CW3E Atmospheric River Outlook: 1 Dec 2023

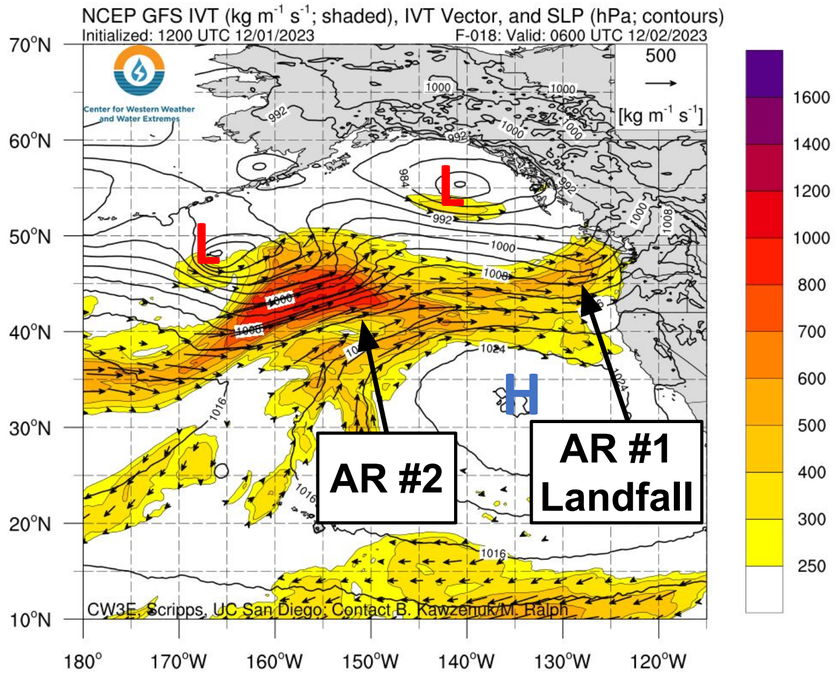
Trio of Atmospheric Rivers Forecast to Impact Pacific Northwest

- An AR associated with a cold storm will bring a brief period of AR conditions tonight into Saturday morning
- Two stronger ARs are forecast to make landfall late Sat 2 Dec and early Mon 4 Dec
- AR1 conditions (based on Ralph et al. 2019 AR scale) are forecast during the first AR
- Nearly all GEFS ensemble members are forecasting an AR4 over northern coastal OR due to a prolonged period (> 72 hours) of continuous AR conditions during the second and third ARs
- A majority of ECMWF EPS members are forecasting a break in AR conditions between the second and third ARs, with AR2/3 conditions likely during the second AR, and AR3/4 conditions likely during the third AR
- The NWS Weather Prediction Center (WPC) is currently forecasting 7-day precipitation totals ≥ 10 inches in the vicinity of the Olympic Mountains, Cascades, and Coast Ranges
- The NWS WPC Extreme Rainfall Outlook highlights a Marginal Risk for flooding for western OR/WA Dec 2-6 with a Slight Risk for the Olympic Peninsula on Dec 5
- Heavy rain, particularly during the second and third ARs, is expected to cause flooding on rivers in western WA and northwestern OR
- Rain falling on fresh snowpack will likely increase flood risk near the Olympic Mountains and WA Cascades
- NWS Seattle and Portland are forecasting at least 1-3 feet of snow in the Olympic Mountains and the Cascades through late Saturday evening
- The NWS Winter Storm Severity Index is showing major to extreme winter storm impacts over the Cascades today through early Sunday due to heavy snowfall

