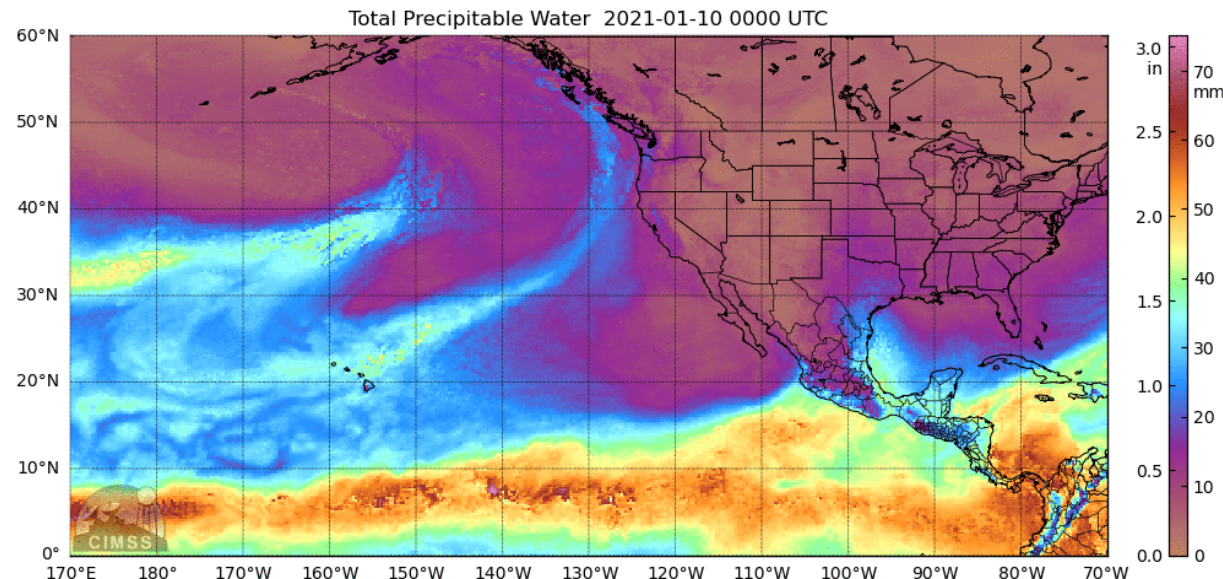


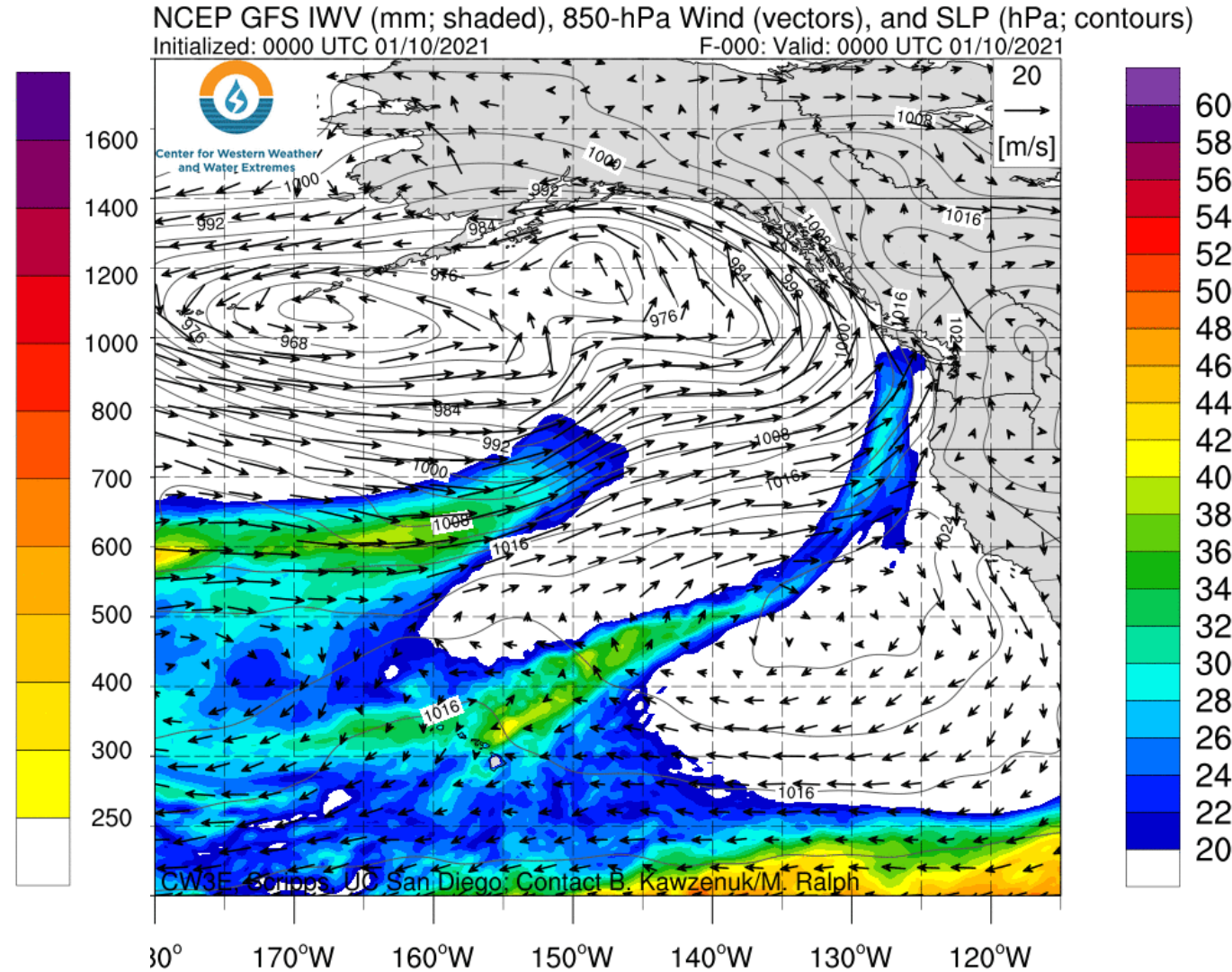
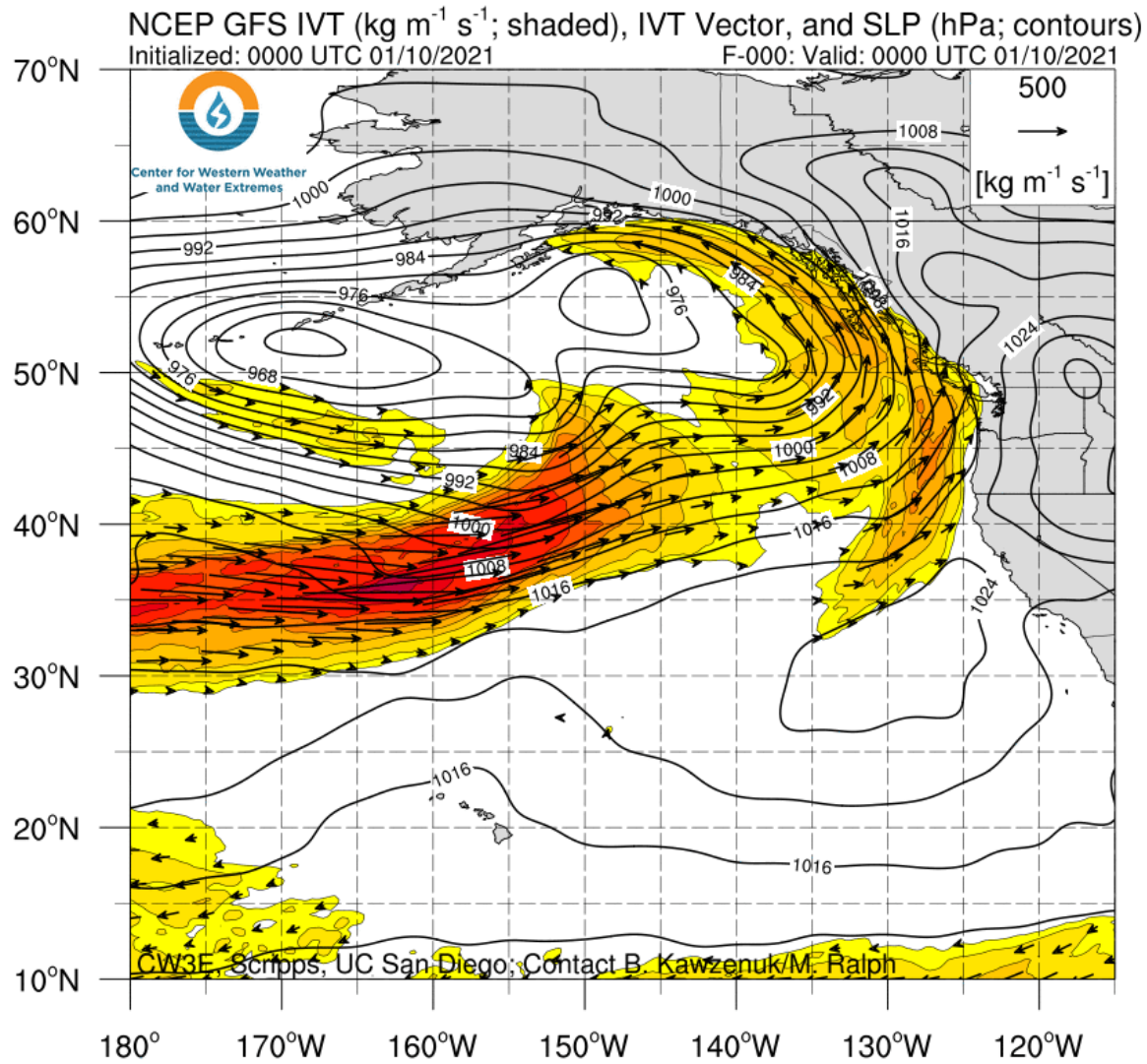
An Extreme Atmospheric River brought AR 5 Conditions and Widespread Hydrologic Impacts to the Pacific Northwest

