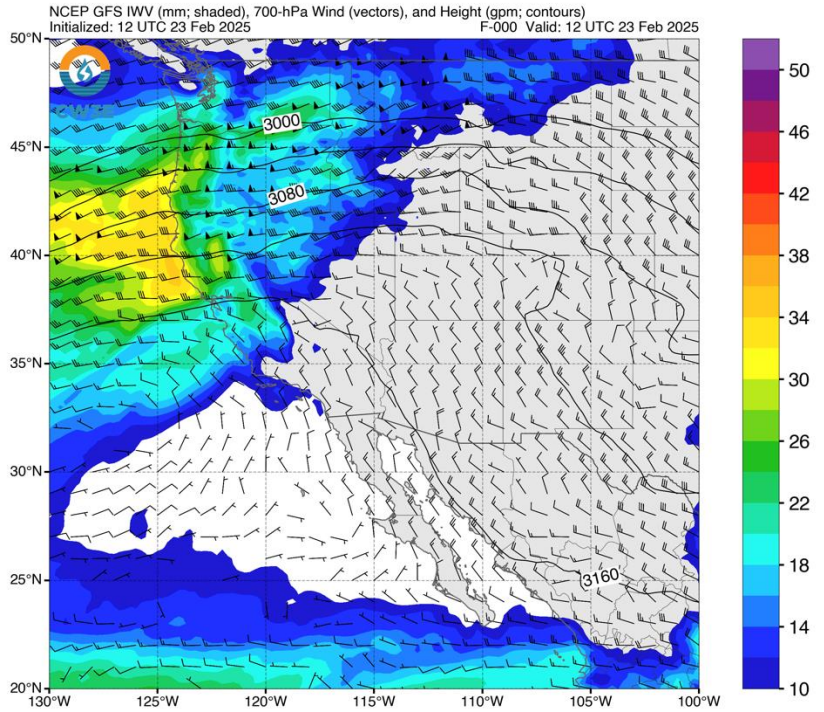
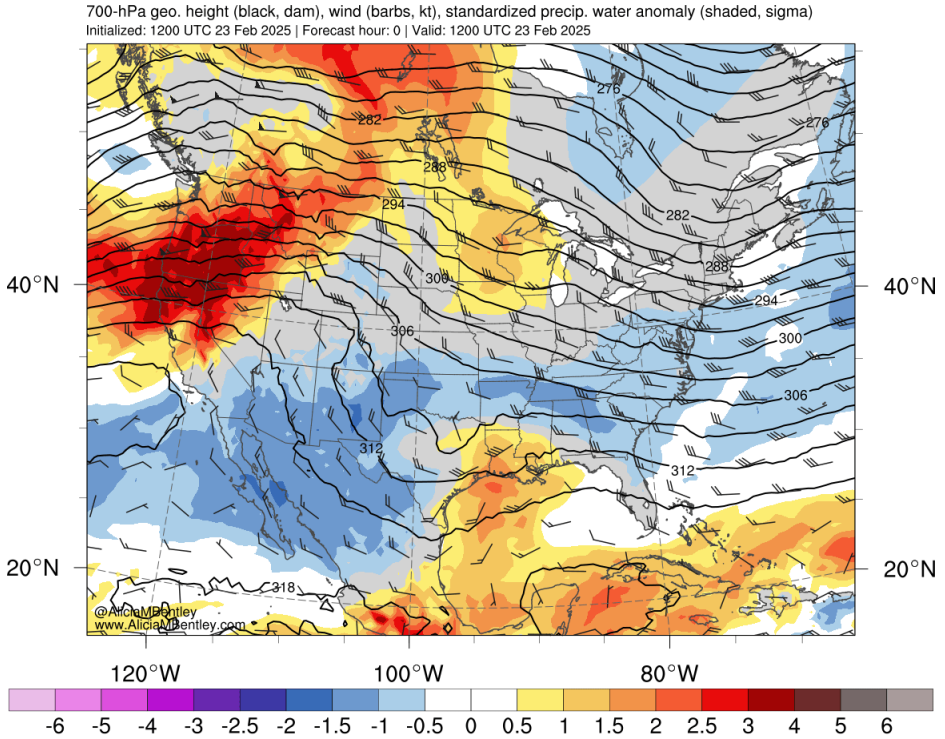
GFS Moisture Analyses and CW3E Sounding of First AR

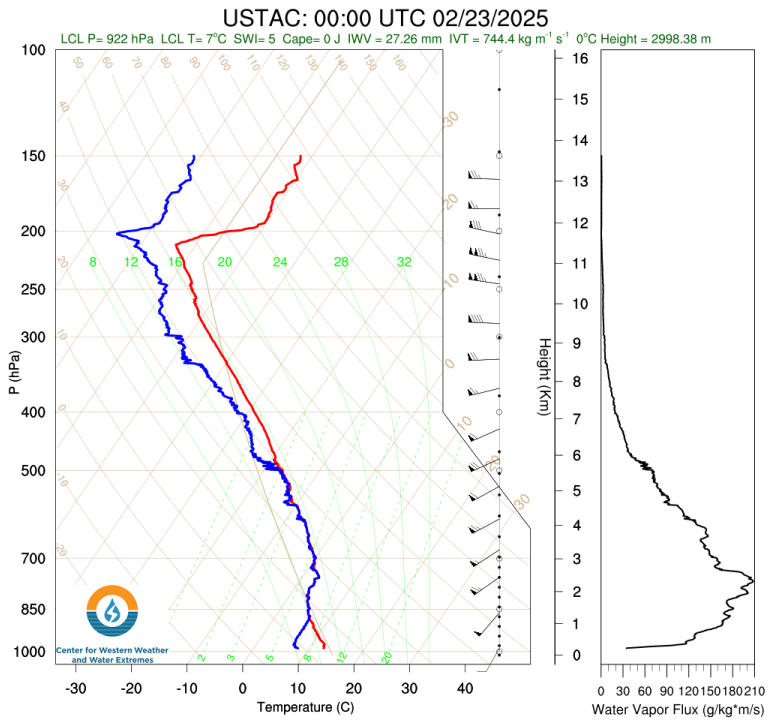
IWV & 700-hPa Heights/Winds



Standardized PWAT Anomalies



USTAC Sounding



- Inland penetration of the first AR brought anomalously warm, moist air into the interior Pacific Northwest.
- GFS analyses showed precipitable water (PWAT) values >3 standard deviations above the climatological mean in eastern Oregon during the morning of Sun 23 Feb.
- The CW3E Field Team launched radiosondes from Tacoma, WA (USTAC), every 3 hours between 7 AM PST Sat 22 Feb and 7 PM PST Sun 23 Feb. A maximum IVT of 744 kg m^{-1} s^{-1}, maximum IWV of 27.3 mm, and maximum freezing level of 2,998 meters (9,837 feet) were recorded during the initial pulse of moisture transport on Sat 22 Feb.