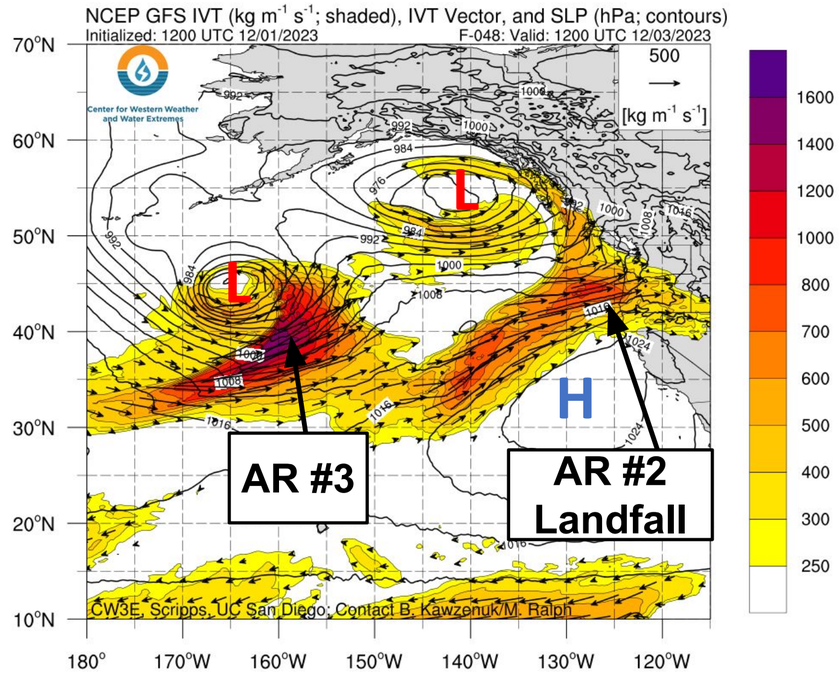
CW3E AR Outlook: 1 Dec 2023

GFS Init 12Z Fri 1 Dec 2023

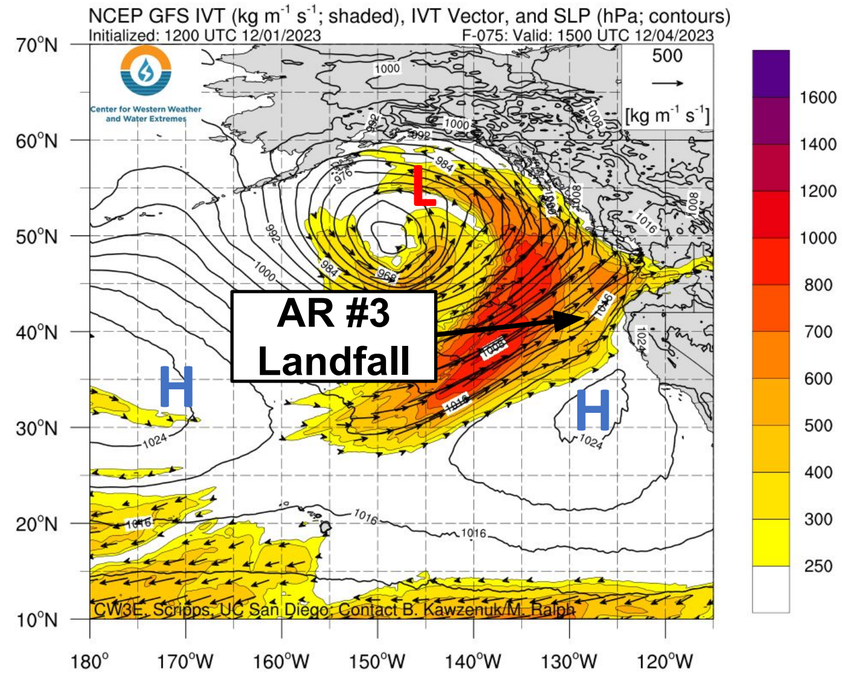
10PM PT Fri 1 Dec 2023



04AM PT Sun 3 Dec 2023



7AM PT Mon 4 Dec 2023

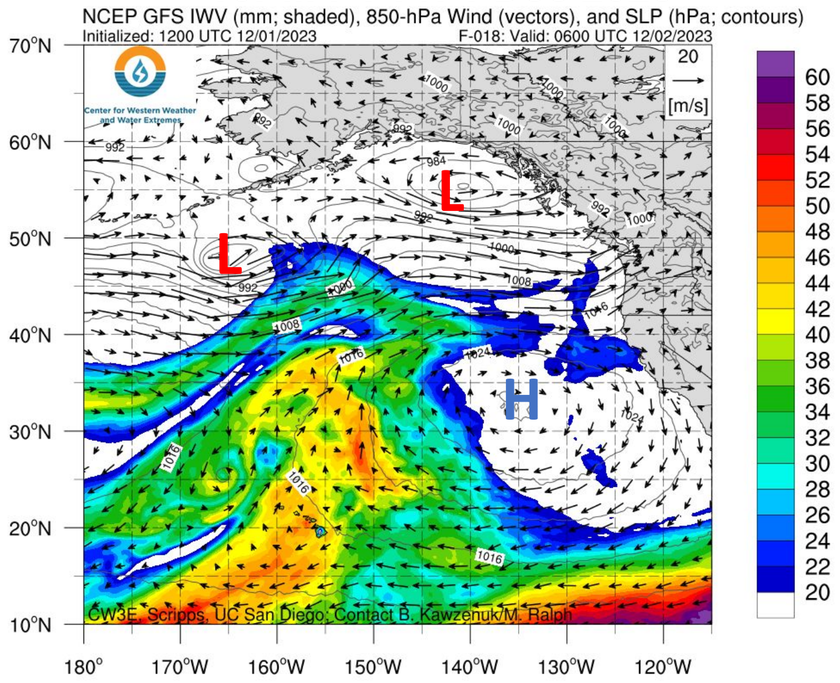


- A trio of ARs are forecast to track across the Pacific and make landfall in the PNW today through early next week
- The 1st AR is forecast to arrive today and bring a brief period of AR conditions to coastal WA/OR
- The 2nd AR is forecast to make landfall late Sat 2 Dec and bring and penetrate further inland, with the core of the AR (IVT > 700 kg m^{-1} s^{-1}) reaching the PNW early Sun 3 Dec
- Following a short break in AR conditions, the 3rd and strongest AR is forecast to arrive the morning of Mon 4 Dec and produce a longer period of AR conditions, with peak IVT > 800 kg m^{-1} s^{-1}