- The AR initially made landfall at ~00 UTC 12 January and brought an initial pulse of IVT magnitudes $>750 \text{ kg m}^{-1} \text{ s}^{-1}$
- A mesoscale frontal wave (MFW) developed along the northern periphery of the initial AR, strengthened and moved onshore at ~00 UTC 13 January
- The secondary pulse of AR conditions was much stronger than the first ($>1000 \text{ kg m}^{-1} \text{ s}^{-1}$) and helped to prolong the overall duration of the event, resulting in AR 5 conditions
- More than 5 inches of precipitation fell in portions of the Pacific Coast Ranges and Cascades, with the highest amounts (locally >10 inches) in the Olympic Peninsula and extreme northwestern Oregon
- Heavy rainfall on saturated/nearly saturated soils produced widespread flooding and landslides
- High winds also caused significant tree damage and power outages in western WA and northwestern OR



Event Summary: 11–13 Jan 2021

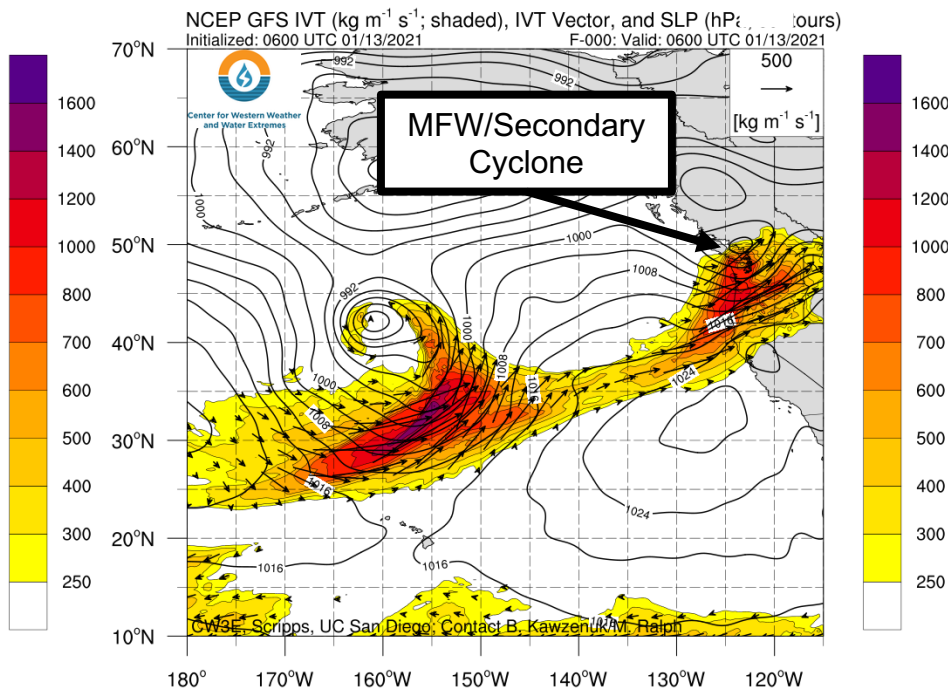
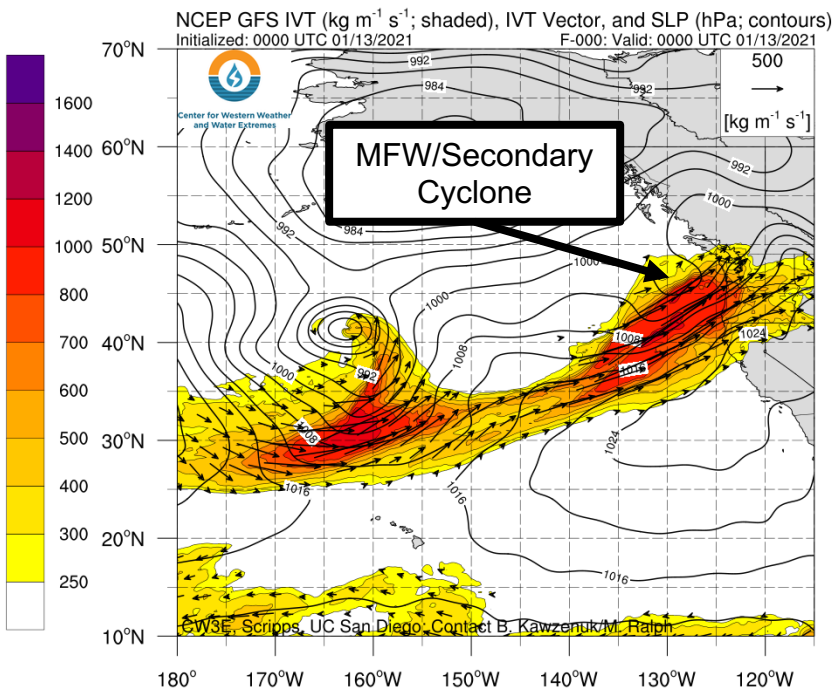
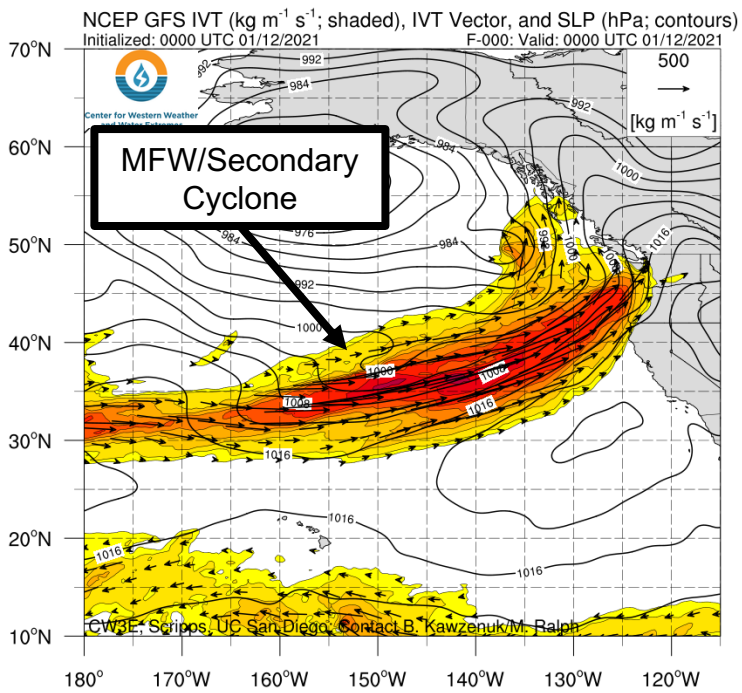
For California DWR's AR Program



Event Summary: 11–13 Jan 2021

For California DWR's AR Program

GFS Analysis



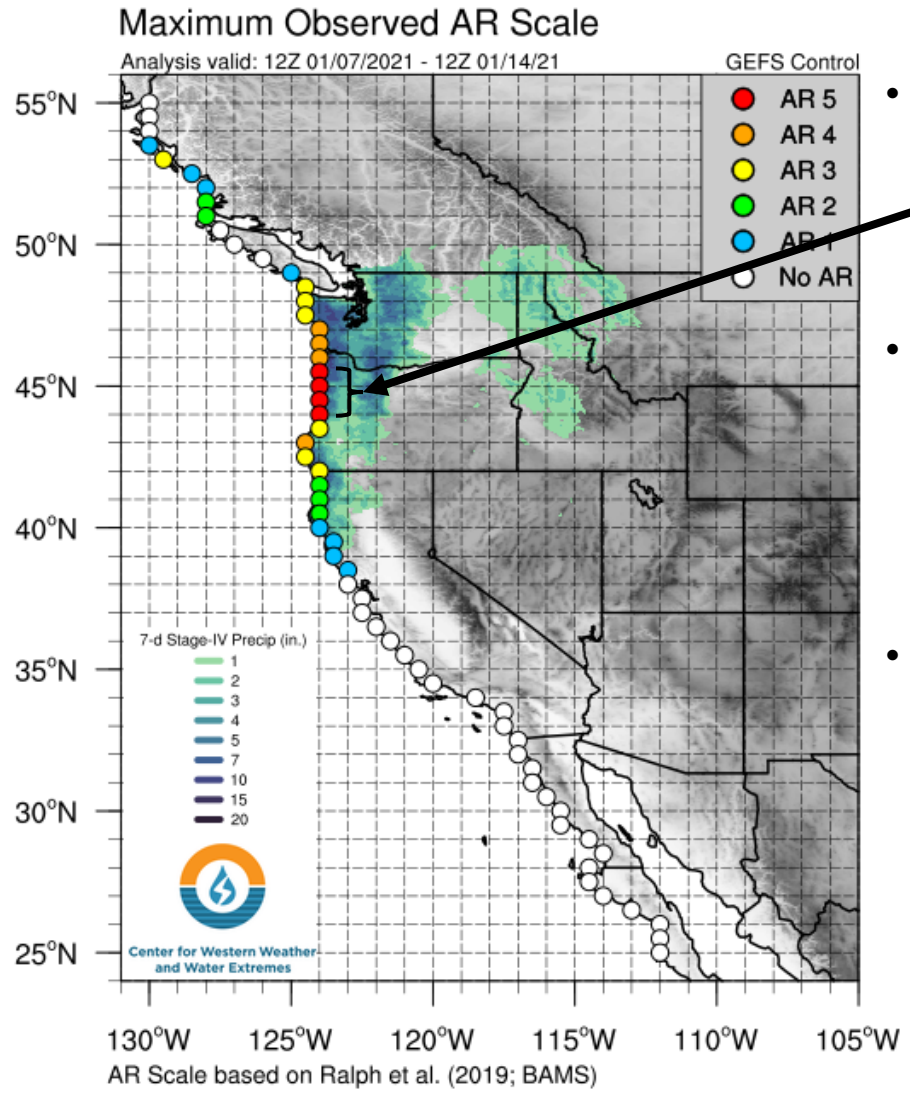
- The AR made landfall over the Pacific Northwest at ~00 UTC 12 January as the mesoscale frontal wave (MFW)/secondary cyclone was forming at ~154°W