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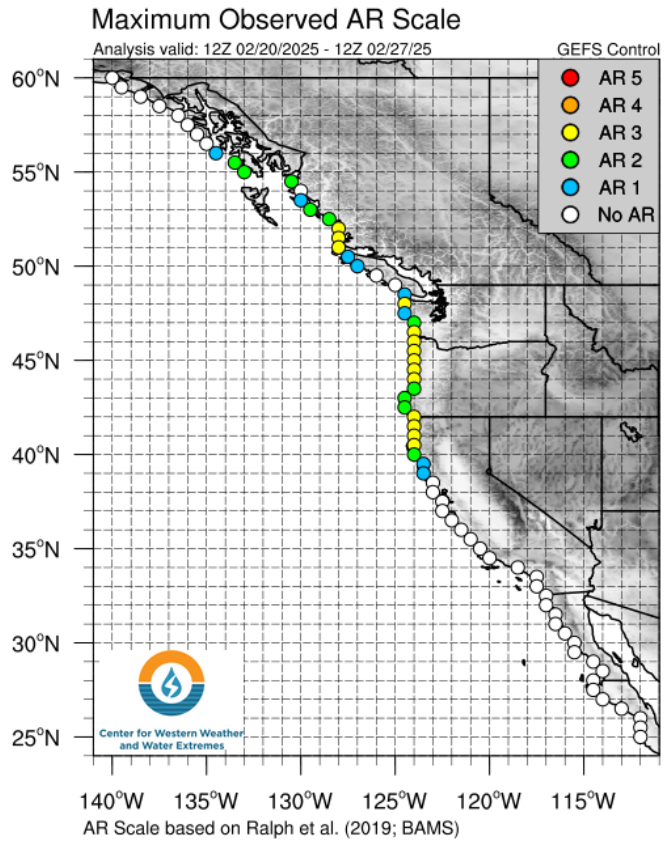
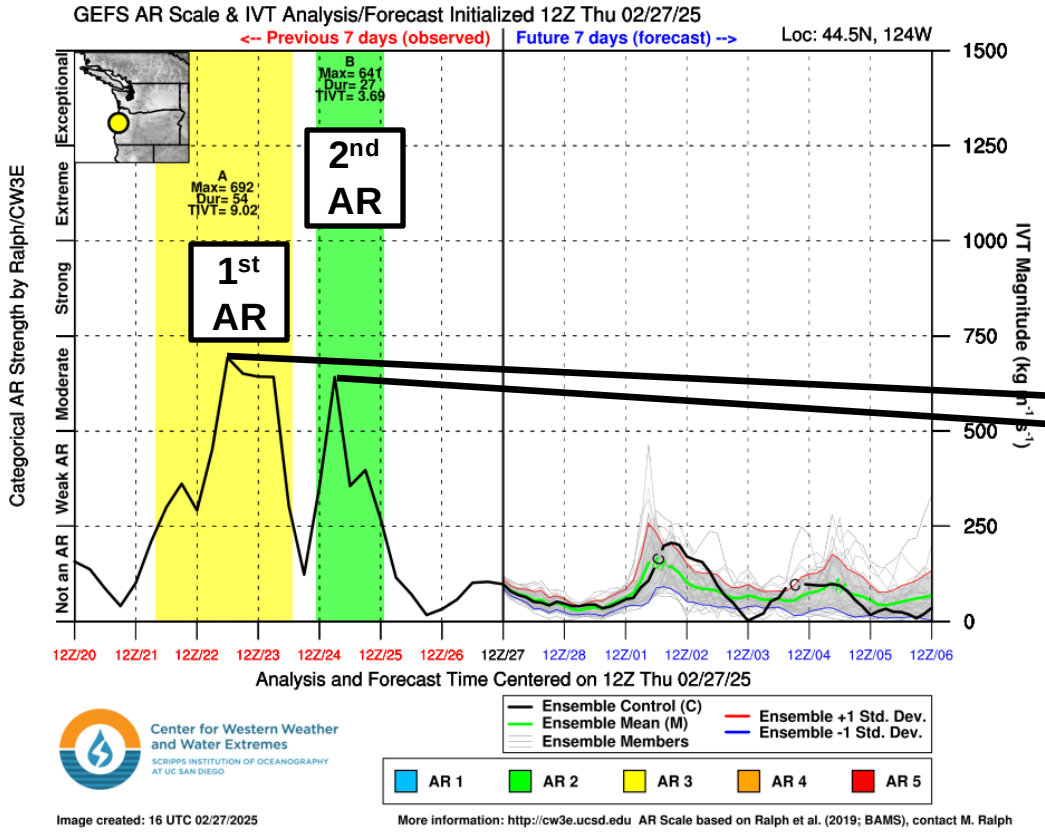
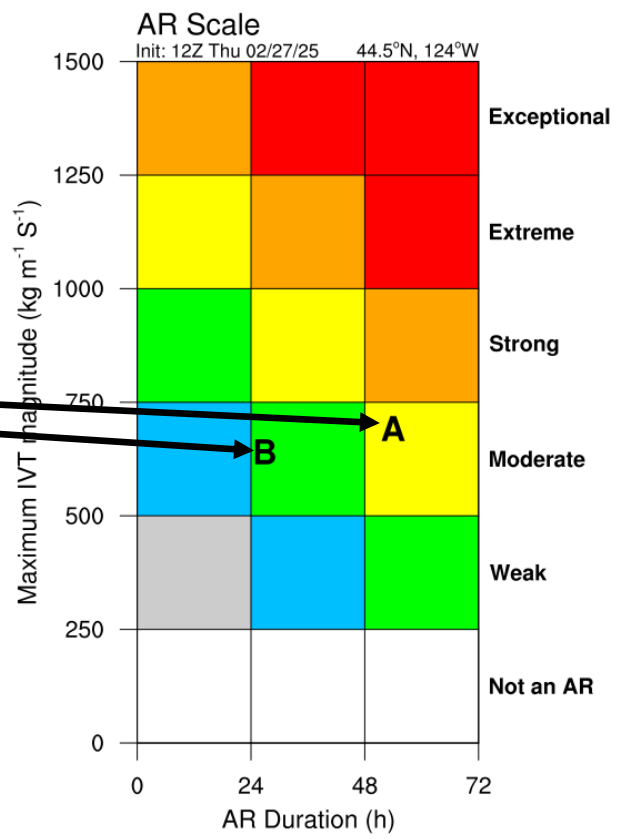
GEFS AR Scale Analysis (Coast)







- The first AR produced AR 2–3 conditions in coastal Oregon and southern coastal Washington.
- Some locations experienced >48 hours of continuous AR conditions due to a weak pulse of moisture transport on Fri 21 Feb that preceded the main AR.
- The second AR produced AR 1–2 conditions in coastal Oregon and Washington. An AR 3 was observed in coastal Northern California due to a lack of a break in AR conditions between the two ARs.

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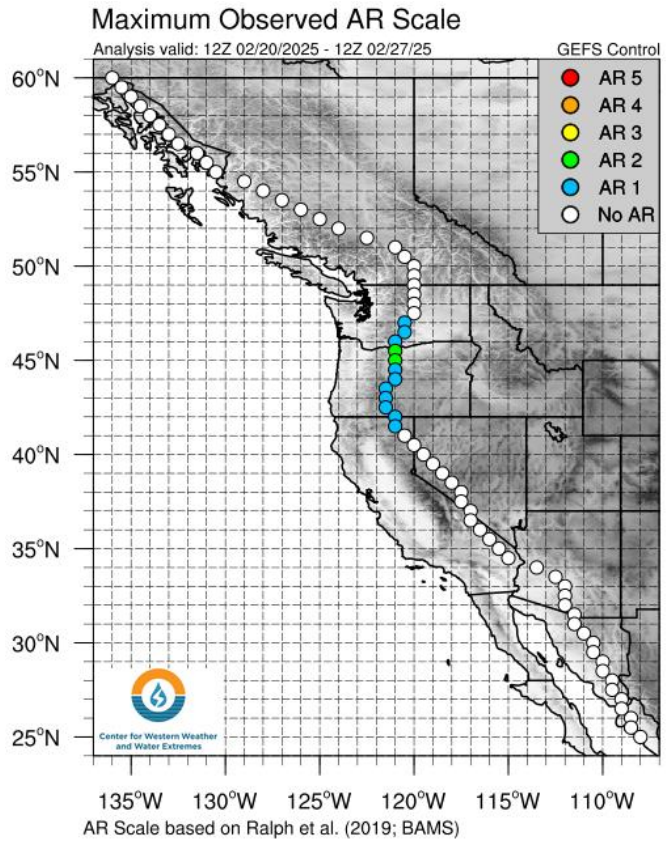
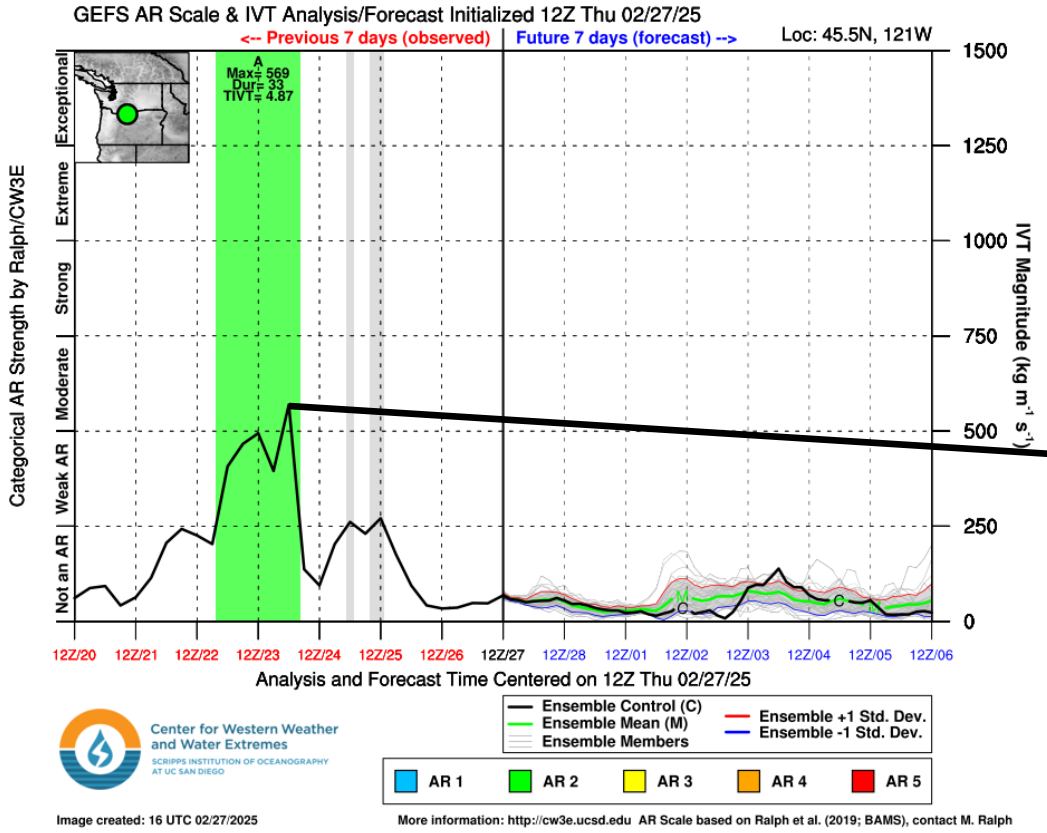
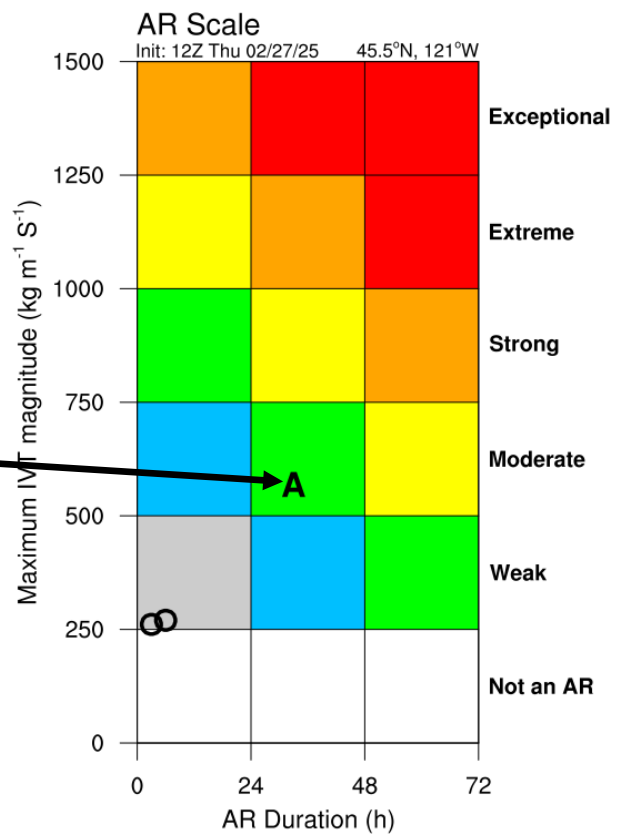
GEFS AR Scale Analysis (Inland)







- Inland penetration of the first AR produced AR 2 conditions east of the Cascades in northern Oregon.
- The GEFS AR Scale analysis shows a maximum IVT of 569 kg m^{-1} s^{-1} and an AR duration of 33 hours at 45.5°N 121°W (Wasco County, OR).