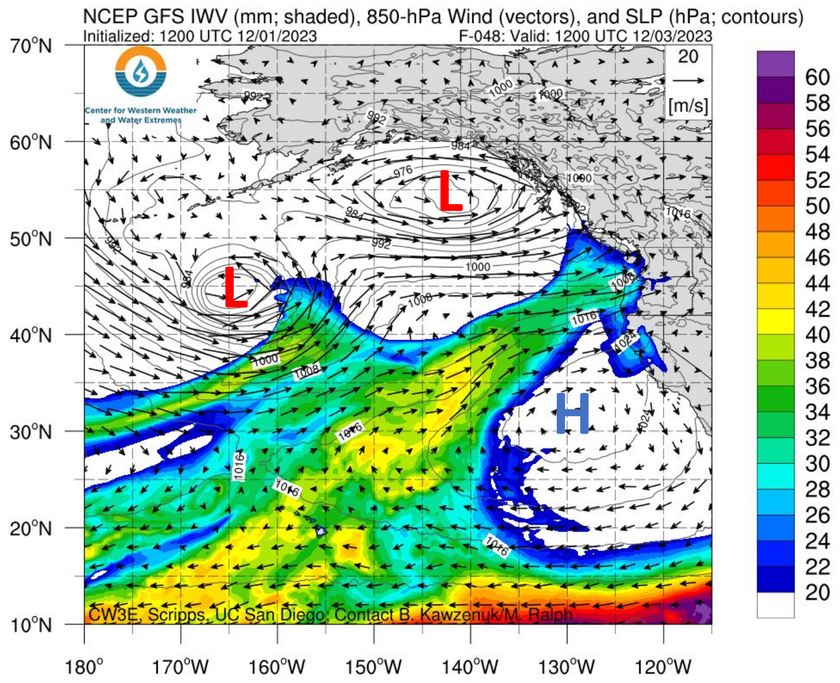
CW3E AR Outlook: 1 Dec 2023

GFS Init 12Z Fri 1 Dec 2023

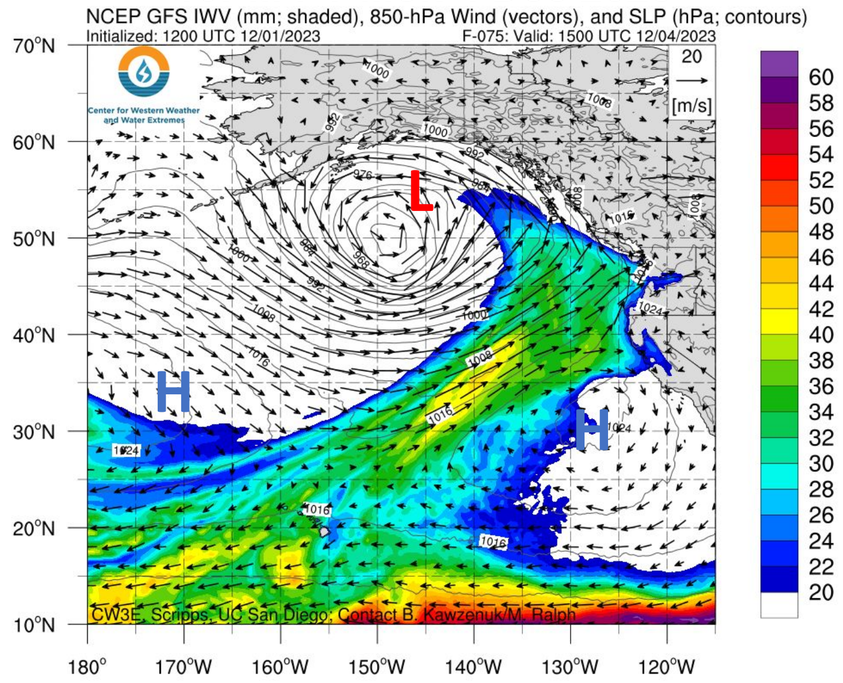
10PM PT Fri 1 Dec 2023



04AM PT Sun 3 Dec 2023

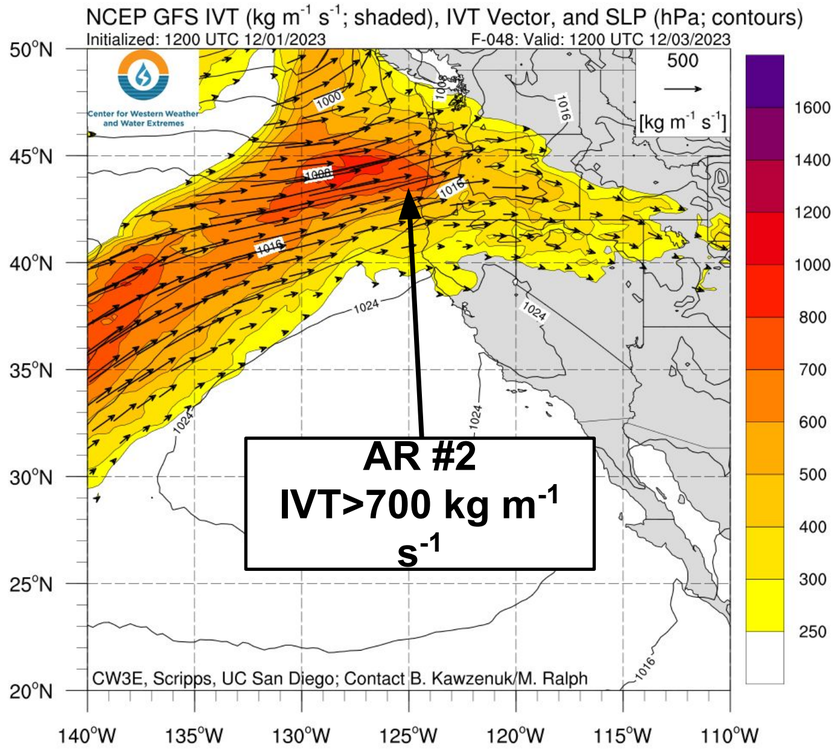


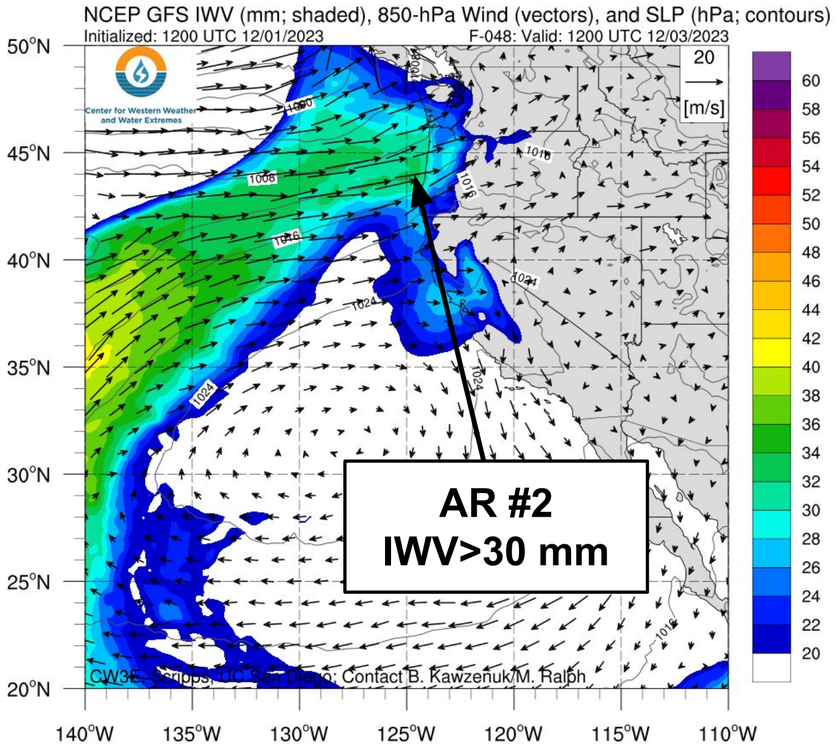
10PM PT Mon 4 Dec 2023



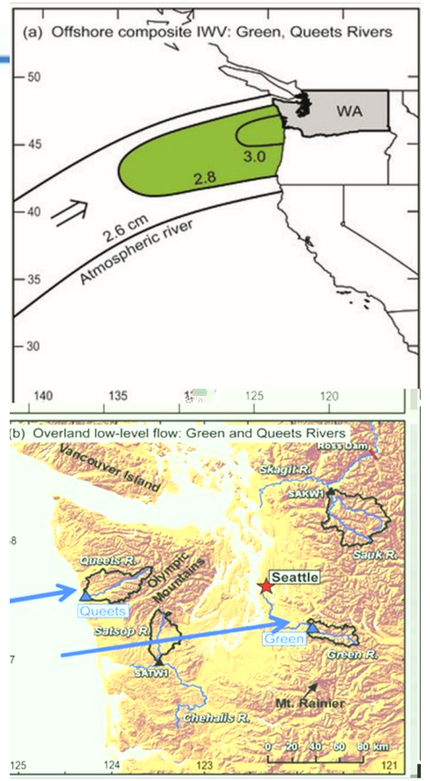
- The second and third ARs will be fed by moisture from the tropical North Pacific
- Initial IVT that makes landfall in the PNW ahead of the 1st AR is primarily wind driven
- Once the high-pressure system off the USWC shifts to the southeast, the moisture in the tropical North Pacific will be transported northward over the ridge and help strengthen the landfalling ARs

CW3E AR Outlook: 1 Dec 2023





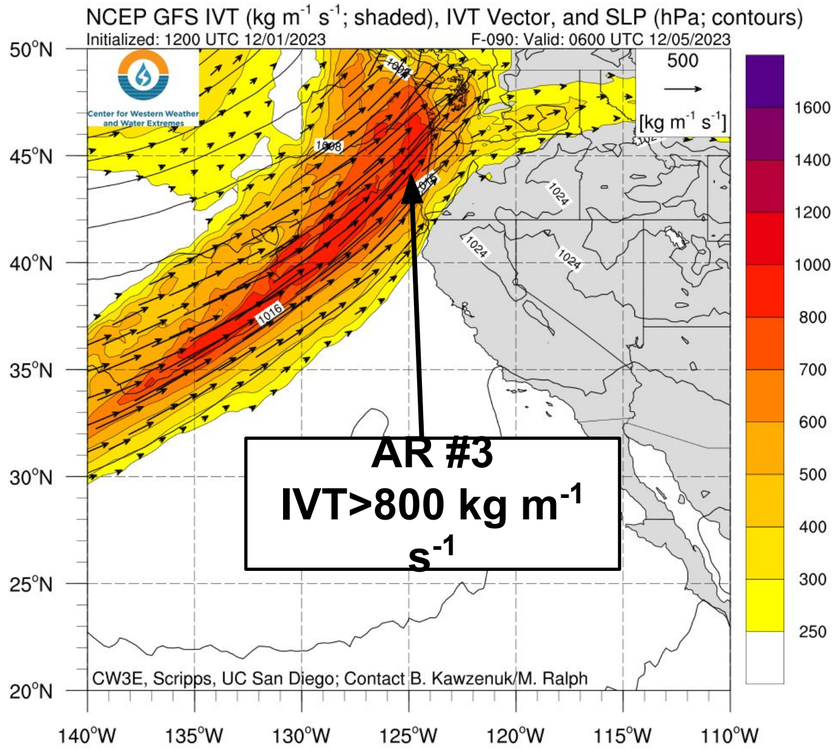
Most Favorable AR Orientation Based on top 10 Flow Days

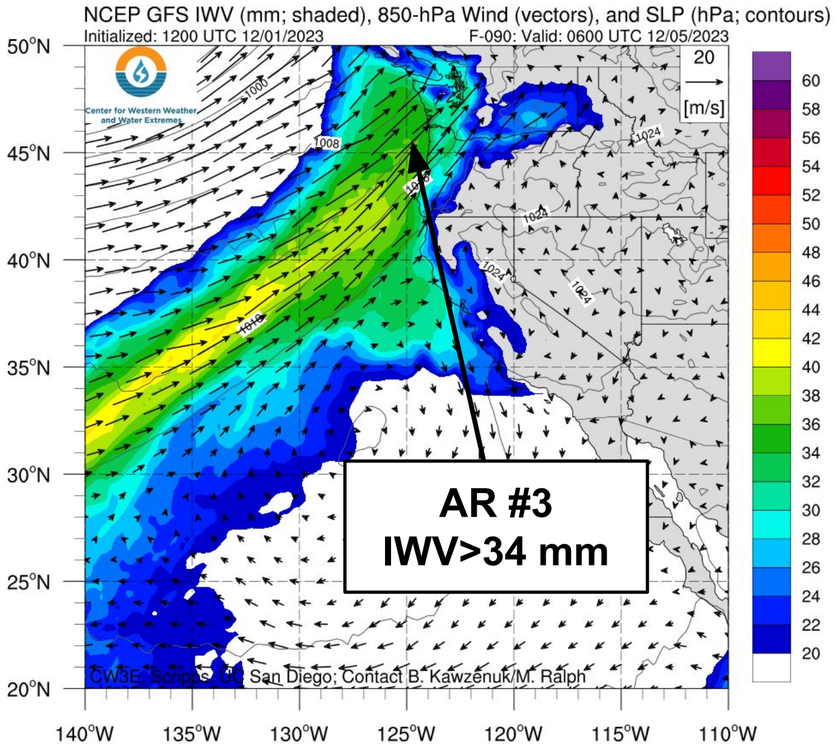


Adapted from Fig. 15 of Neiman et al. (2011)

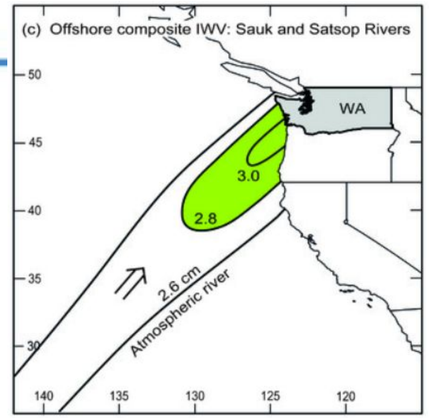
- The second AR is forecast to make landfall on 2 Dec (Sat) with west-southwesterly integrated vapor transport (IVT) >600 kg m^{-1} s^{-1} over northwestern Oregon.
- The second AR contains a robust moisture plume with integrated water vapor (IWV) values > 30 mm extending from the tropical North Pacific to the Pacific Northwest, with significant inland moisture penetration.
- Prior research by Neiman et al. (2011) found that the top 10 annual daily flows in the Green River are associated with a very similar pattern (west-southwesterly low-level moisture transport within an AR making landfall north of a high-pressure system)