- The MFW continued to strengthen before initially making landfall at ~00 UTC 13 January

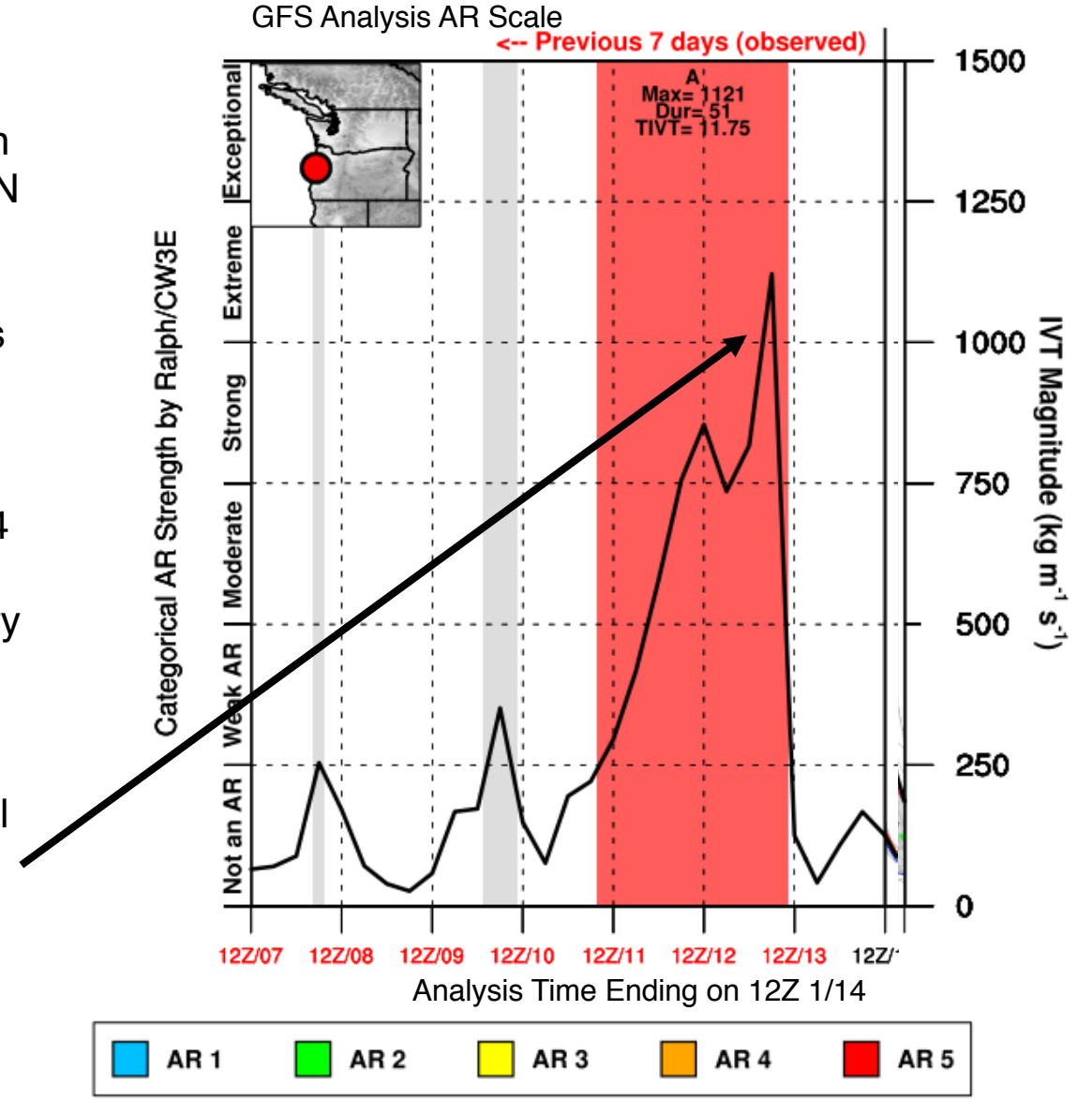
- Six hours later, the MFW became a closed surface low, moved onshore, and brought IVT $>1000 \text{ kg m}^{-1} \text{ s}^{-1}$ to coastal Oregon

Event Summary: 11–13 Jan 2021

For California DWR's AR Program



- Several locations over coastal Oregon from ~44.5 to 45.5°N experienced AR 5 conditions
- Other coastal points from far Northern California to the Olympic Peninsula experienced AR 3–4 conditions
- The MFW/secondary cyclone brought a secondary pulse of extreme IVT >1000 kg m⁻¹ s⁻¹ to coastal Oregon, which lead the AR 5 conditions



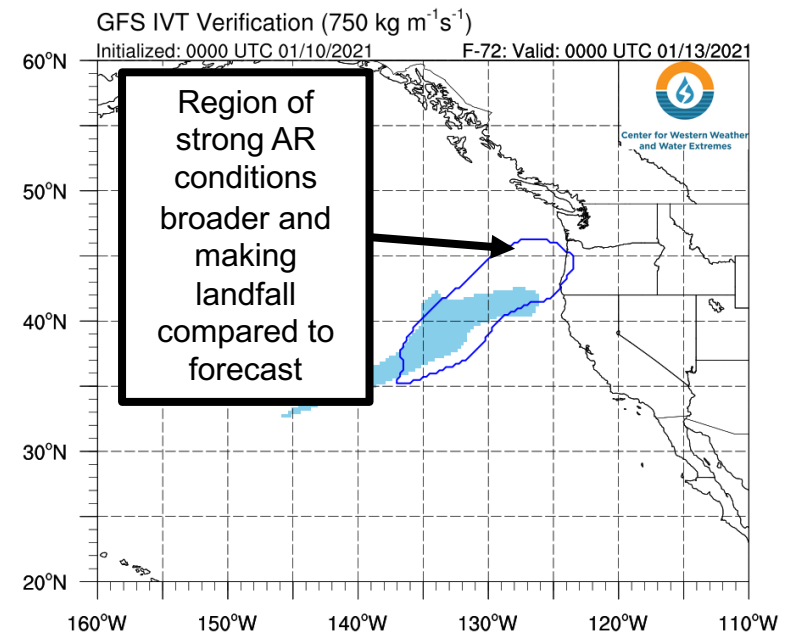
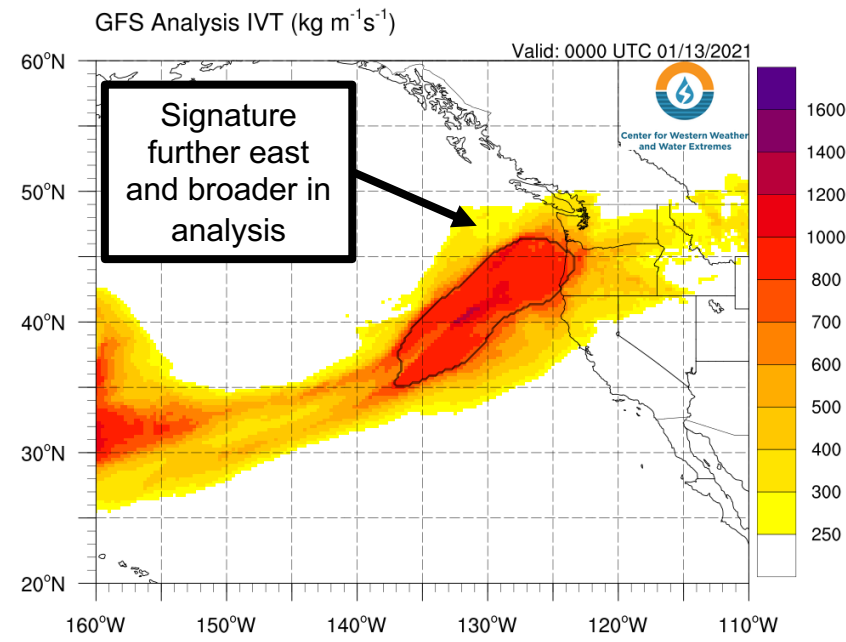
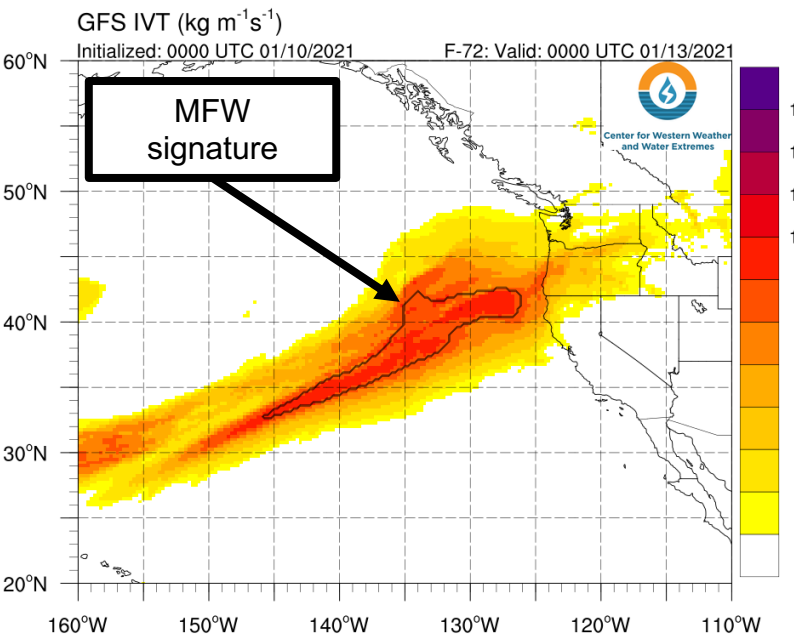
Event Summary: 11–13 Jan 2021

For California DWR's AR Program

72-hour Forecast (Valid: 00 UTC 13 Jan.)