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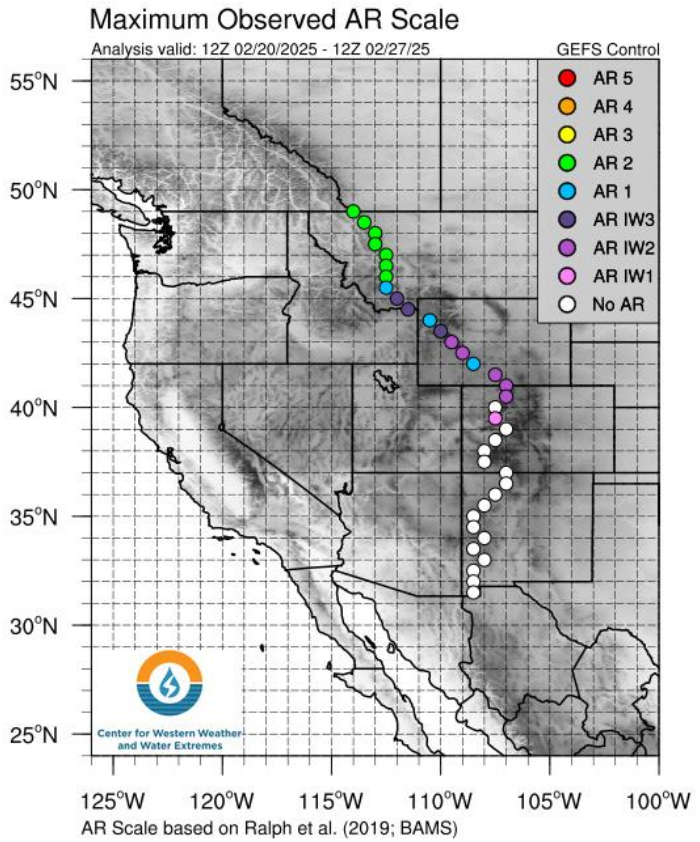
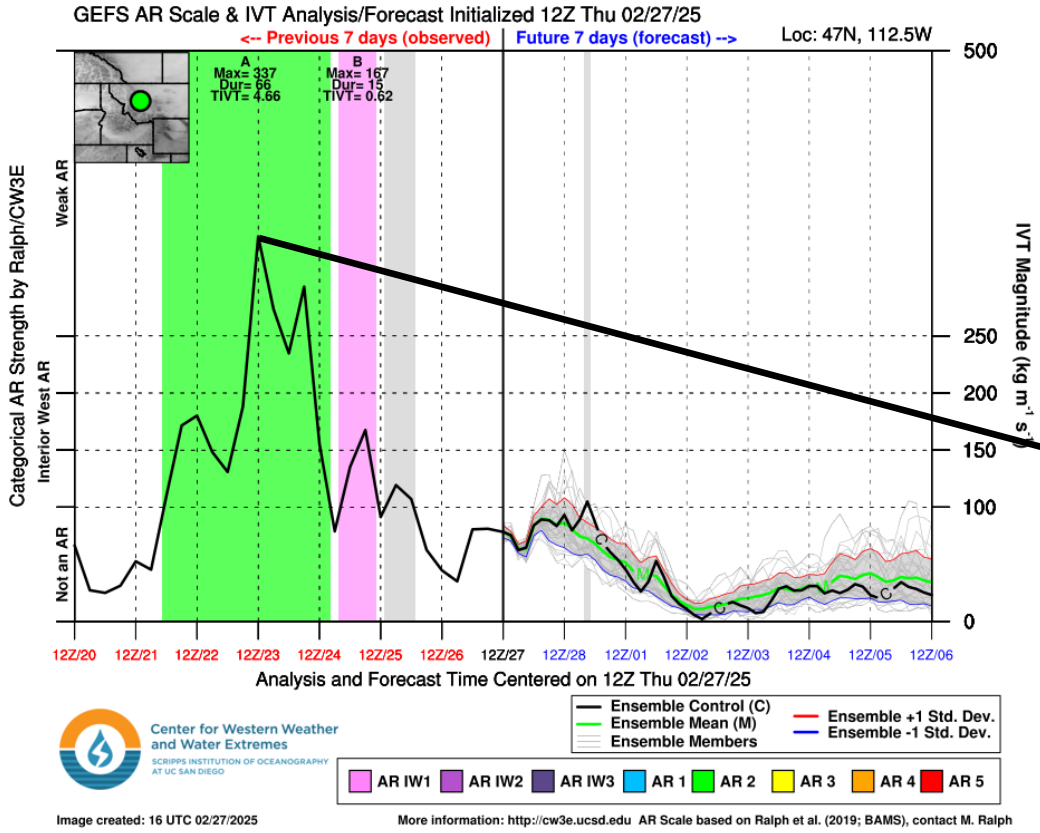
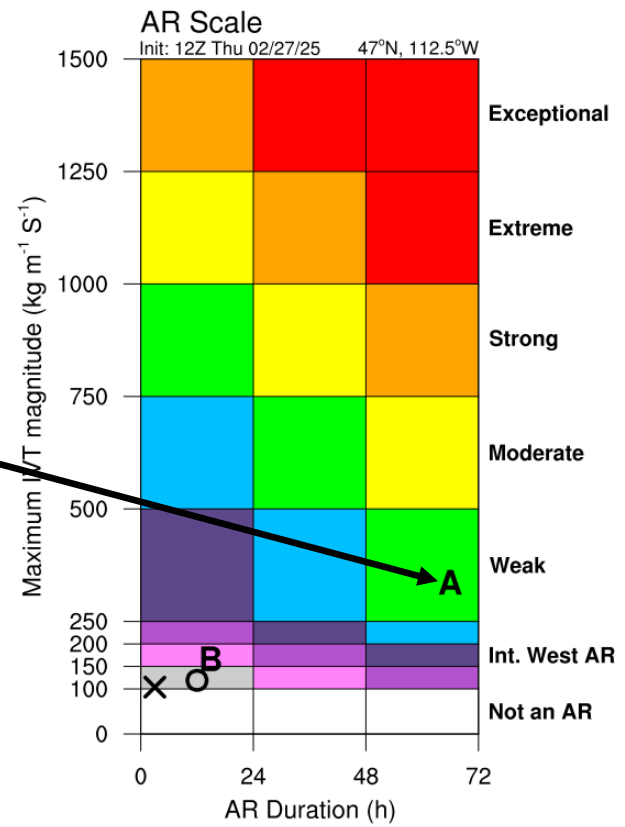
GEFS AR Scale Analysis (Interior West)







- Inland penetration of the first AR and the preceding IVT pulse also brought an extended period of enhanced moisture transport to portions of Idaho and western Montana.
- A version of the GEFS AR Scale analysis adapted for the interior western US shows a maximum IVT of 337 kg m^{-1} s^{-1} and 66 hours of IVT ≥100 kg m^{-1} s^{-1} at 47°N 112.5°W (Lewis and Clark County, MT).