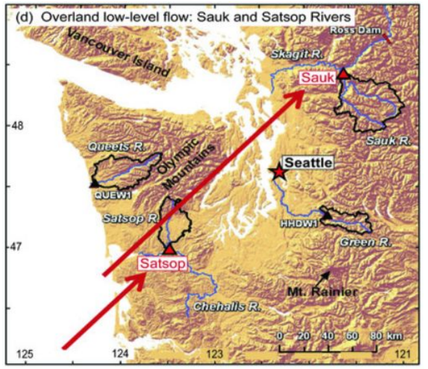
CW3E AR Outlook: 1 Dec 2023





Most Favorable AR Orientation Based on top 10 Flow Days

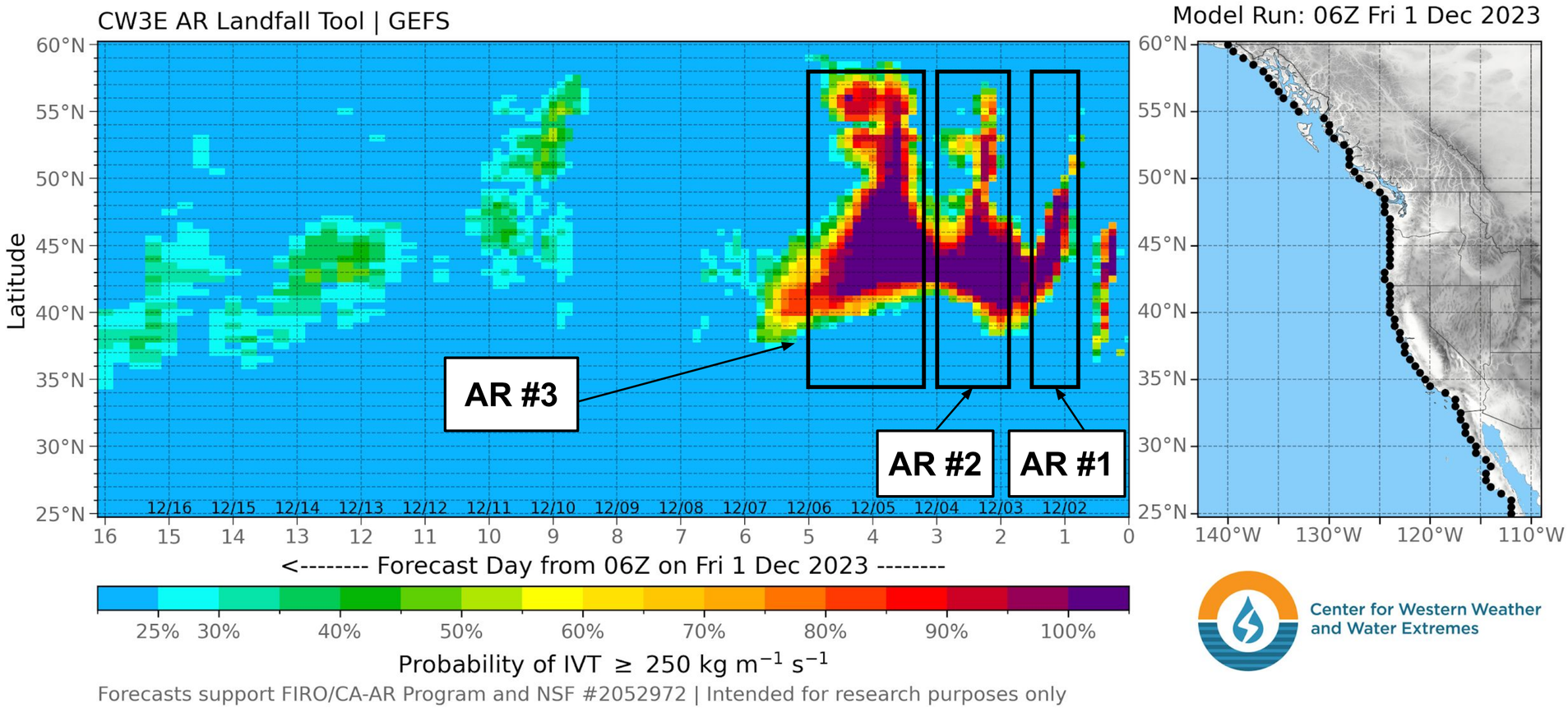




Adapted from Fig. 15 of Neiman et al. (2011)

- The third AR is forecast to make landfall late on 4 Dec (Mon) with southwesterly integrated vapor transport (IVT) exceeding 700 kg m^{-1} s^{-1} along the coast of northwestern OR and southwestern WA
- The southwesterly IVT direction favors orographic enhancement of precipitation along the southern slopes of the Olympic Mountains and the western slopes of the Cascades in northern WA
- Neiman et al. (2011) found that the top 10 annual daily flows in the Sauk and Satsop Rivers are associated with a similar pattern

CW3E AR Outlook: 1 Dec 2023

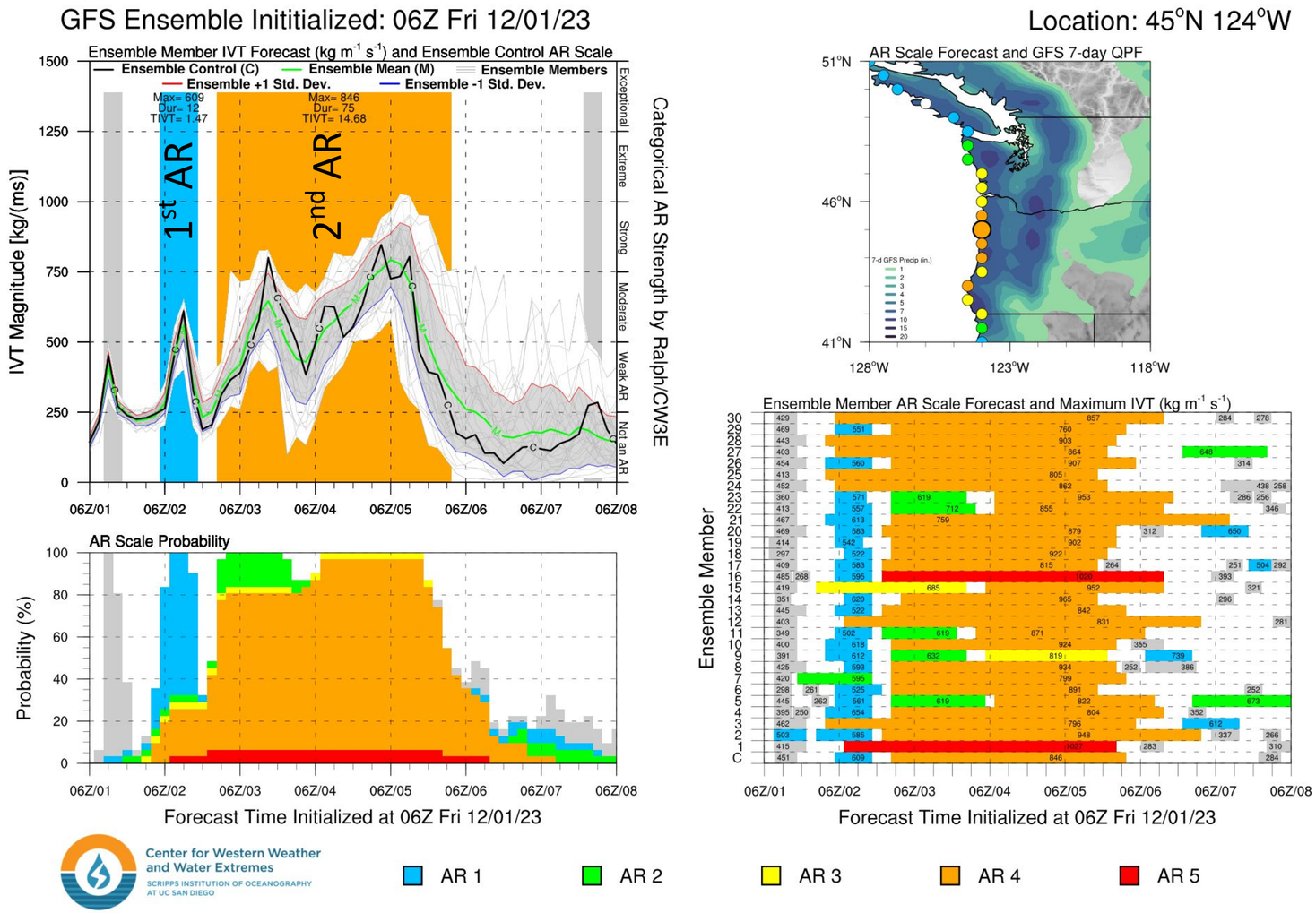


- Two strong ARs are forecast to make landfall in Washington and Oregon on 2-6 December

- GEFS AR Landfall Tool (coastal and foothills transects) illustrate high confidence (>95 %) of IVT > 250 kg m^{-1} s^{-1} in two pulses on 2-3 Dec (**AR#1**) and 5-6 Dec (**AR#2**).