Analysis (F-00)

Forecast and Analysis AR Objects



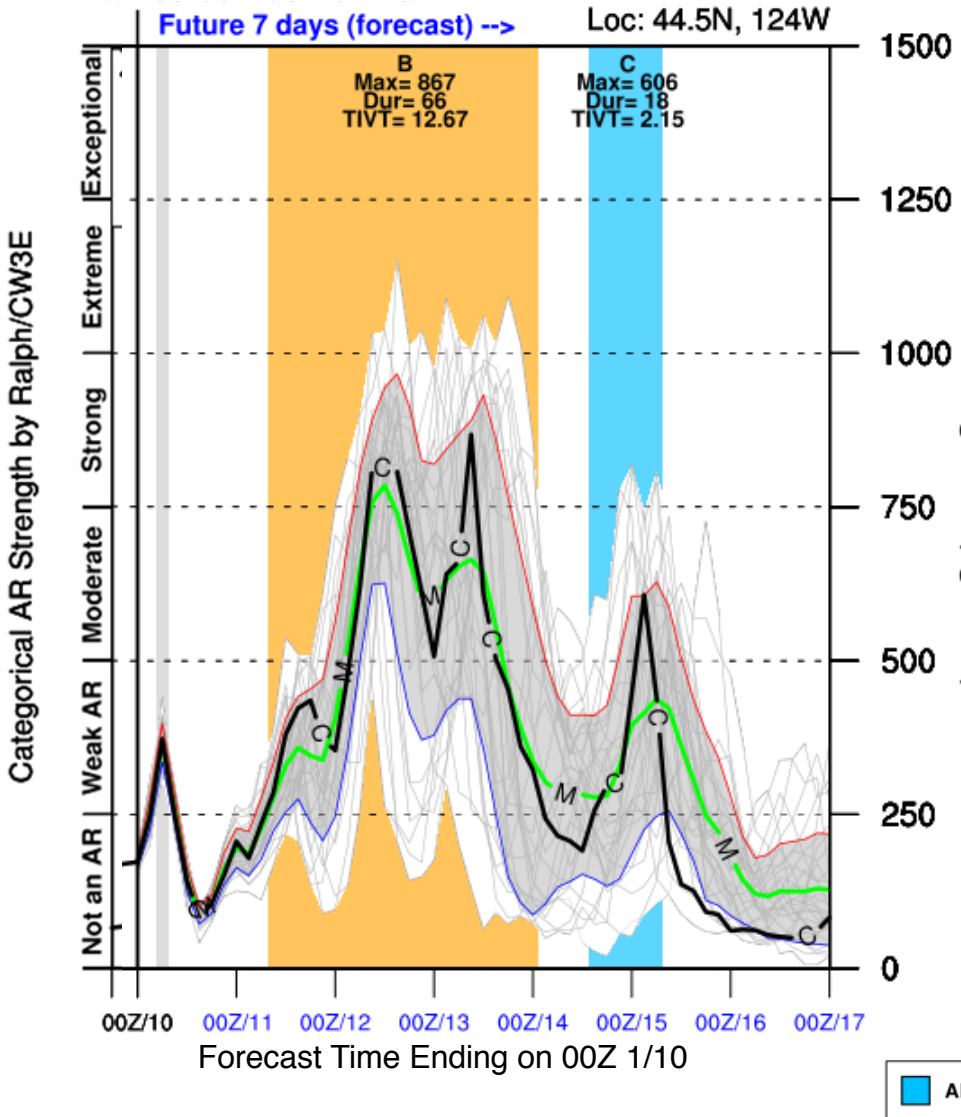
Forecasted objects shaded (unmatched objects in gray)
Observed objects contoured (unmatched objects in black)

- While the GFS was able to forecast the formation of an MFW within the AR, the overall strength and progression of the MFW and subsequent AR were not forecast well
- The 72-hour forecast initialized at 00 UTC 10 January and Valid 00 UTC 13 January suggested the MFW would be centered around 42°N and 135°W, while analysis shows the MFW made landfall at this time
- The forecasts of the MFW also had a much narrower and elongated region of strong AR conditions ($IVT > 750 \text{ kg m}^{-1} \text{ s}^{-1}$) compared to analysis

Event Summary: 11–13 Jan 2021

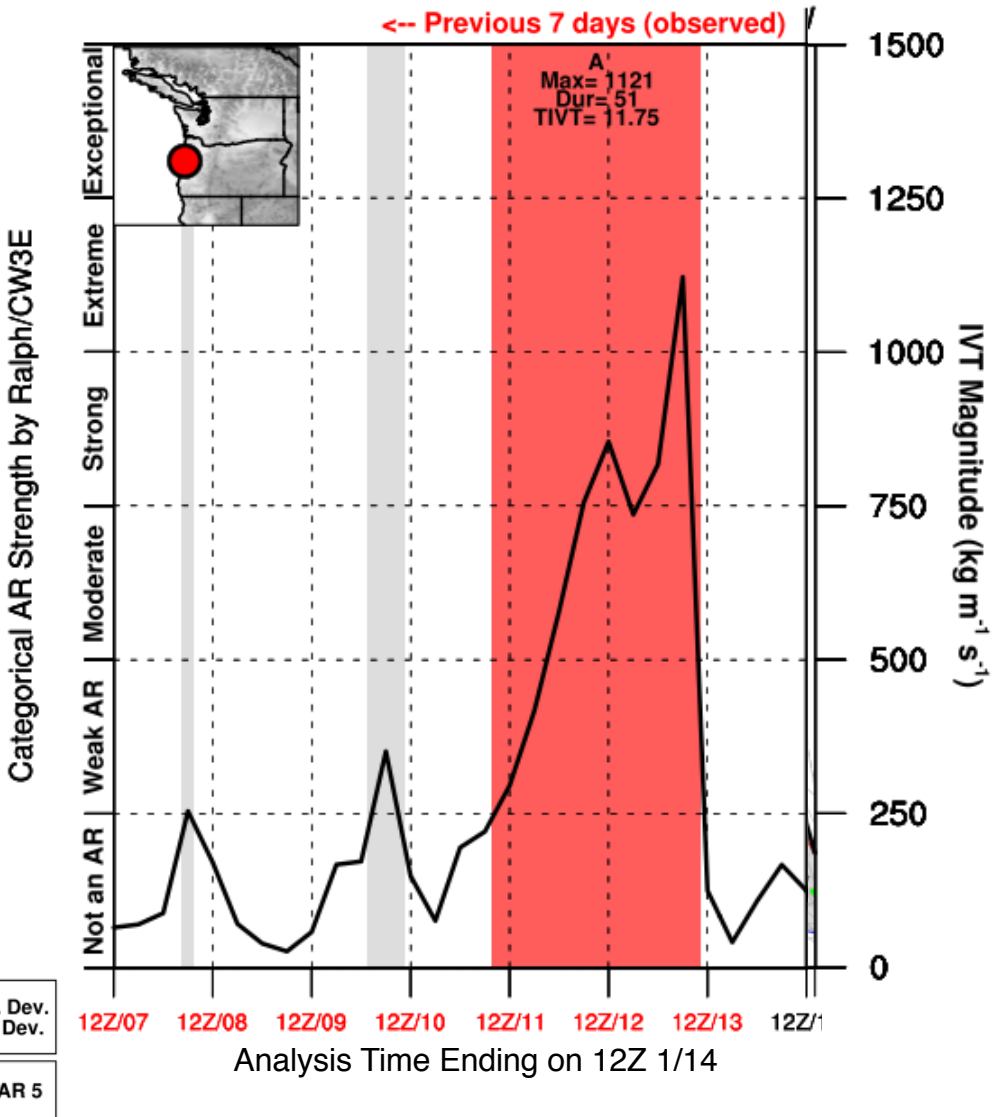
For California DWR's AR Program

GEFS Forecast IVT and AR Scale



- The misrepresentation of the MFW by the GFS and GEFS led to a large under-forecast of IVT magnitude and AR Scale over Coastal OR
- [Left] 72 hours prior to the MFWs landfall, the GEFS mean was predicting a maximum IVT of $\sim 700 \text{ kg m}^{-1} \text{ s}^{-1}$ and AR 4 conditions at 44.5°N
- [Right] The GFS Analysis shows that the same location experienced a maximum IVT of $1121 \text{ kg m}^{-1} \text{ s}^{-1}$ and AR 5 conditions