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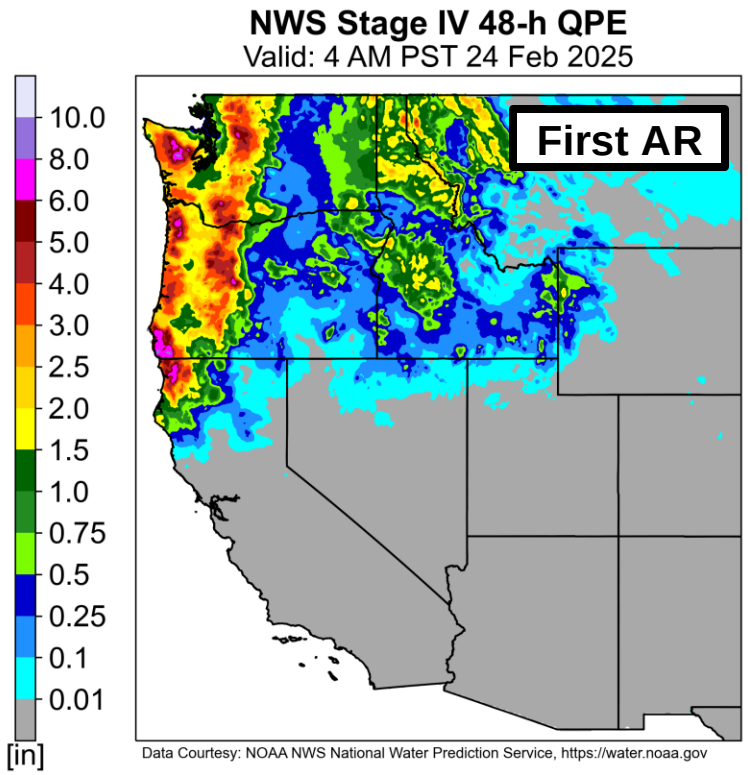
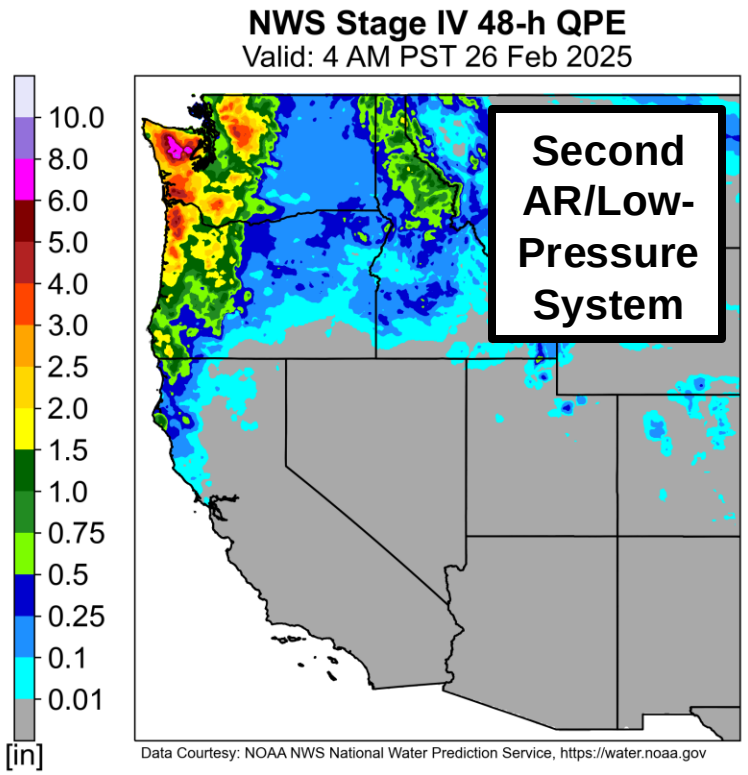
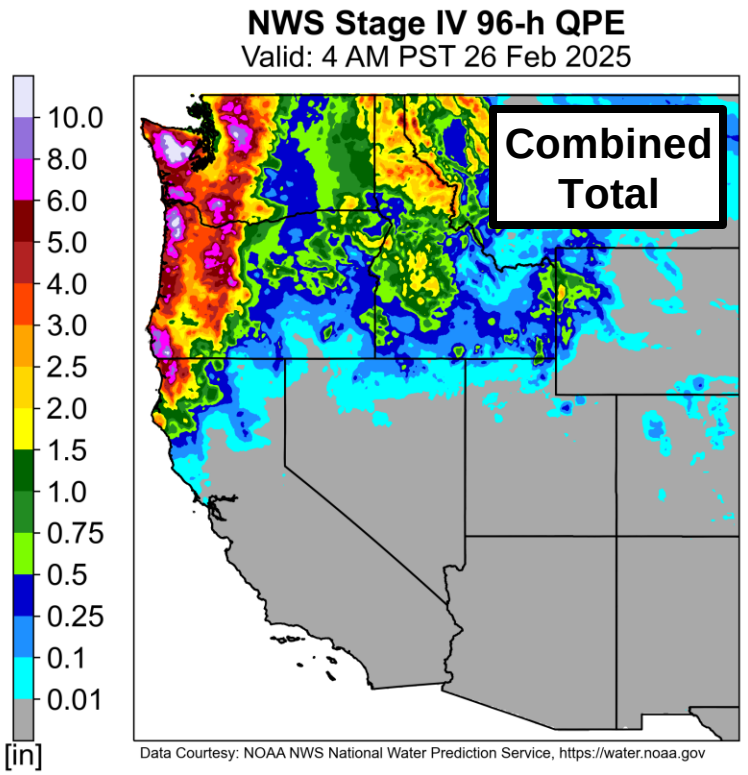
Observed Precipitation







- The first AR produced 4–8 inches of precipitation in portions of the Olympic Mountains, Cascades, Oregon Coast Ranges, and Del Norte County, CA, as well as 0.5–2 inches of precipitation in eastern Washington and much of western Idaho.
- The heaviest precipitation from the second AR and low-pressure system was primarily limited to coastal Washington and northwestern Oregon, with as much as 6–8 inches in the Olympic Mountains.
- Total 4-day precipitation across both storms exceeded 10 inches in the Olympic Mountains.

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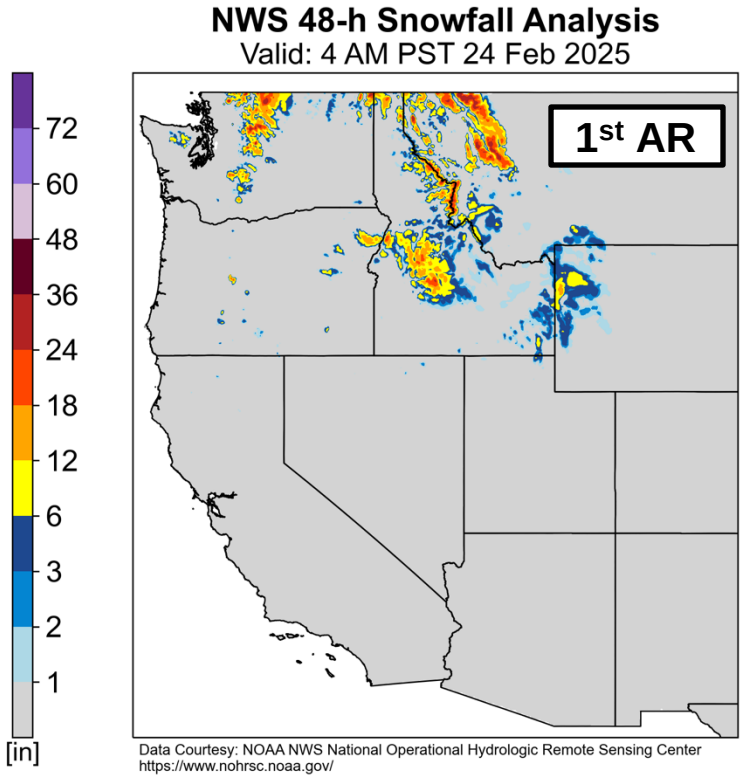
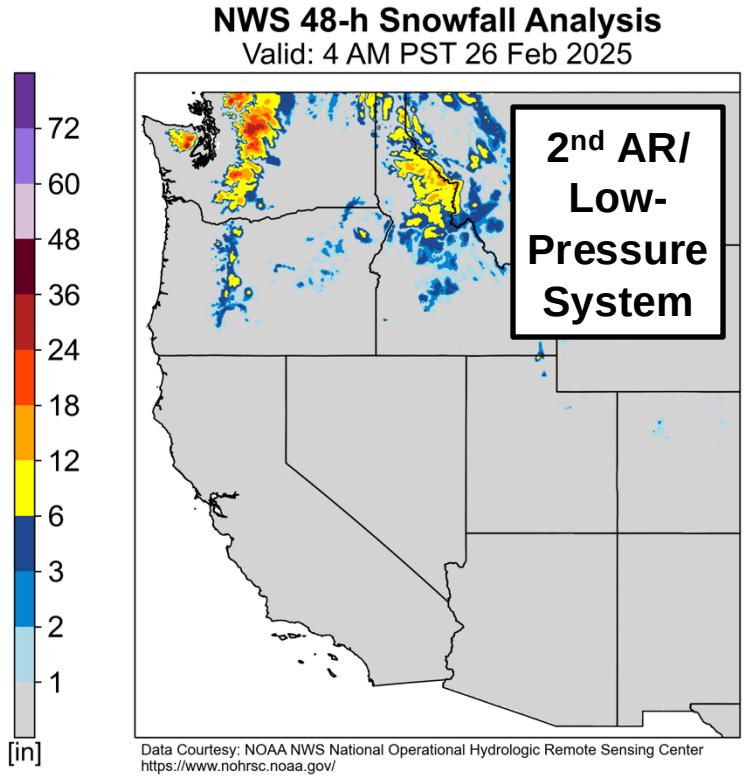
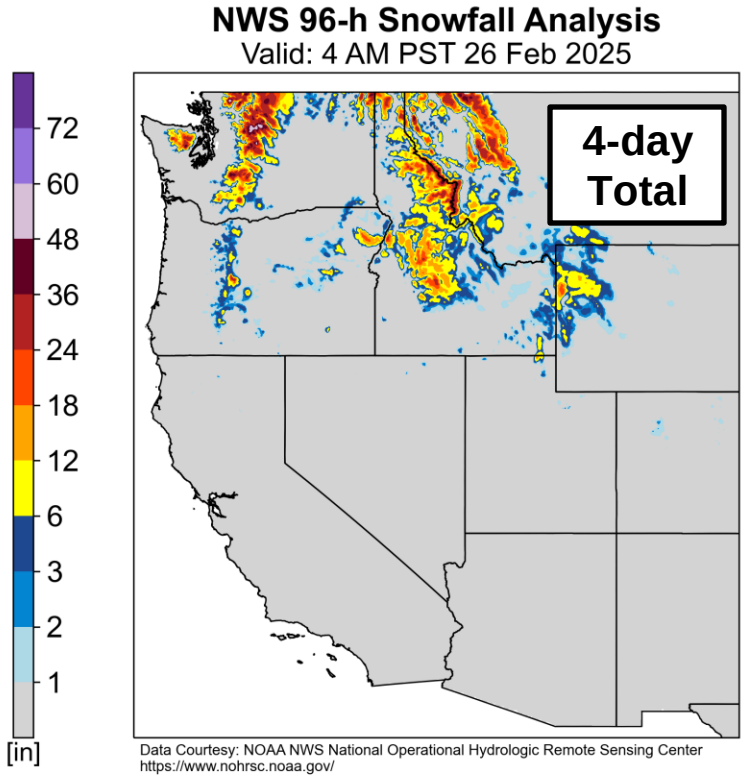
Observed Snowfall







- Due to high freezing levels, snowfall accumulations during the first AR were severely limited below 6,000 feet across the entire northwestern US.
- Lower freezing levels during the second storm allowed for significant snowfall accumulations (>12 inches) in the Olympic Mountains and Washington Cascades.
- An estimated 24–48 inches of total snow fell in the highest elevations of the Olympic Mountains, Washington Cascades, Bitterroot Mountains, and northwestern Montana across both storms.