CW3E AR Outlook: 1 Dec 2023

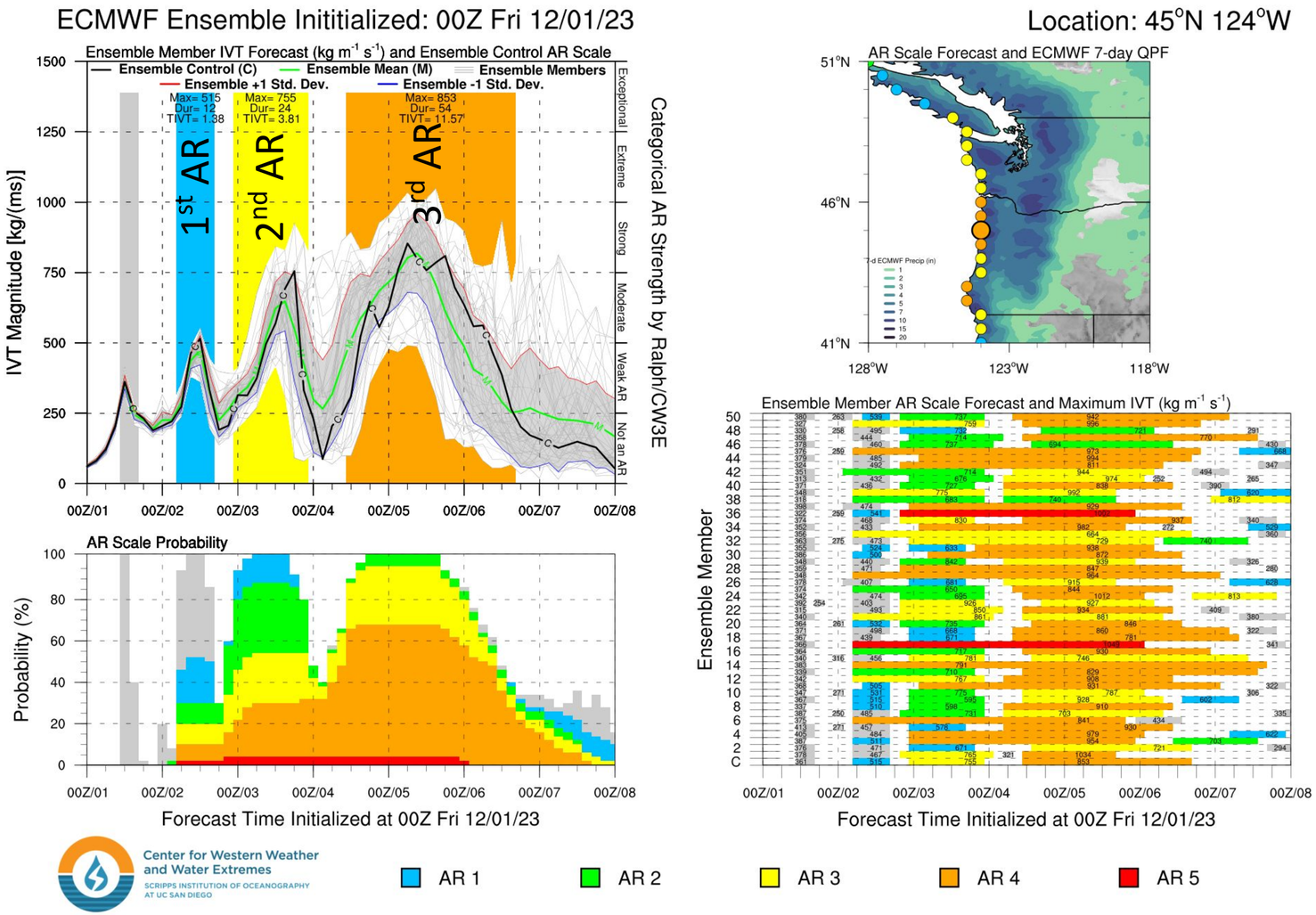
GEFS 7-day AR Scale and IVT Forecast



- For the <u>first AR</u> period, 31/31 (100%) GEFS ensemble members are forecasting at least AR1 conditions at 45° N, 124.0° W (coastal OR)
- 31/31 (100%) of the members (including the control) are forecasting at least AR4 conditions during the second and third ARs between 2 and 5 Dec
- Some members are showing a short break in AR conditions around 00Z 4 Dec, but given the high peak in IVT (IVT > 750 kg m^{-1} s^{-1}), the third AR still registers as an AR4
- Several of the GEFS members are showing continuous AR conditions from the onset of the <u>first AR</u>

CW3E AR Outlook: 1 Dec 2023

ECMWF EPS 7-day AR Scale and IVT Forecast



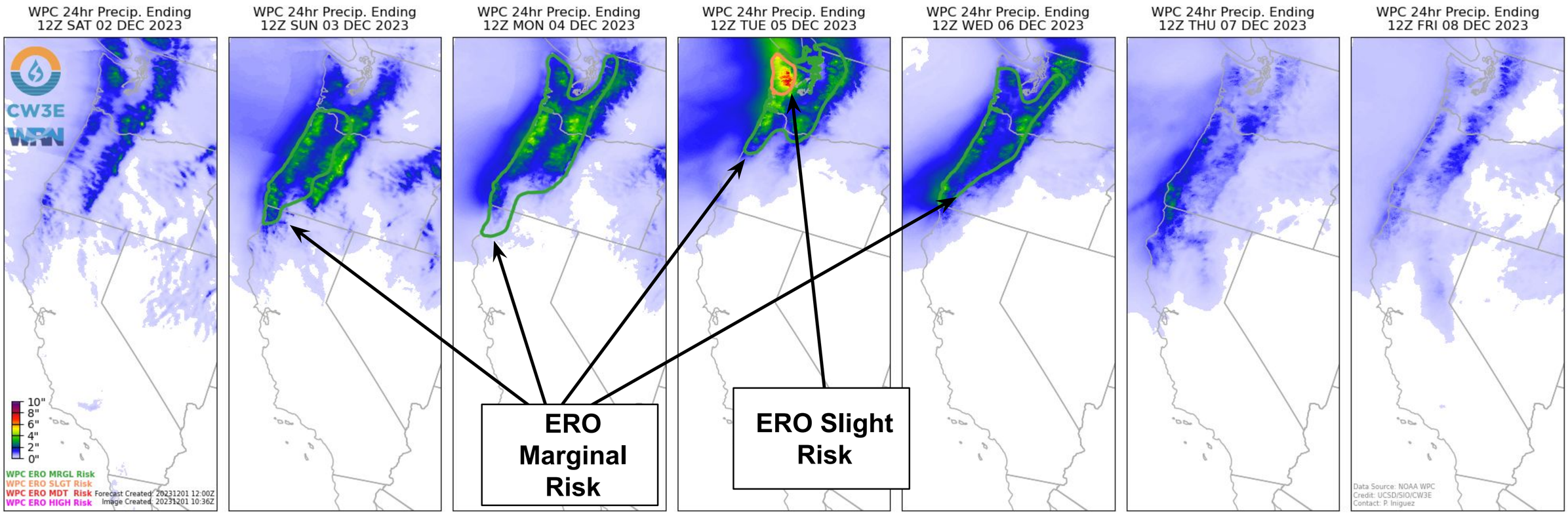
AR 1 AR 2 AR 3 AR 4 AR 5

Image created: 10 UTC 12/01/2023

More information: http://cw3e.ucsd.edu AR Scale based on Ralph et al. (2019; BAMS), contact M. Ralph

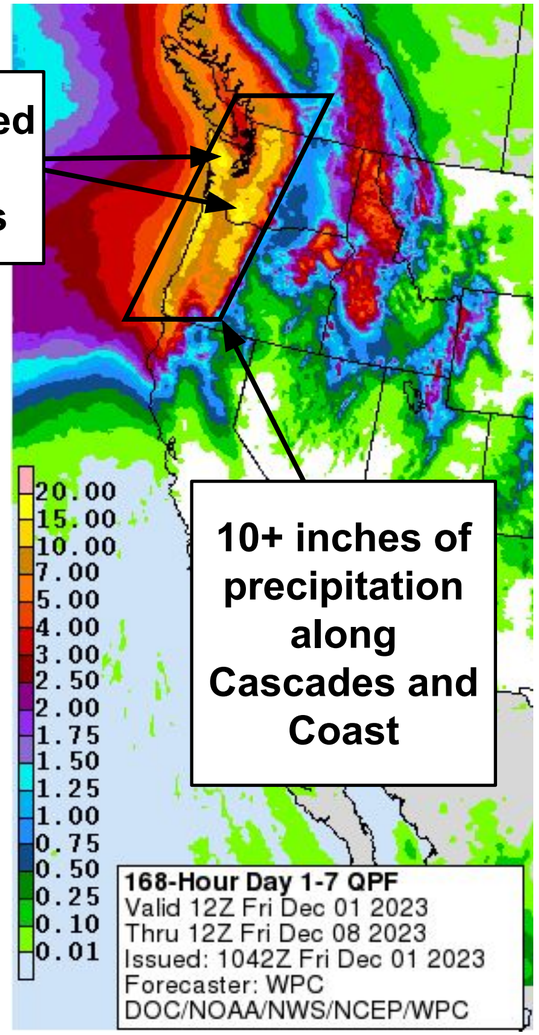
- The EPS is showing three distinct AR periods due to a break in AR conditions around 00Z 4 Dec
- For the first AR period, 26/51 (51%) EPS ensemble members are forecasting at least AR1 conditions
- For the second AR period, 44/51 (86%) EPS ensemble members are forecasting at least AR2 conditions and 33/51 (65%) are forecasting a break in AR conditions
- For the third AR period, 48/51 (94%) of EPS Ensemble members forecasting at least AR3 conditions, and a majority are forecasting AR4 conditions.
- Much like the GEFS, several EPS members are also showing continuous AR conditions from the onset of the first AR