GFS Analysis IVT and AR Scale

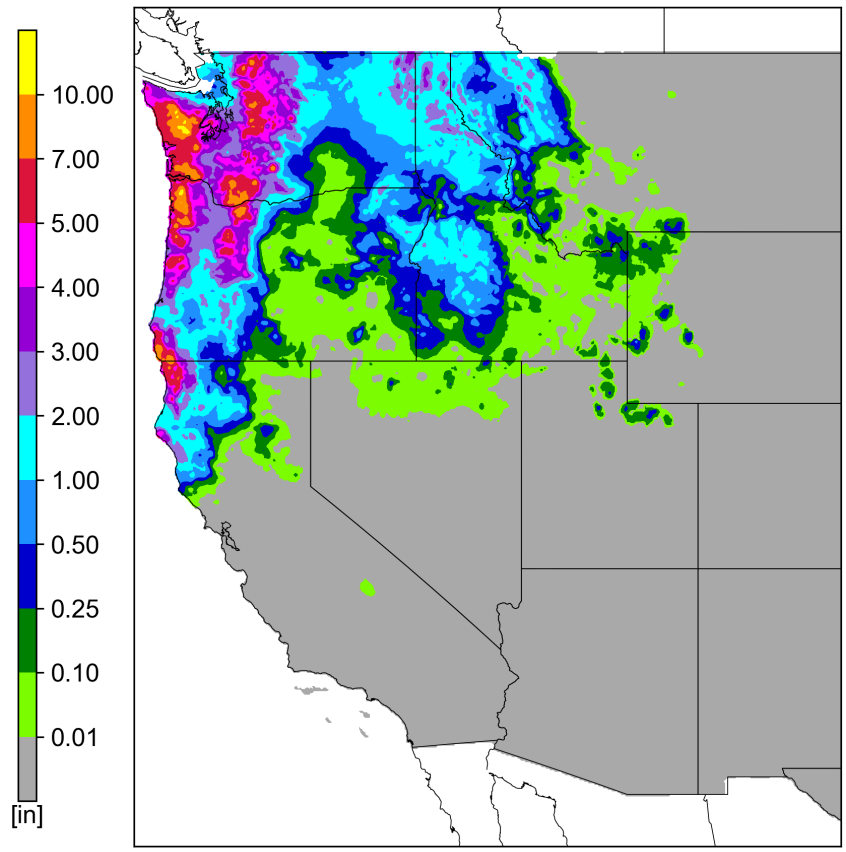


Event Summary: 11–13 Jan 2021

For California DWR's AR Program

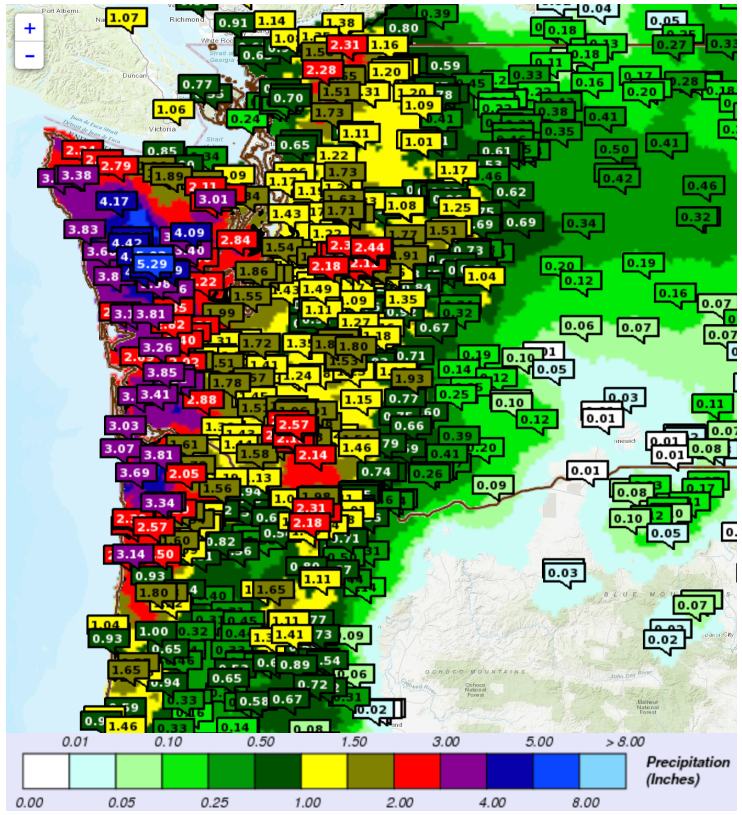
NCEP Stage IV 48-h QPE

Valid: 1200 UTC 11–13 Jan



NWRFC 24-h Observed Precip

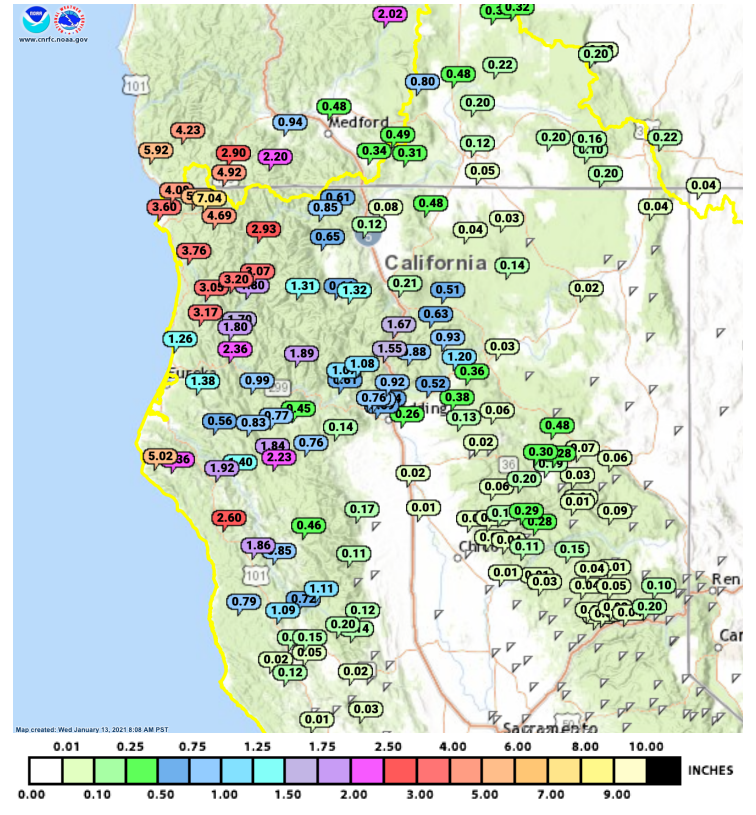
Valid: 1200 UTC 11–12 Jan



Source: NOAA/NWS NWRFC, <https://www.nwrfc.noaa.gov/>

CNRFC 24-h Observed Precip

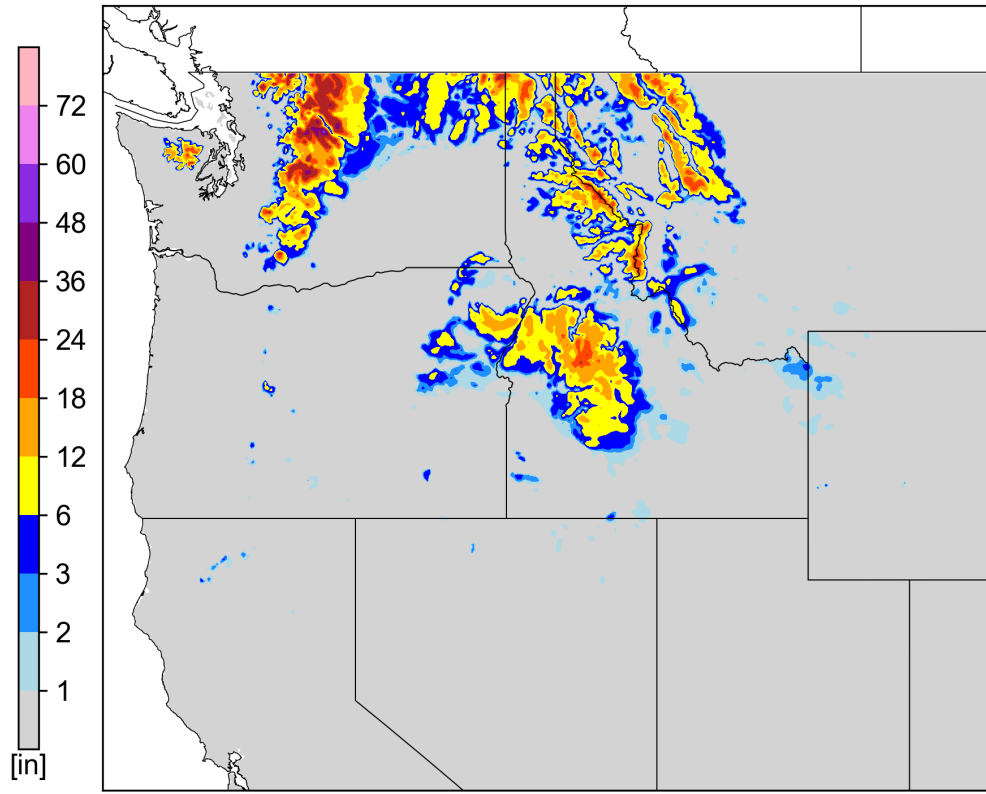
Valid: 1200 UTC 12–13 Jan



Source: NOAA/NWS CNRFC, <https://www.cnrfc.noaa.gov/>

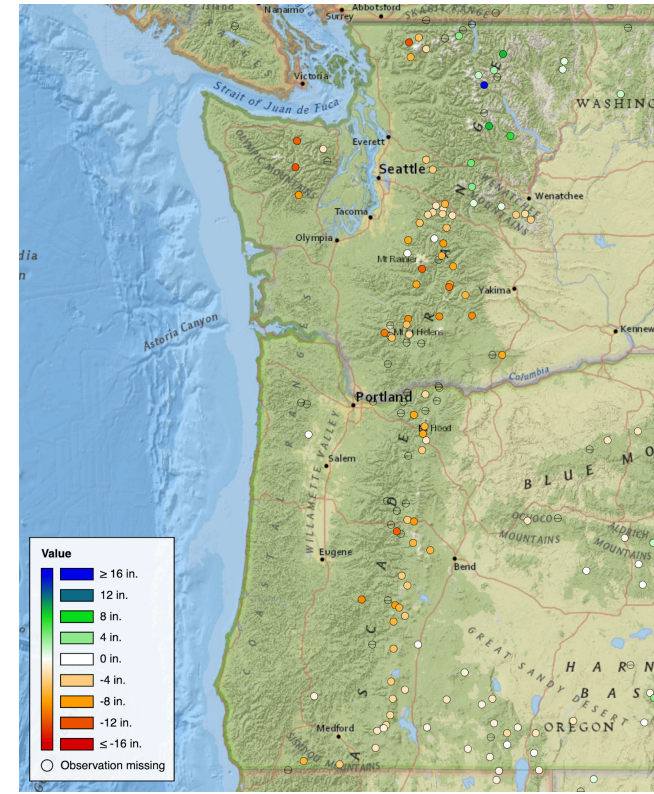
- More than 5 inches of precipitation fell in portions of the Pacific Coast Ranges and Cascades during the 48 hours ending at 1200 UTC (4 AM PST) 13 Jan, with the highest amounts (locally > 10 inches) in the Olympic Peninsula and extreme northwestern Oregon
- The heaviest precipitation during the first 24-h period occurred in western Washington and northwestern Oregon
- The heaviest precipitation during the second 24-h period occurred in extreme southwestern Oregon and northwestern California
- Hoquiam Airport (2.32 inches on 11 Jan) and Olympia Airport (3.04 inches on 12 Jan) set new daily precipitation records