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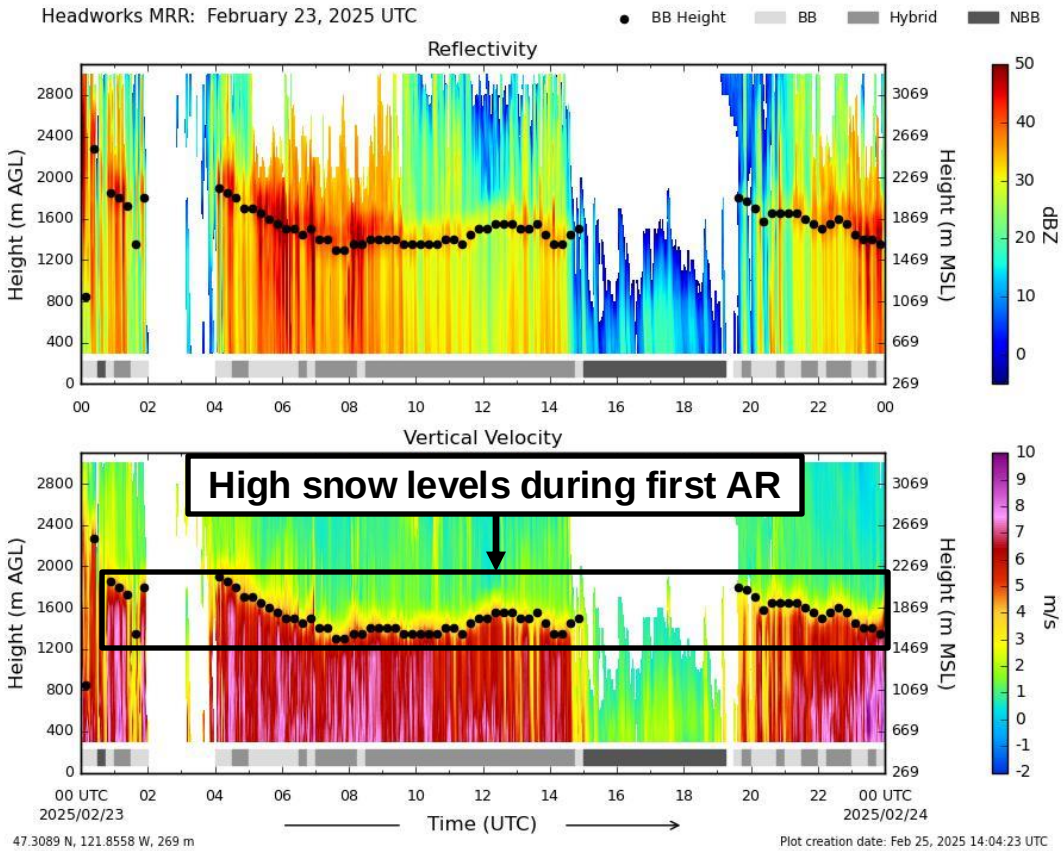
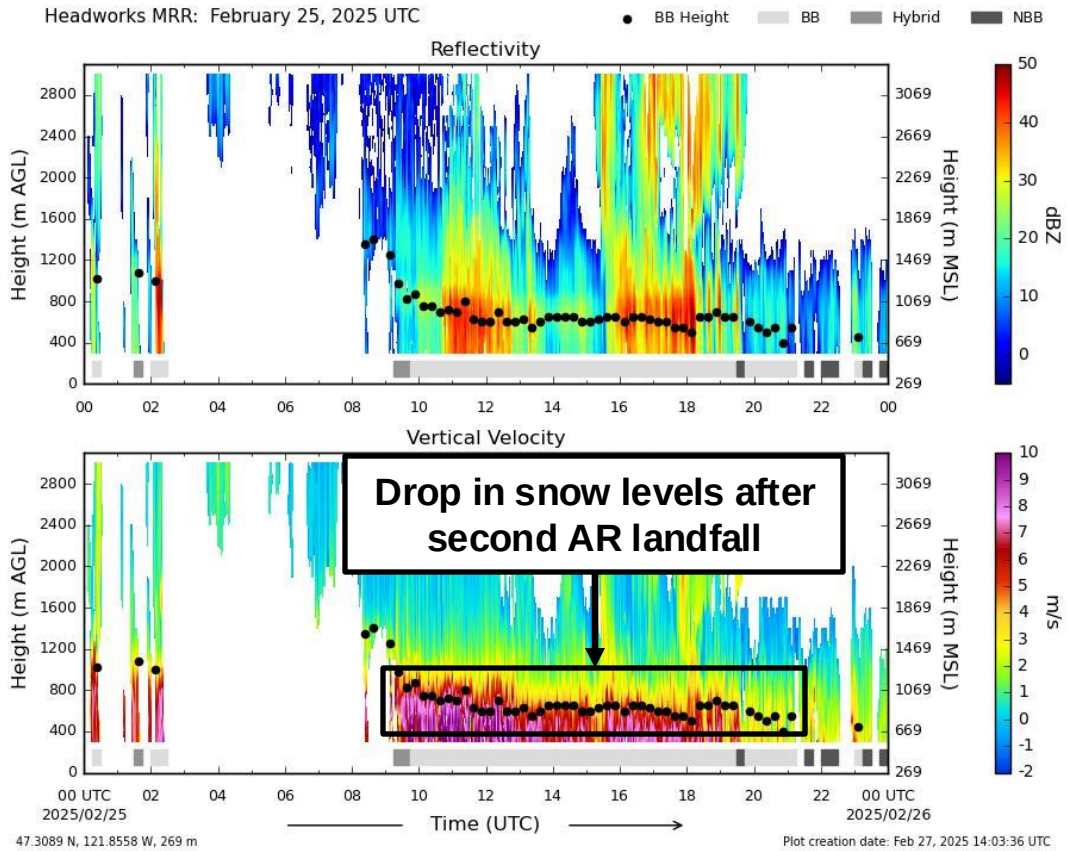
CW3E Observations: Headworks MicroRain Radar





- CW3E's MicroRain Radar (MRR) in the Green River Basin captured the high snow levels during the first AR (indicated by bright band heights between ~5,000 feet and 7,000 feet on Sun 23 Feb).
- The Headworks MRR also captured the drop in snow levels following the passage of a cold front after the second AR landfall (indicated by bright band heights <4,000 feet on Mon 24 Feb).

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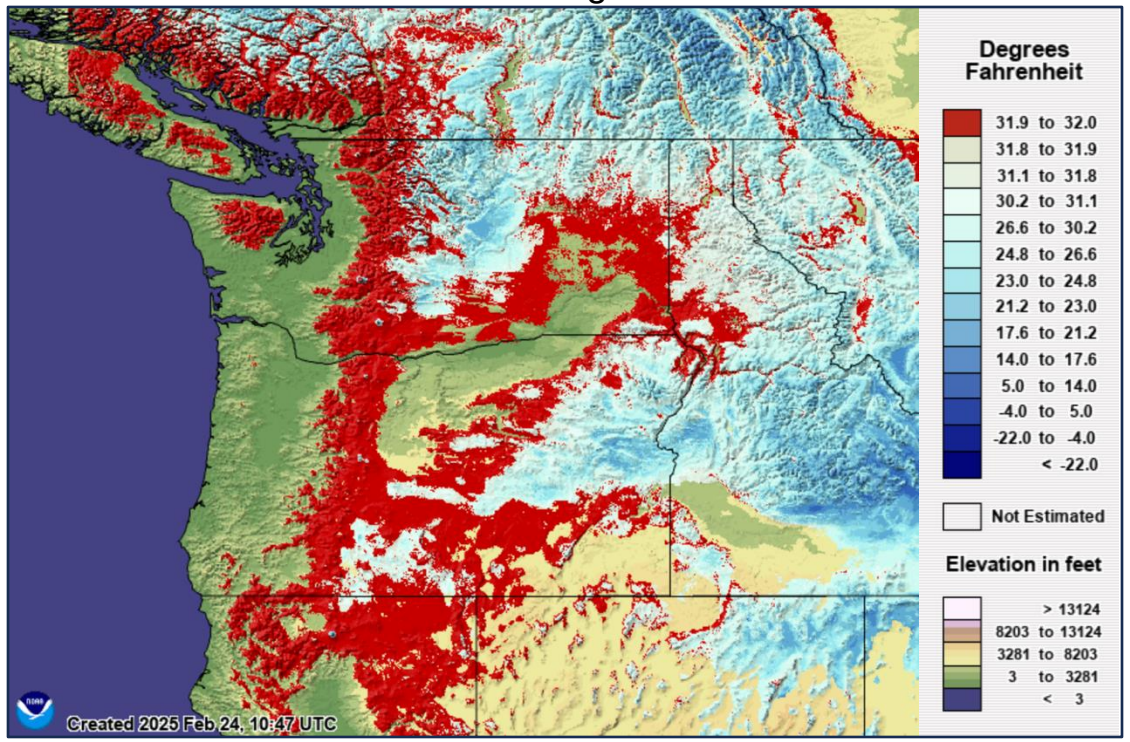
Changes in Snowpack