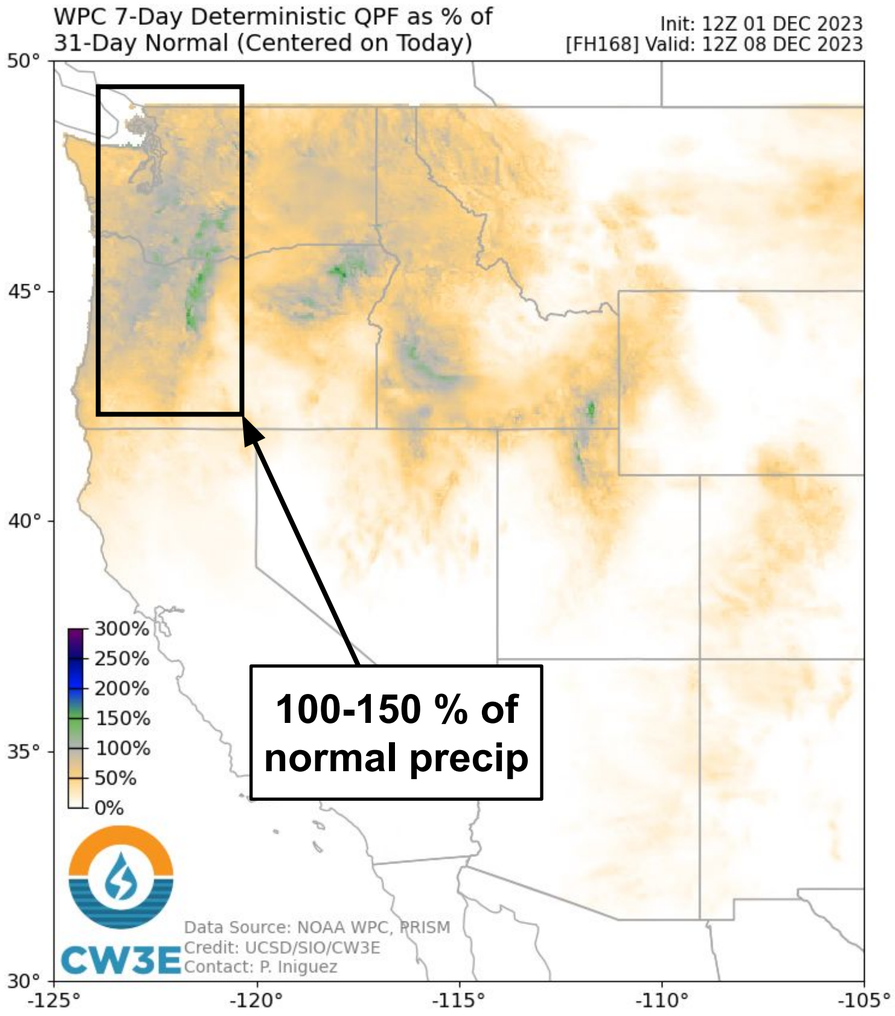
CW3E AR Outlook: 1 Dec 2023



- The NWS WPC is currently forecasting precipitation totals ≥ 2 inches for regions near the Cascade Range and along the OR/WA coast for each of the next seven days, with peak 24-hour precipitation around 6-8 inches over the Olympic Peninsula during the third AR on Mon 4 Dec - Tue 5 Dec
- Excessive Rainfall Outlooks from the WPC show marginal risk of flooding for the regions receiving the most precipitation during each AR as well as a slight risk for the Olympic Peninsula on Mon 4 Dec into Tue 5 Dec

CW3E AR Outlook: 1 Dec 2023



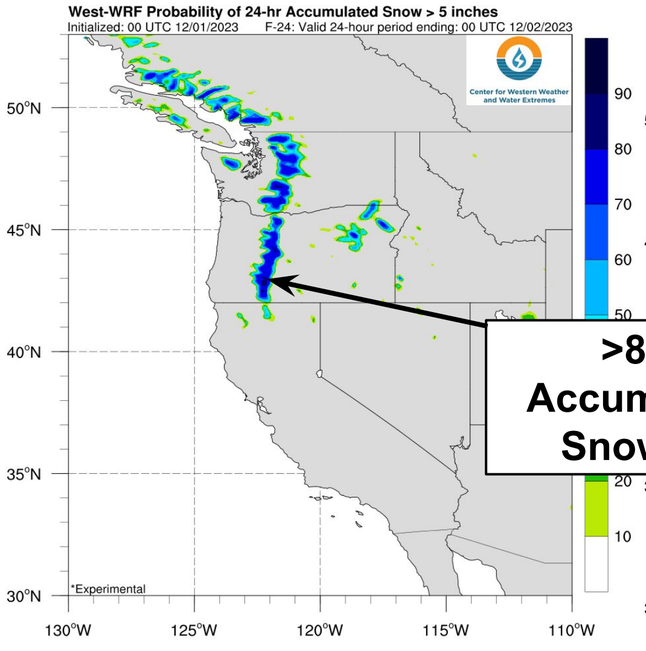


- The NWS Weather Prediction Center is forecasting **7-day precipitation totals >10-15 inches** along windward slopes of Cascades, Olympic Peninsula and Oregon Coast.
- Over the next seven days, portions of Washington and Oregon along the Cascade Range are **forecast to receive 100-150%** of normal precipitation for late November through early December