NOHRSC 48-h Interpolated Snowfall Valid: 1200 UTC 11–13 Jan



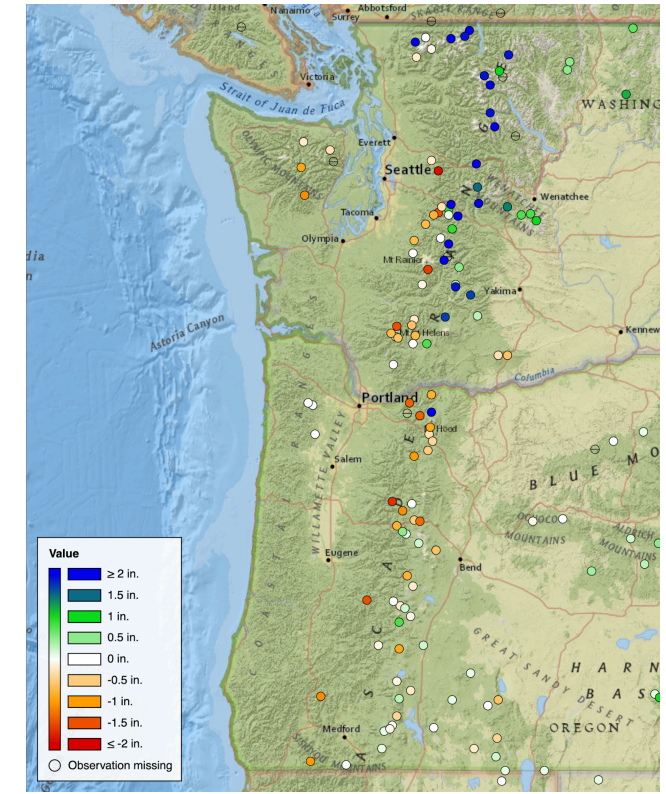
Source: NOAA/NWS NOHRSC, <https://www.nohrsc.noaa.gov/>

Snow Depth Change Valid: 12–13 Jan (Start of Day)



Source: USDA NRCS National Water and Climate Center, <https://www.wcc.nrcs.usda.gov/>

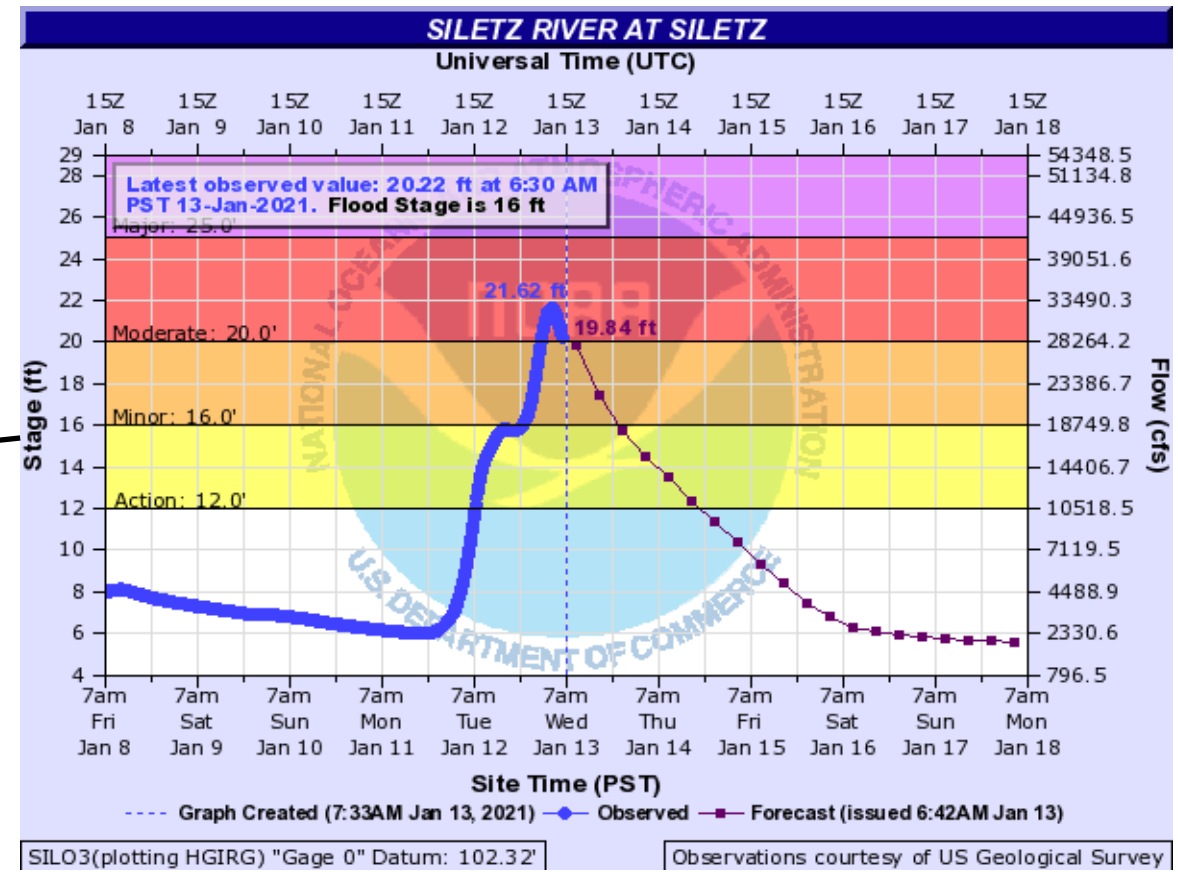
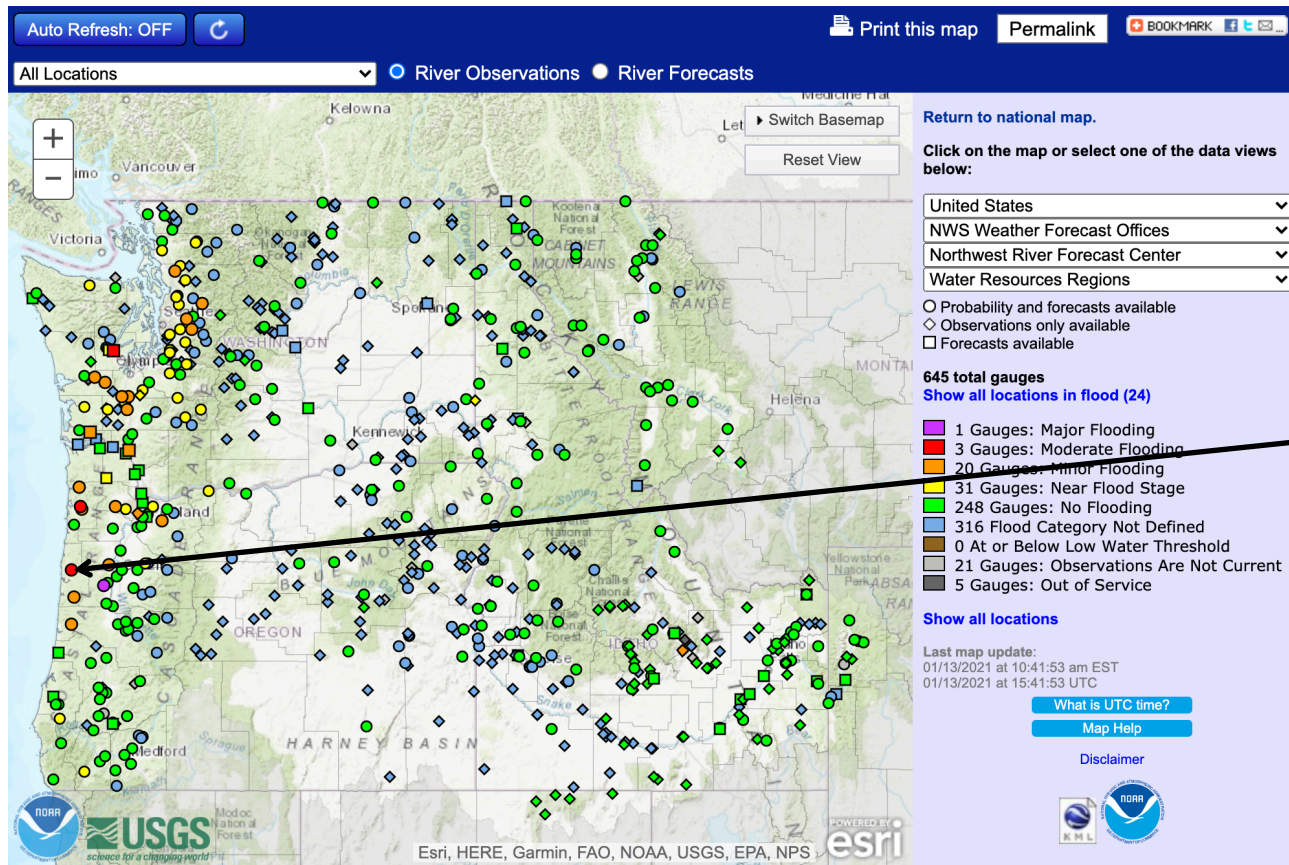
SWE Change Valid: 12–13 Jan (Start of Day)



- Significant snowfall accumulations (1–3 feet) occurred in the higher terrain of the Olympic Mountains, Washington Cascades, Salmon River Mountains, and Bitterroot Mountains
- Snowfall totals below 6,000 ft in the Olympic Mountains and Cascades were limited by rising freezing levels associated with the AR
- While most SNOTEL sites in these areas recorded decreases in snow depth between 12 Jan and 13 Jan, some sites actually recorded large increases in snow water equivalent (SWE) due to the snowpack absorbing water rather than melting and becoming runoff