Modeled Snowpack Temperature

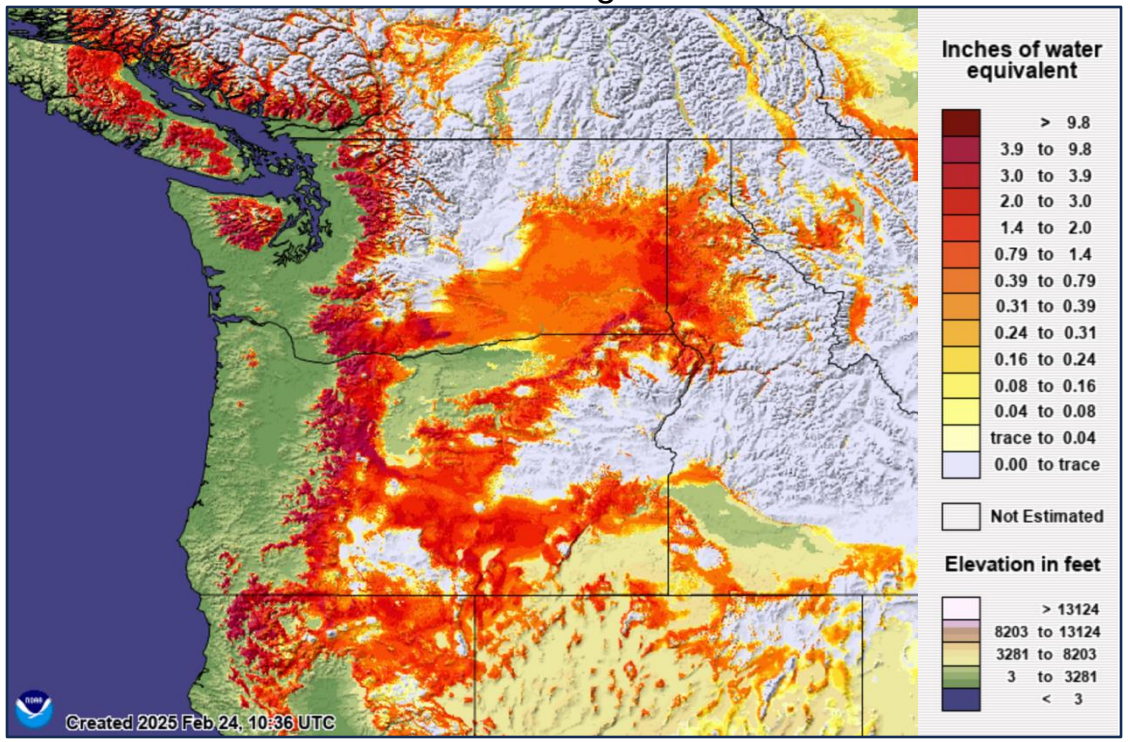
Valid 24-h Period Ending 10 PM PST 23 Feb



Credit: NOAA/NWS National Operational Hydrologic Remote Sensing Center

Modeled Snowmelt

Valid 48-h Period Ending 9 PM PST 23 Feb



Credit: NOAA/NWS National Operational Hydrologic Remote Sensing Center

- Antecedent snowpack conditions (marginal snowpack temperatures and existing snowpack at lower-to-middle elevations) and high freezing levels created favorable conditions for snowmelt and rain-on-snow in the Cascades and portions of the interior Pacific Northwest.
- Modeled snowmelt suggests that these areas saw substantial losses in snowpack during the first AR.

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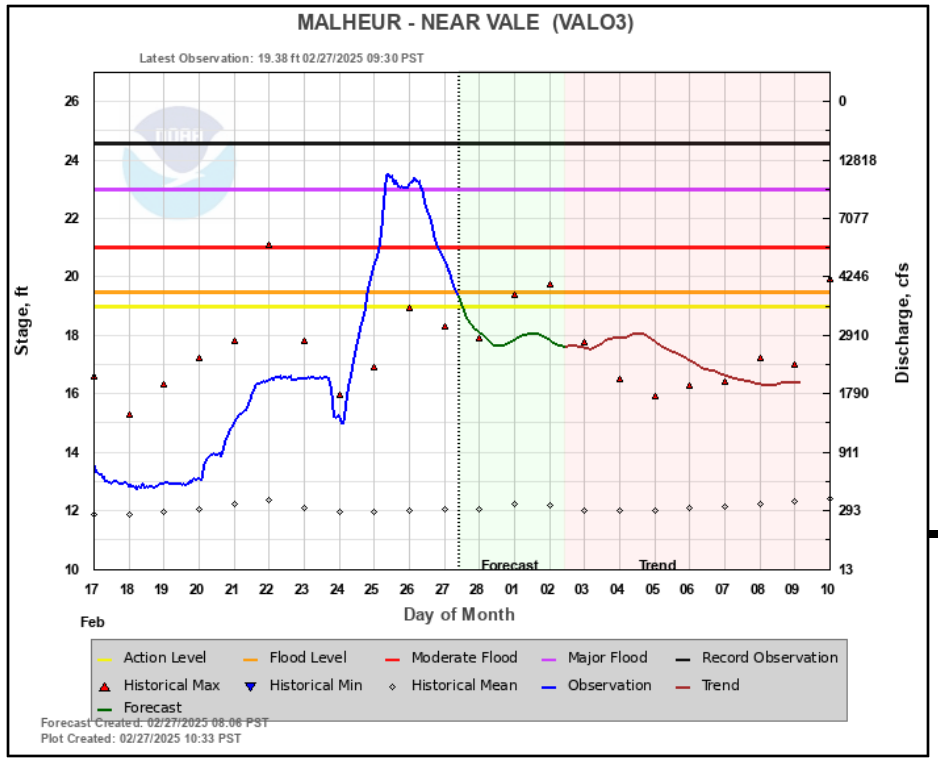
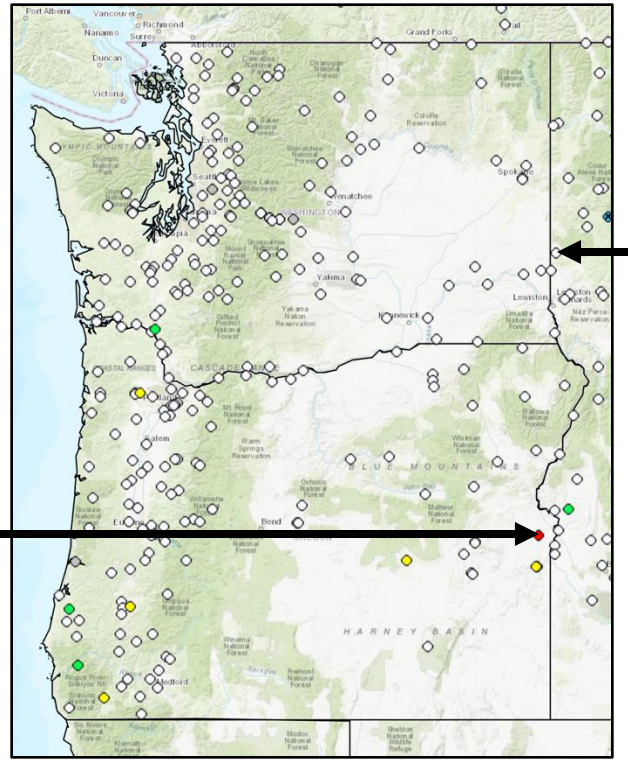
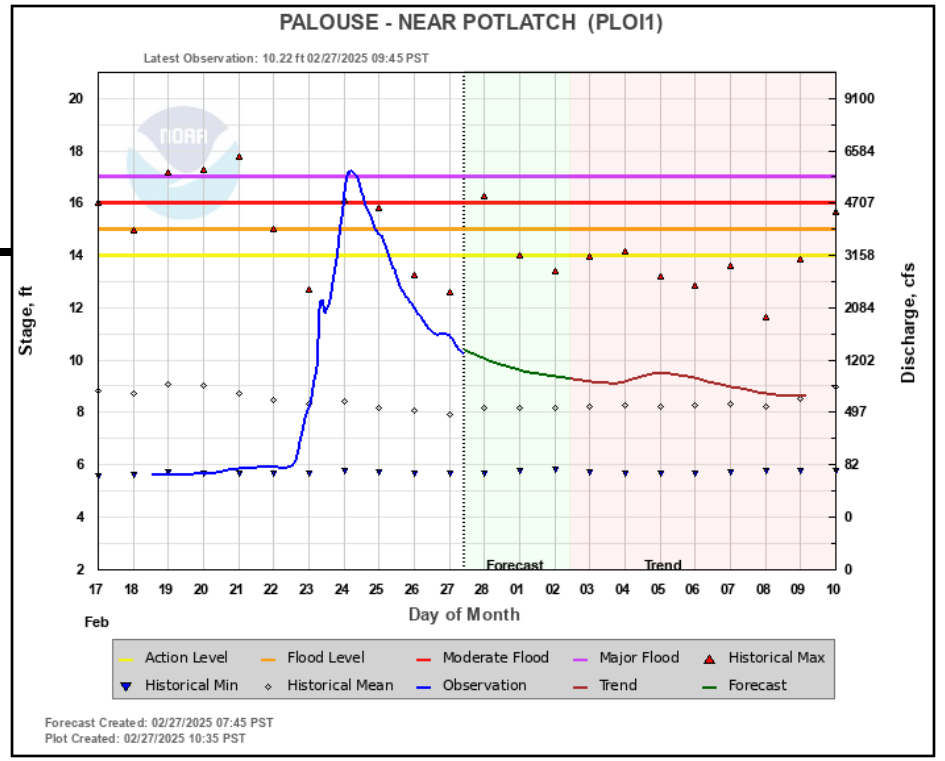
Hydrologic Impacts







Credit: NOAA/NWS Northwest River Forecast Center

- The combination of snowmelt and heavy rain during the first AR resulted in significant riverine flooding in interior portions of the Pacific Northwest.
- The Palouse River near Potlatch, ID (PLOI1), and Malheur River near Vale, OR (VALO3), both exceeded **major flood stage**.
- The peak stage height of 23.55 feet at VALO3 is the 3rd highest peak stage ever recorded at this location (continuous records for peak streamflow date back to WY 1994).