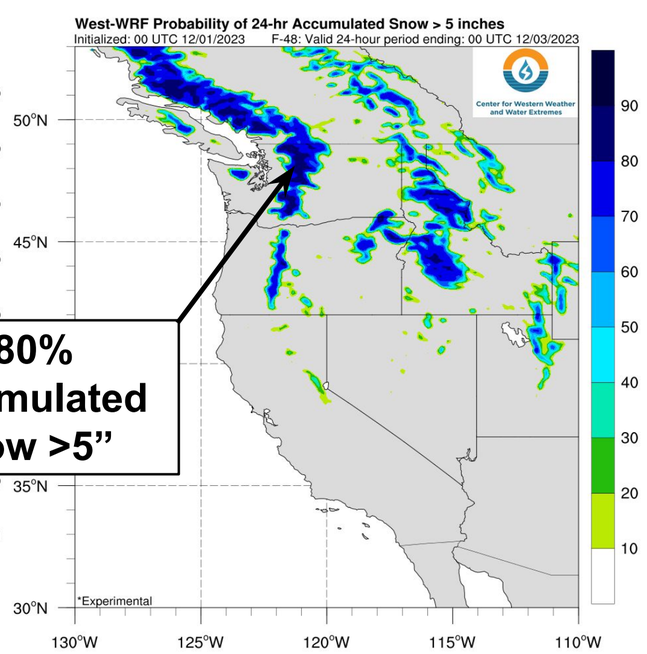
CW3E AR Outlook: 1 Dec 2023

West-WRF Ensemble Probability Maps

24-Hour Period Ending 4 PM PT 1 Dec

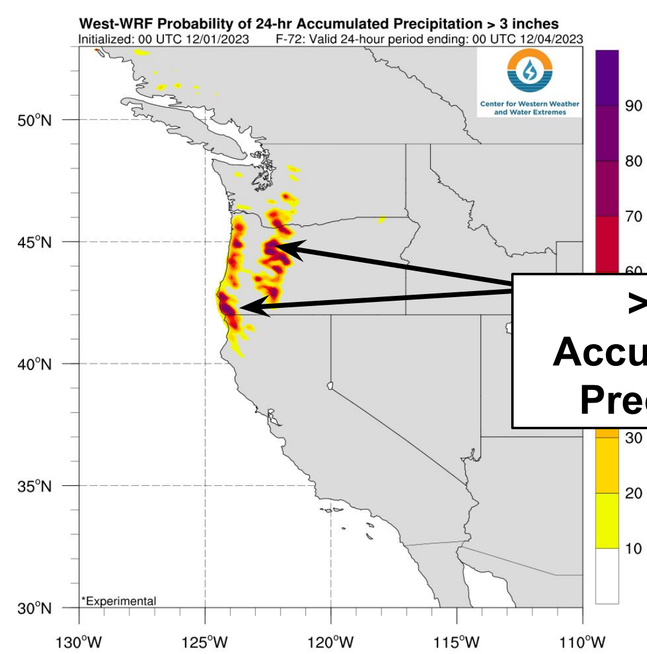


24-Hour Period Ending 4 PM PT 2 Dec

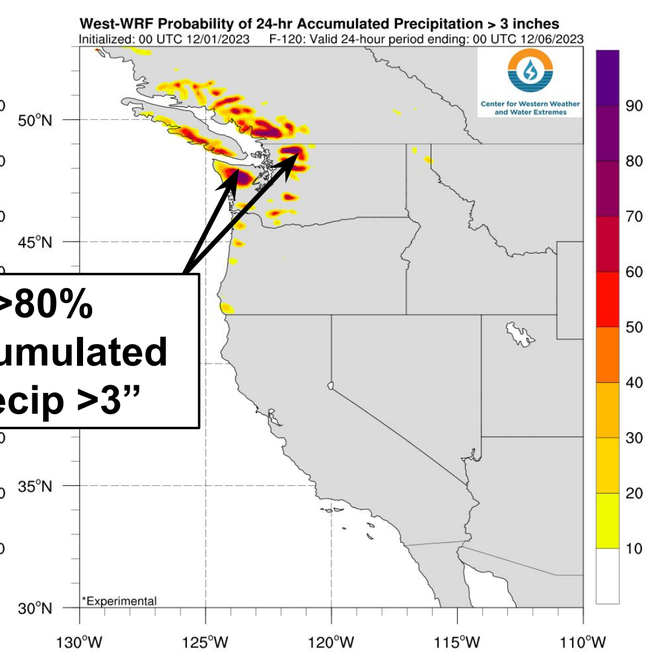


>80% Accumulated Snow >5”

24-Hour Period Ending 4 PM PT 3 Dec



24-Hour Period Ending 4 PM PT 5 Dec



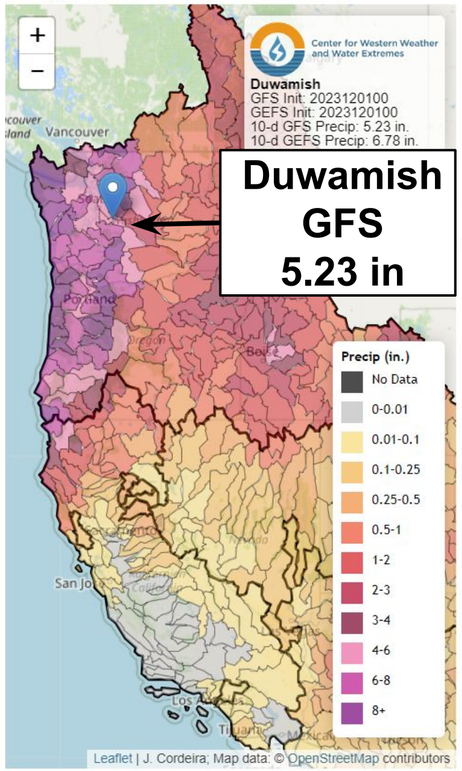
>80% Accumulated Precip >3”

- The West-WRF ensemble is forecasting high probabilities of snow >5” over the Cascade Range in the two days ahead of the strongest IVT associated with the first AR
- During the 24-hr periods encompassing the first and second AR landfalls, there are high probabilities of >3” of accumulated precipitation over the Oregon Coast and foothills and Olympic Peninsula and Northern Cascades respectively.

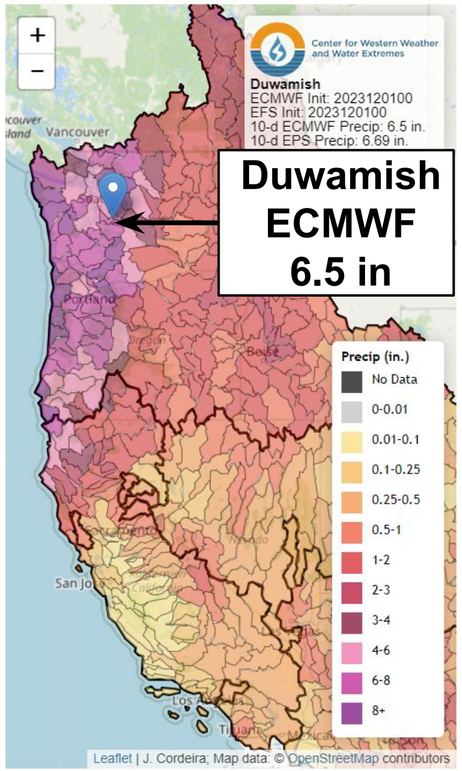
CW3E AR Outlook: 1 Dec 2023

10-day Watershed Precipitation Forecasts (Initialized 00Z 1 Dec)