Event Summary: 11–13 Jan 2021

For California DWR's AR Program

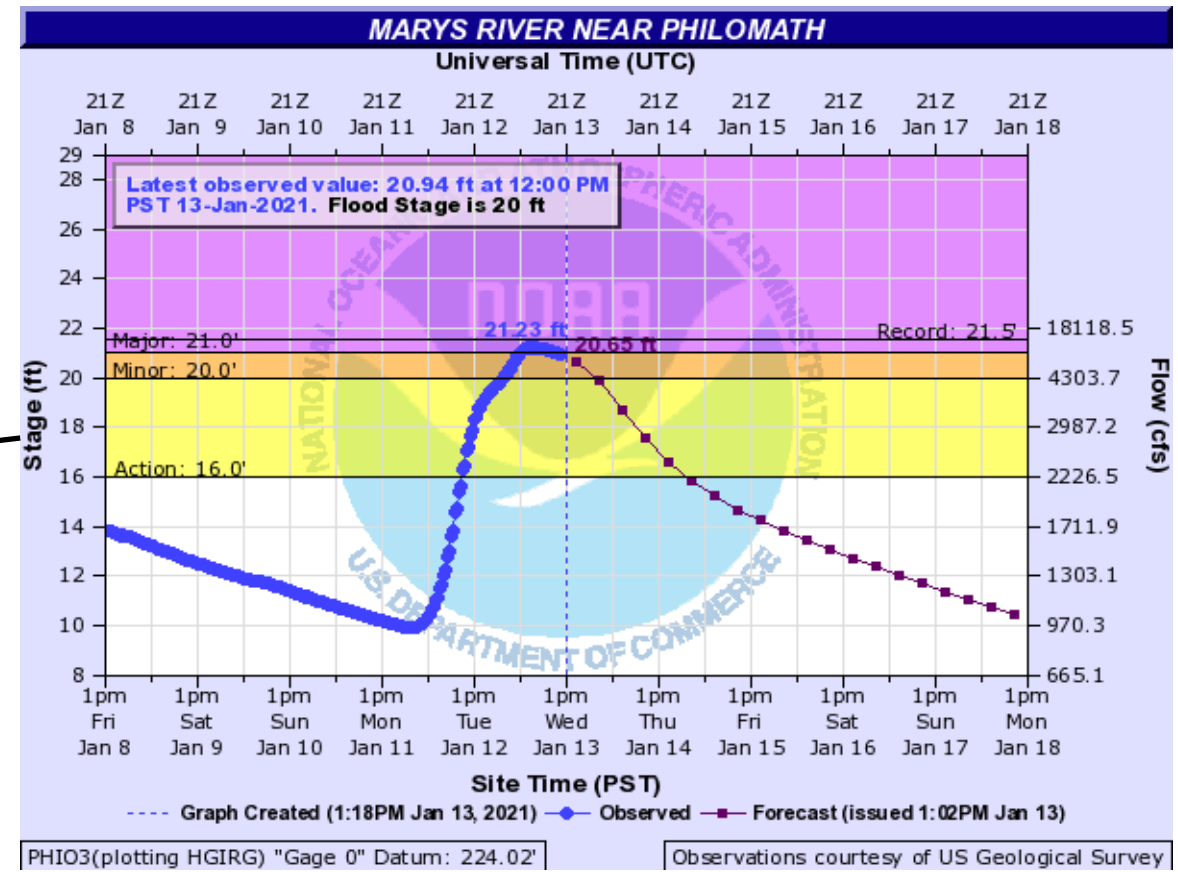
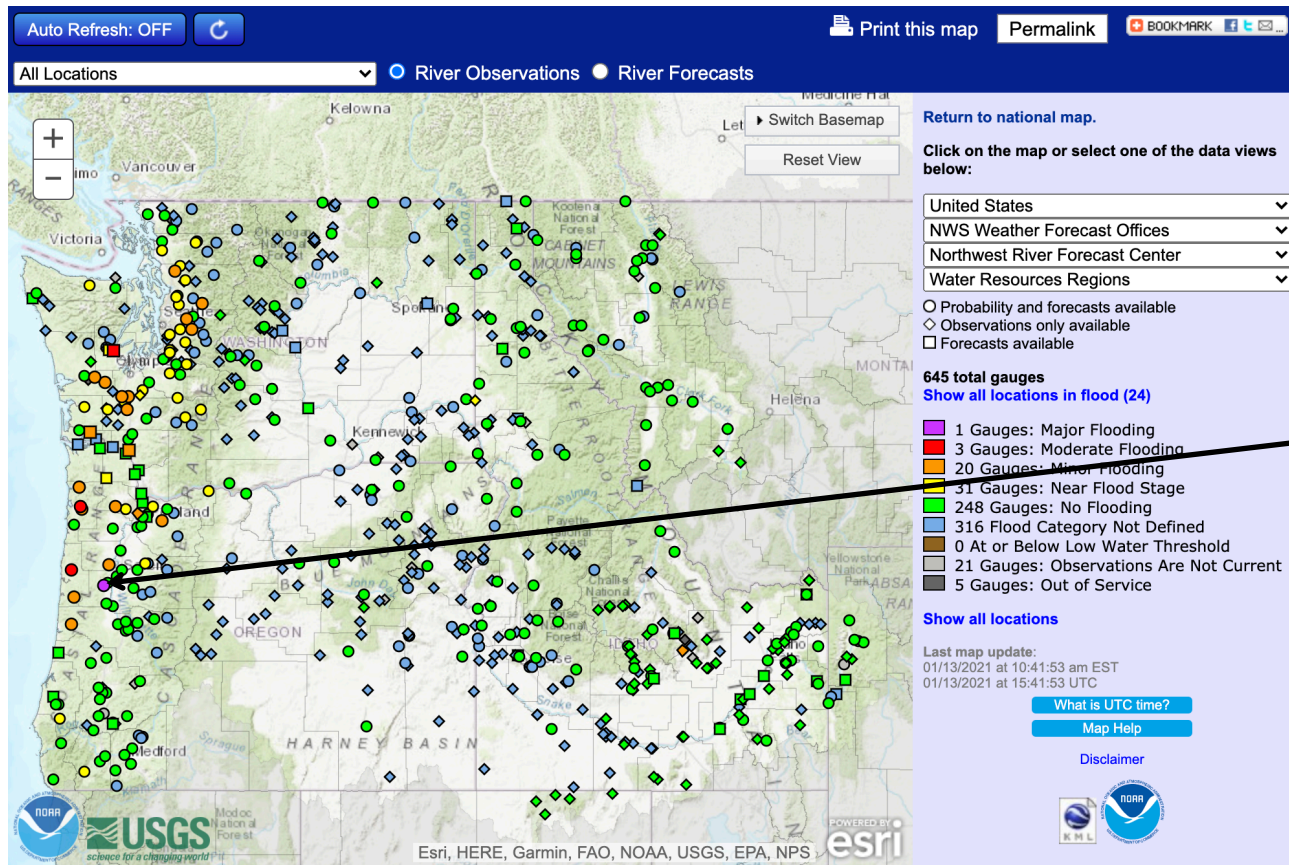


Source: NOAA/NWS Advanced Hydrologic Prediction Service, <https://water.weather.gov/ahps/>

- Heavy precipitation caused widespread riverine flooding in western Washington and Oregon
- The Siletz River (at Siletz, OR) rose nearly 14 feet in 24 hours, reaching a peak stage height of 21.62 ft (moderate flood stage) at 3:30 AM PST on 13 Jan

Event Summary: 11–13 Jan 2021

For California DWR's AR Program



Source: NOAA/NWS Advanced Hydrologic Prediction Service, <https://water.weather.gov/ahps/>

- The Marys River (near Philomath, OR) reached major flood stage shortly after midnight on 13 Jan
- The peak stage of 21.23 ft was the second-highest peak stage ever recorded at this location
- The Skokomish River (near Potlach, WA) recorded its fifth-highest peak stage (17.81 ft)

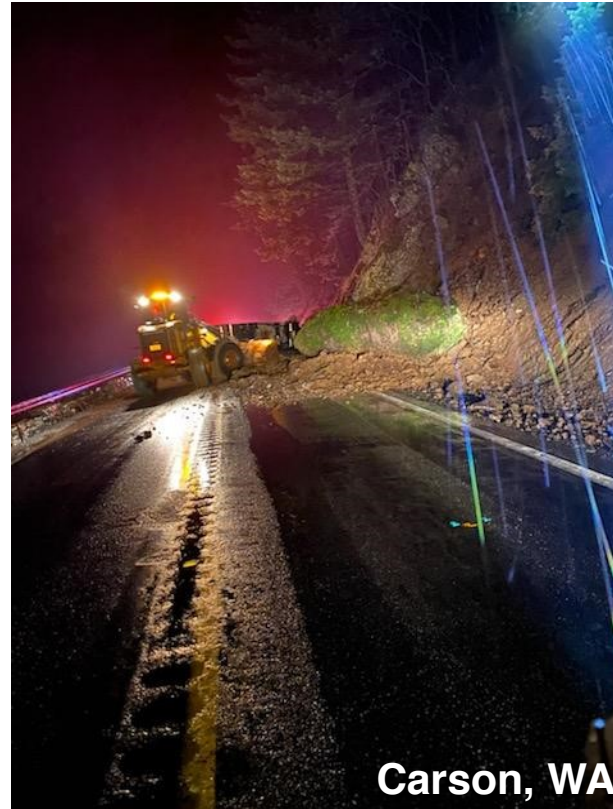
Landslide on I-84



Troutdale, OR

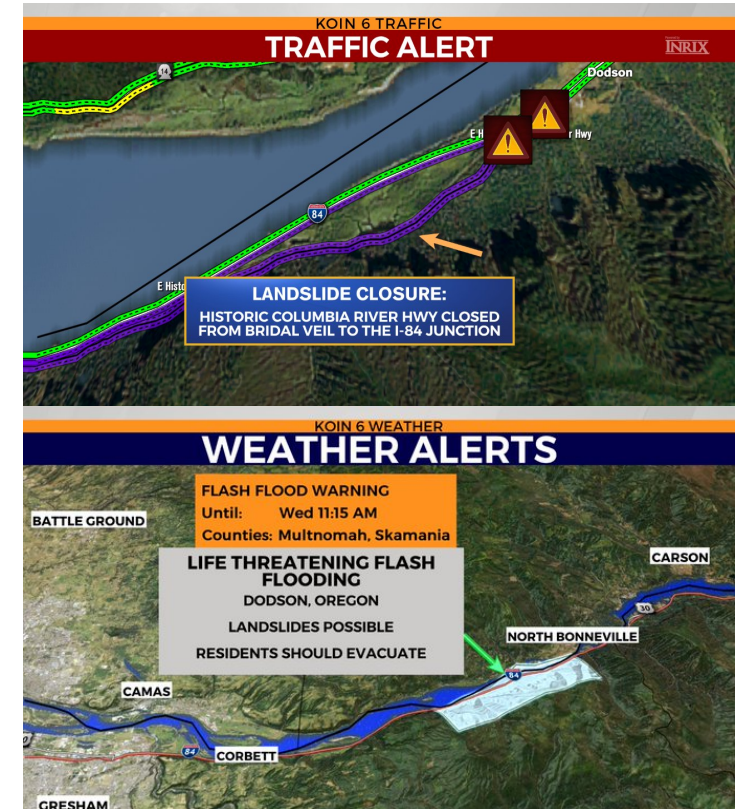
Source: Multnomah County Sheriff's Office, <https://mcsso.us/>