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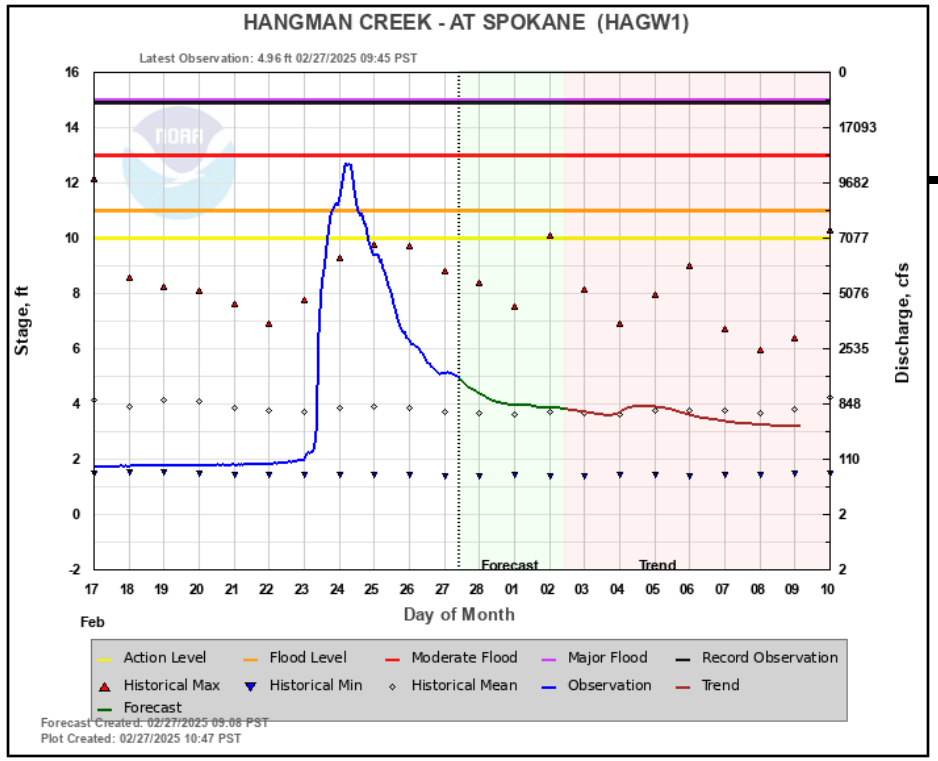
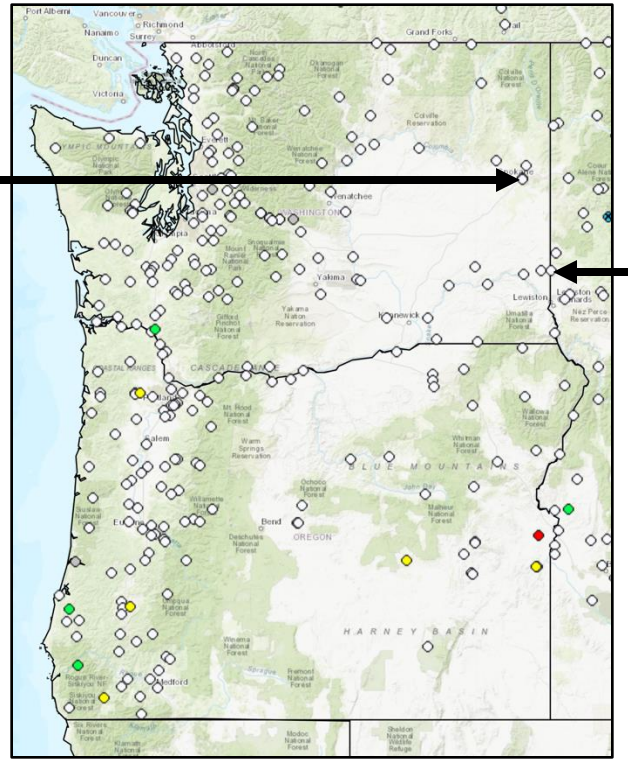
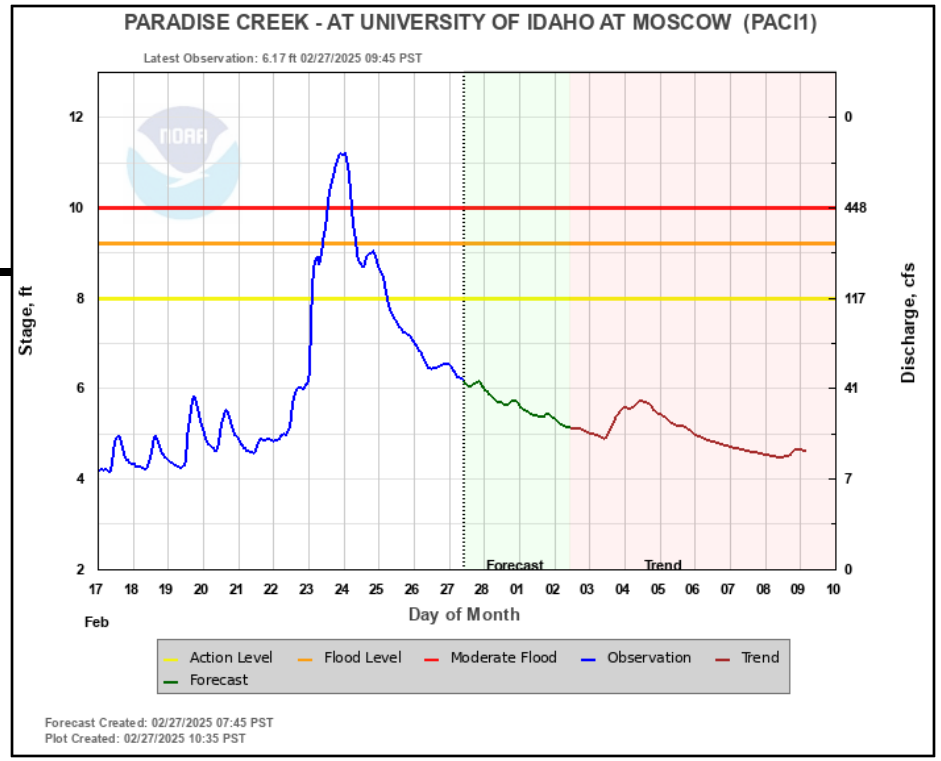
Hydrologic Impacts







Credit: NOAA/NWS Northwest River Forecast Center

- Paradise Creek at the University of Idaho (PACI1) crested above **moderate flood stage**, reaching a peak stage height of 11.21 feet. This is the 3rd highest peak stage ever recorded at this station (records for peak streamflow date back to WY 1979).
- Hangman Creek at Spokane (HAGW1) crested just below **moderate flood stage**, reaching a peak stage height of 12.82 feet. This is the 5th highest peak stage ever recorded at this station (records for peak streamflow date back to WY 1949).

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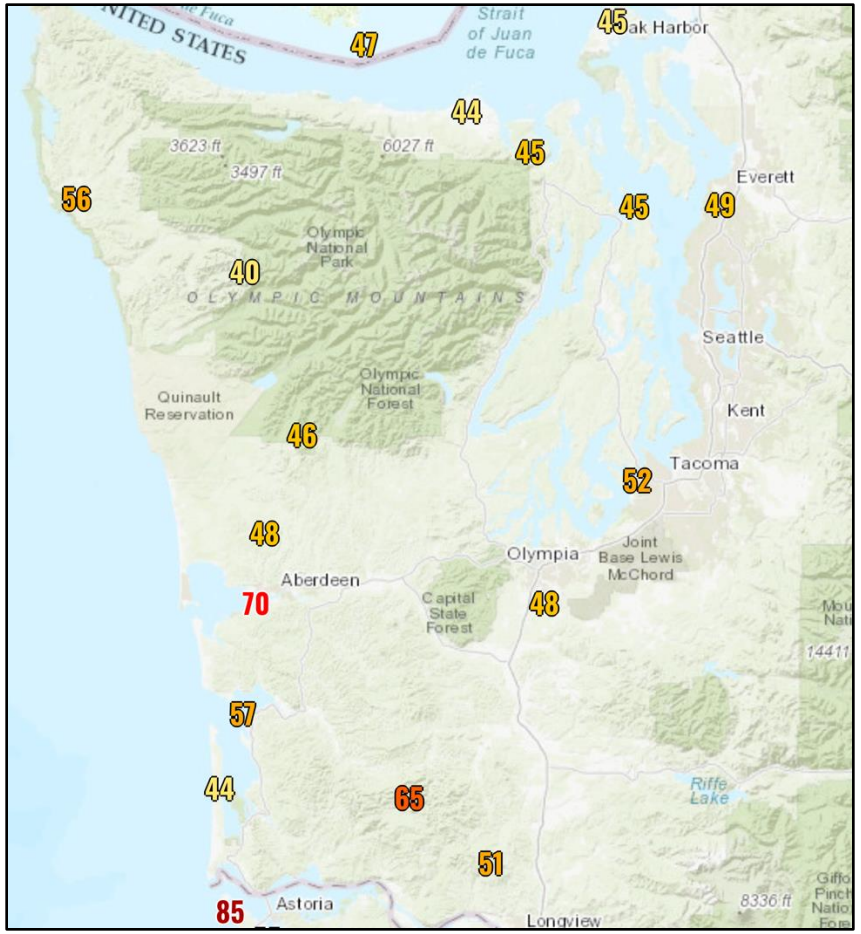
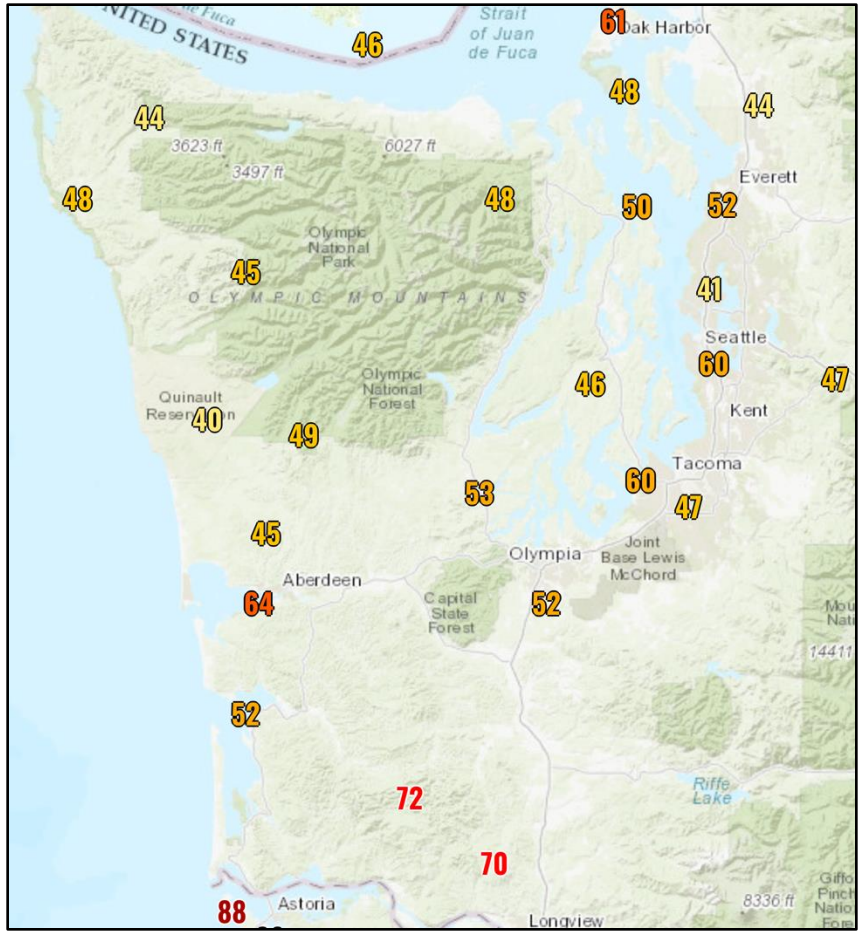
Wind Reports