Landslide on SR 14



Carson, WA

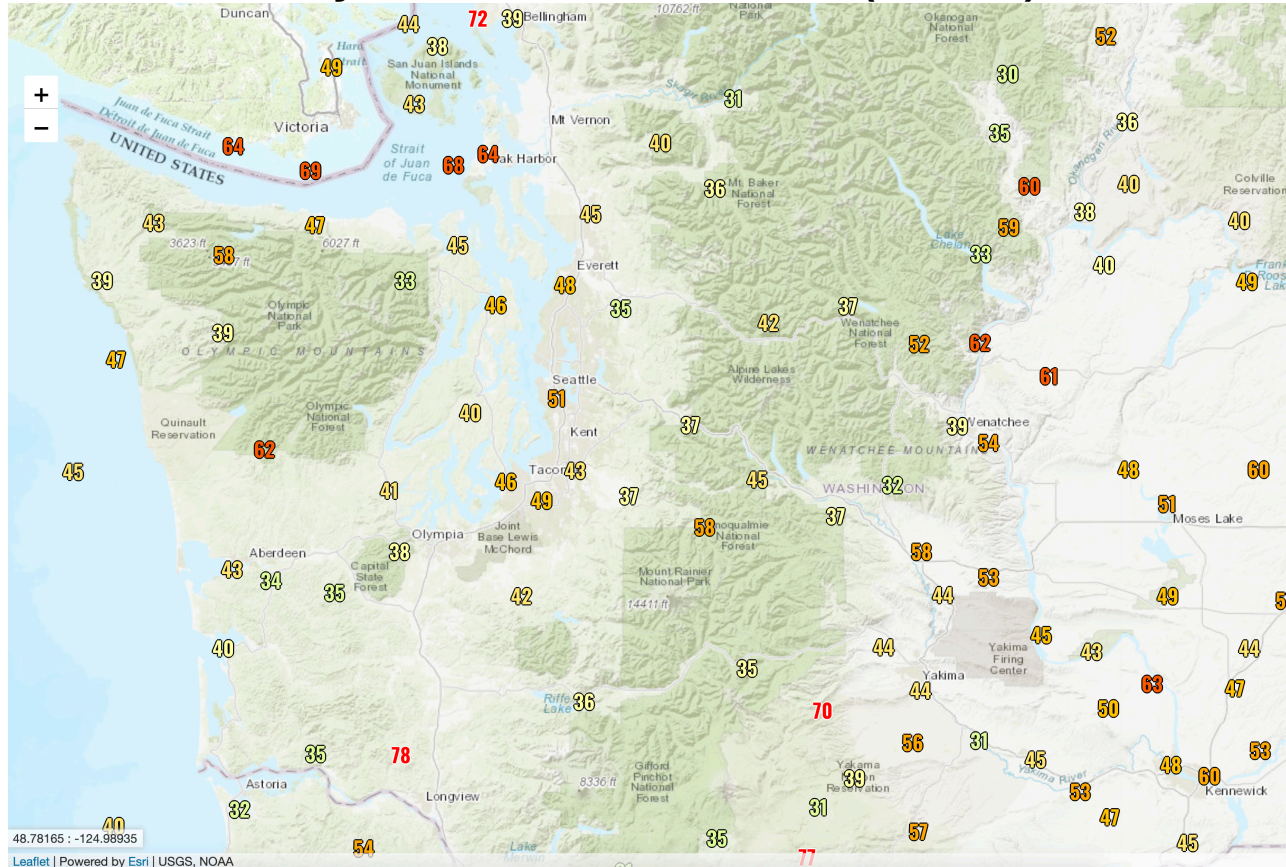
Source: Washington State DOT, <https://wsdot.wa.gov/>



Source: KOIN 6 News, <https://www.koin.com/>

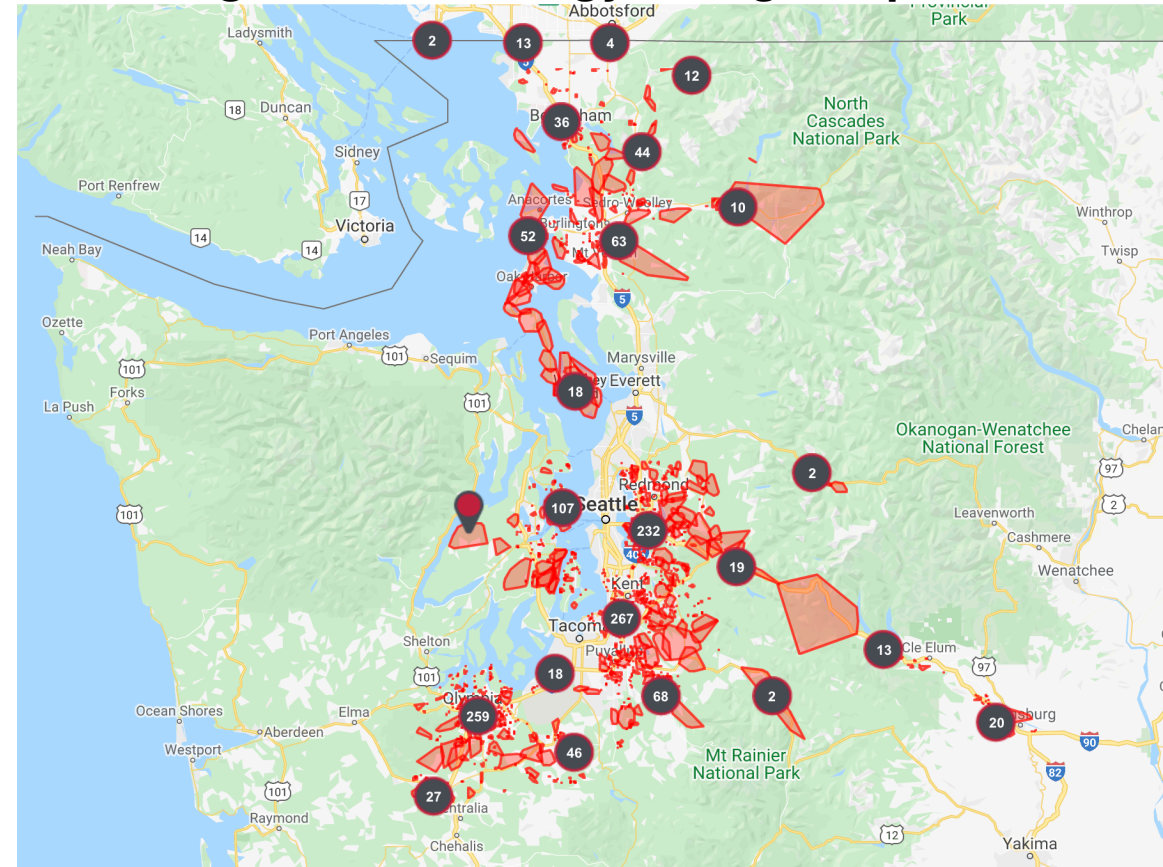
- Intense rainfall on saturated soils caused numerous landslides in southwestern Washington and northwestern Oregon
- Landslides closed sections of I-84/US-30 in Multnomah County, OR, and SR-14 in Skamania County, WA
- Residents of Dodson, OR, were encouraged to evacuate due to potentially life-threatening flash flooding on 13 Jan

Daily Maximum Wind Gust (13 Jan)



Source: NOAA/NWS Western Region Headquarters, <https://www.wrh.noaa.gov/>

Puget Sound Energy Outage Map



Source: Puget Sound Energy, <https://www.pse.com/>

- Strong winds caused widespread tree damage and power outages in portions of western Washington and northwestern Oregon
- NWS Seattle was reporting nearly 560,000 power outages throughout the county warning area as of early morning 13 Jan
- About 315,000 Puget Sound Energy customers were without power as of 4:30 AM PST 13 Jan
- Notable wind gusts: Sandy Pt. Shores (72 mph), Ferndale (70 mph), Smith Island (68 mph), Whidbey Island NAS (64 mph)

Event Summary: 11–13 Jan 2021

For California DWR's AR Program

Station	1–13 Jan 2021 Precip (in)	1–13 Jan Normal Precip (in)	Departure from Normal (in)	Normal Jan Precip (in)
Quillayute Airport, WA	12.64	6.26	6.38	14.61
Hoquiam Airport, WA	12.45	4.57	7.88	10.33
Astoria Airport, OR	12.24	4.50	7.74	10.20
Olympia Airport, WA	10.11	3.35	6.76	7.84
Seattle-Tacoma Airport, WA	7.53	2.45	5.08	5.57
Scappoose, OR	6.94	3.11	3.83	6.52
Salem Airport, OR	6.77	2.68	4.09	5.96
McMinnville, OR	6.44	2.83	3.61	6.10
WFO Seattle, WA	6.18	2.25	3.93	4.81
Hillsboro, OR	6.07	2.88	3.19	6.06
Vancouver, WA	5.93	2.56	3.37	5.50
Portland Intl Airport, OR	5.47	2.20	3.27	4.88

Source: NOAA/NWS WFO Portland (<https://www.weather.gov/pqr/>) & WFO Seattle (<https://www.weather.gov/sew/>)

- January 2021 is off to an extremely wet start across western Washington and northwestern Oregon, with many stations reporting more than double the normal (1981–2010 average) month-to-date precipitation as of 14 Jan
- Many stations have already exceeded the normal monthly total precipitation for January