Max Observed Wind Gust: 24 Feb



Max Observed Wind Gust: 25 Feb



Credit: NOAA/NWS Western Region Headquarters

- As the surface cyclone intensified and approached the Washington coast on Mon 24 Feb, strengthening pressure gradient near the low's center resulted in strong winds over western Washington and Oregon.
- Several airports in western Washington reported wind gusts >50 mph late Mon 24 Feb into early Tue 25 Feb.
- Hoquiam, Bowerman Airport recorded a maximum wind gust of 70 mph and maximum sustained winds of 45 mph around 8 PM PST Mon 24 Feb.

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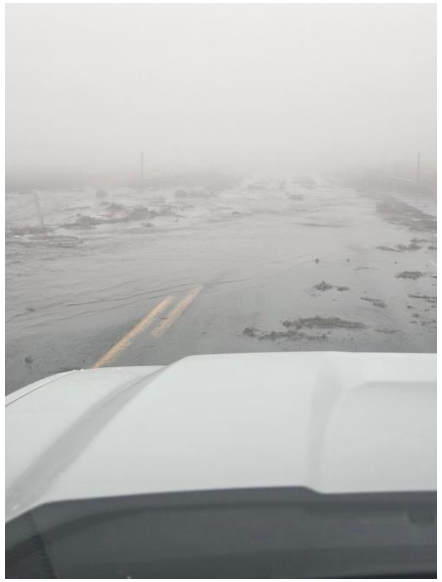
Impacts

- Heavy rain and snowmelt during the first AR caused roadway and property flooding as well as mudslides in eastern Washington.
- Significant flooding along the Malheur River resulted in a 33-mile closure of US 20 in eastern Oregon.
- Strong winds during the second storm caused widespread tree damage and power outages in western Washington and northwestern Oregon.
- At least 200,000 customers lost power in western Washington, with Kitsap County particularly hard hit. At least 90,000 customers lost power in northwestern Oregon.

Flooding on WA SR 231



Credit: Washington State DOT

Flooding on US 20 Along Malheur River

Credit: Oregon DOT

Downed Tree on Vehicle in Port Orchard, WA

Credit: KOMO News

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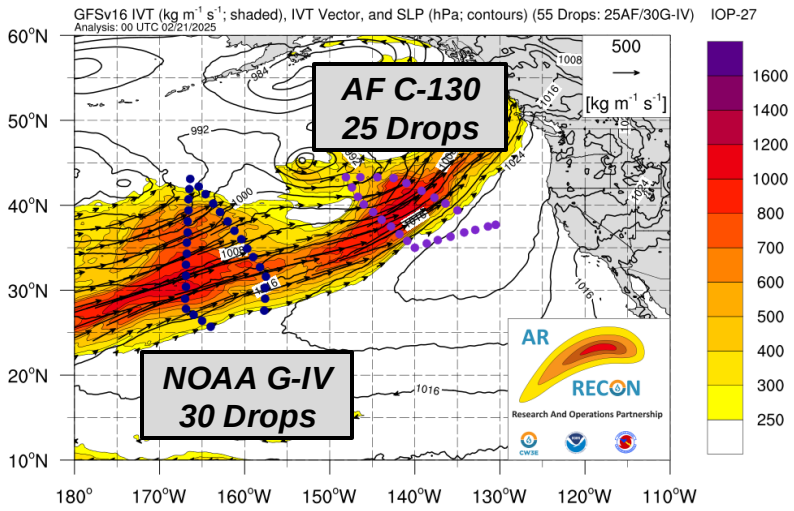
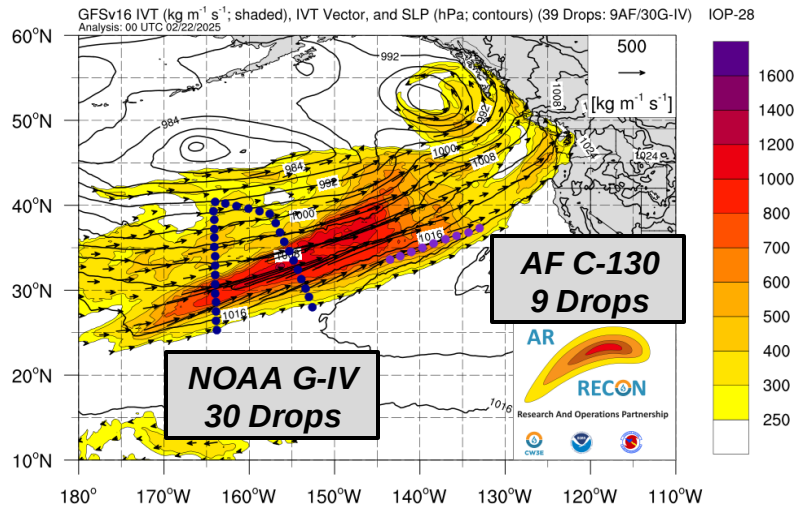
AR Recon Flights

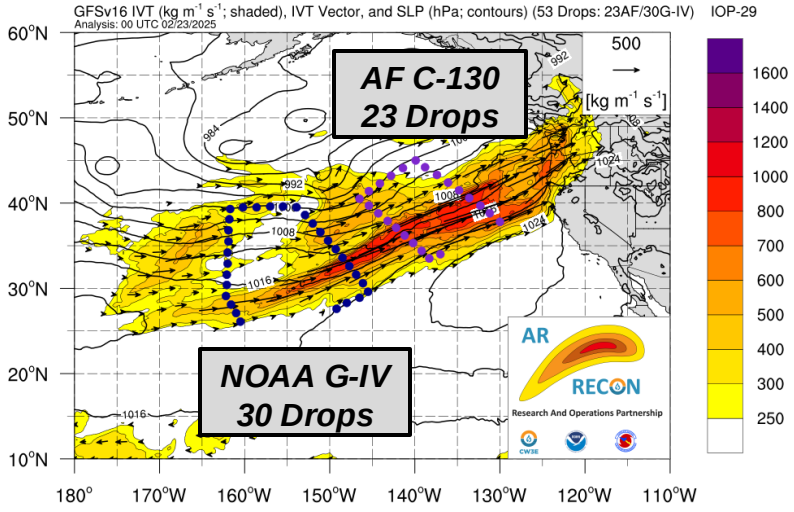
IOP-27: 21 Feb 2025



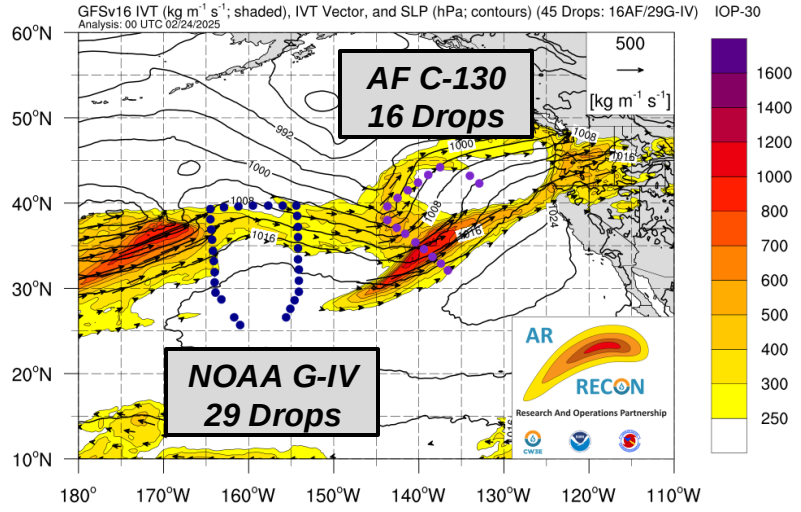
IOP-28: 22 Feb 2025



IOP-29: 23 Feb 2025



IOP-30: 24 Feb 2025



- In coordination with NOAA and the Air Force, CW3E's Atmospheric River Reconnaissance (AR Recon) field campaign successfully carried out a sequence of four IOPs targeting the two ARs, nearby essential atmospheric structures, and regions of forecast sensitivity.
- 192 dropsondes were successfully deployed across four NOAA G-IV flights and four Air Force C-130 flights.
- Data from these flights were assimilated in near-real time into global forecast models and will be archived for future research purposes.

F. Martin Ralph (UCSD/SIO/CW3E) - PI
Vijay Tallapragada (NWS/NCEP) - Co-PI
Anna Wilson (UCSD/SIO/CW3E) - Coordinator