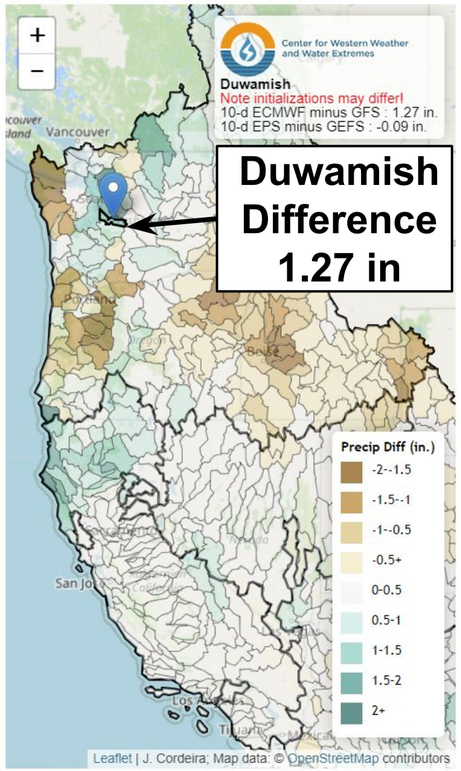
10-day GFS/GEFS Precipitation Forecasts

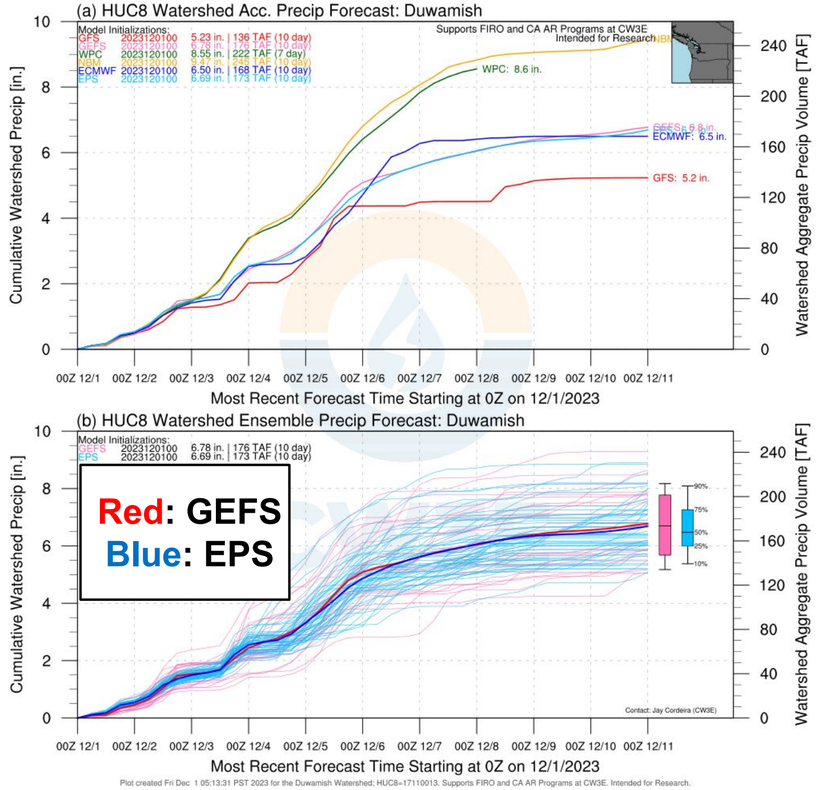


10-day ECMWF/EFS Precipitation Forecast



10-day Difference Precipitation Forecast

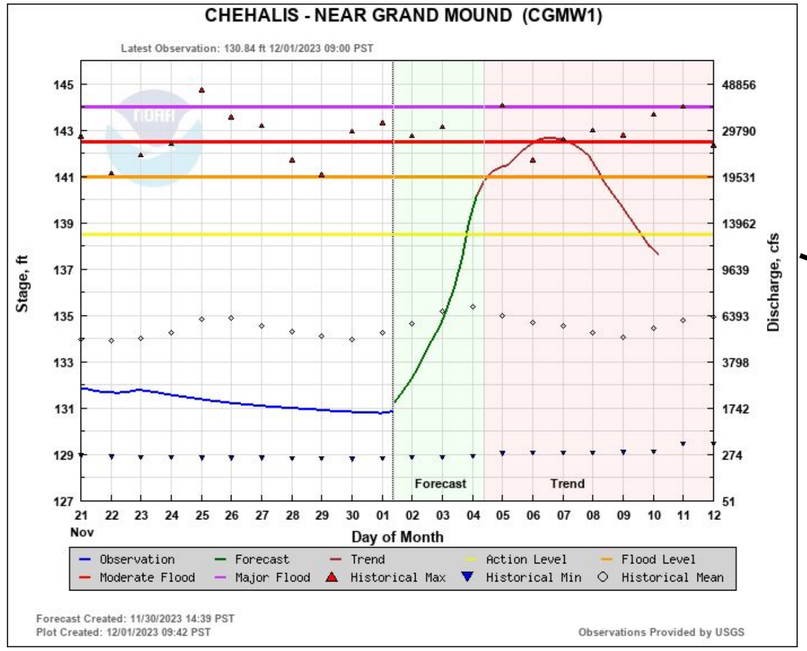


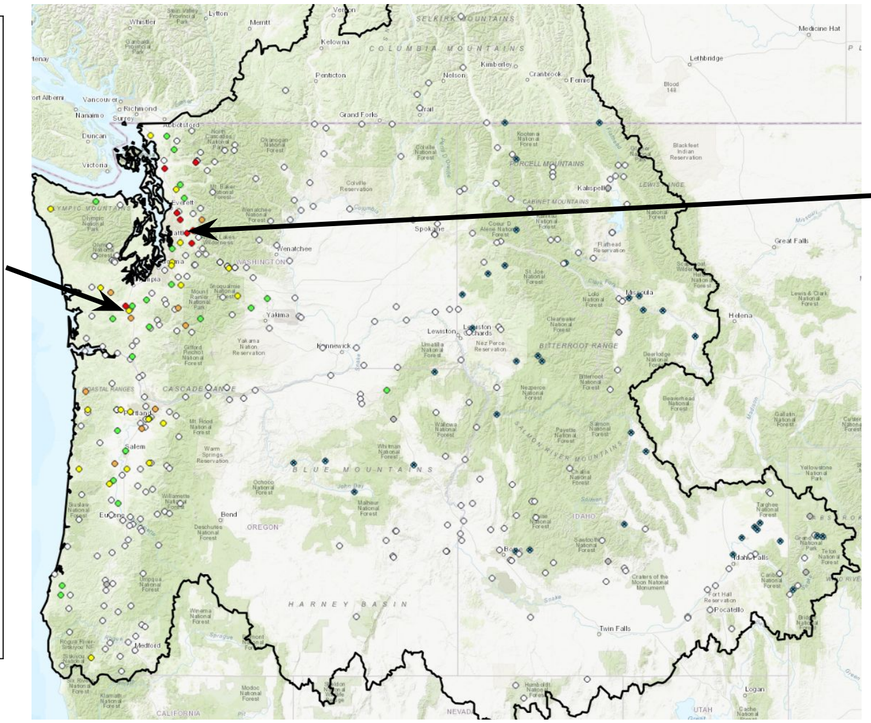


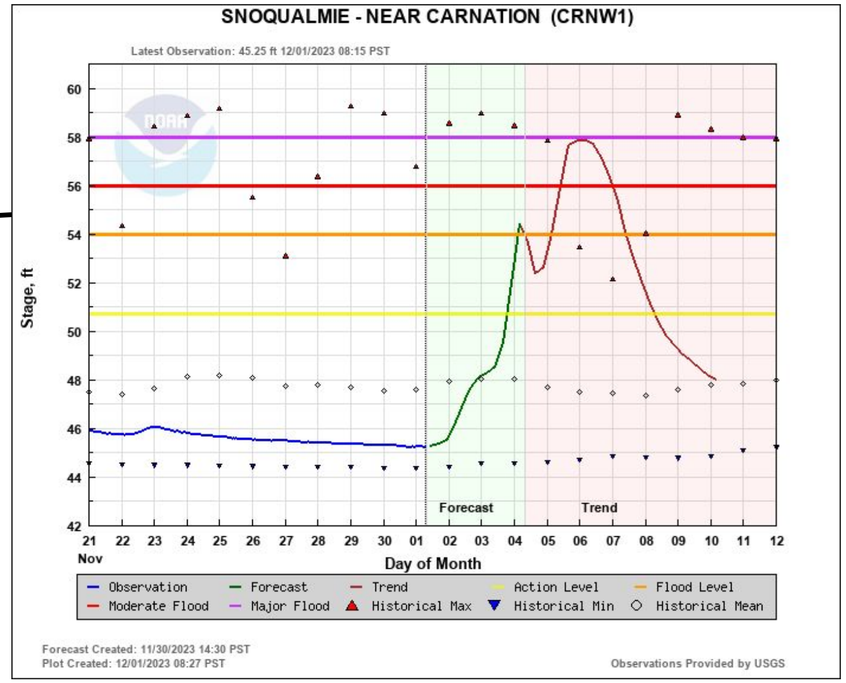
- The 00Z ECMWF is forecasting higher 10-day watershed precipitation totals in the northern Cascades while the 00Z GFS has higher precipitation along the coast and the central Cascades
- The 00Z GFS is forecasting 5.23” of mean areal precipitation in the Duwamish watershed over the next 10 days, while the 00Z ECMWF is forecasting 6.5” over the same watershed. While ensemble members show large spread in 10-day totals for the Duwamish, the majority of members are clustered around 6"-8", indicating greater confidence in heavy precipitation.

CW3E AR Outlook: 1 Dec 2023

NWS NWRFC River Stage Forecasts



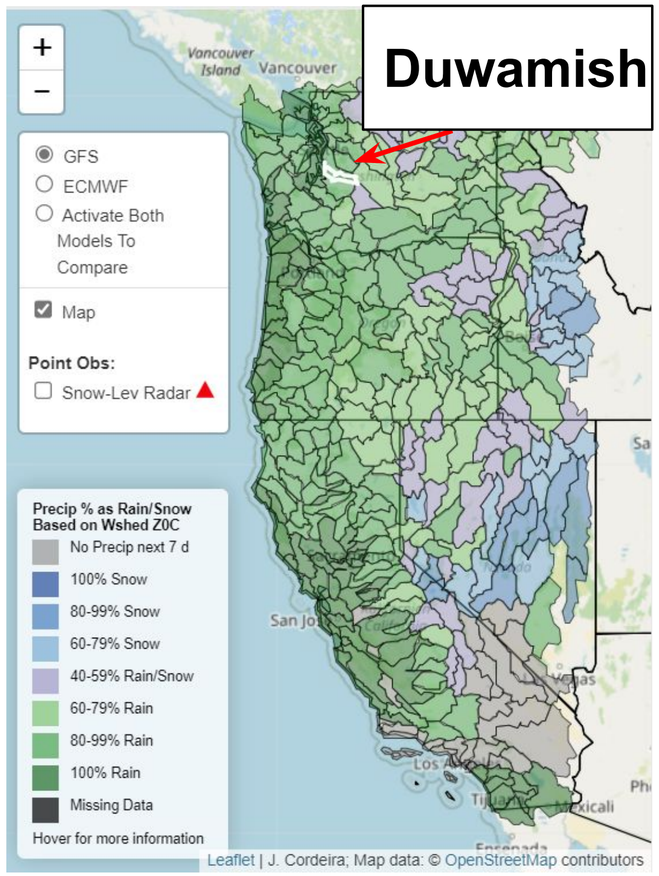


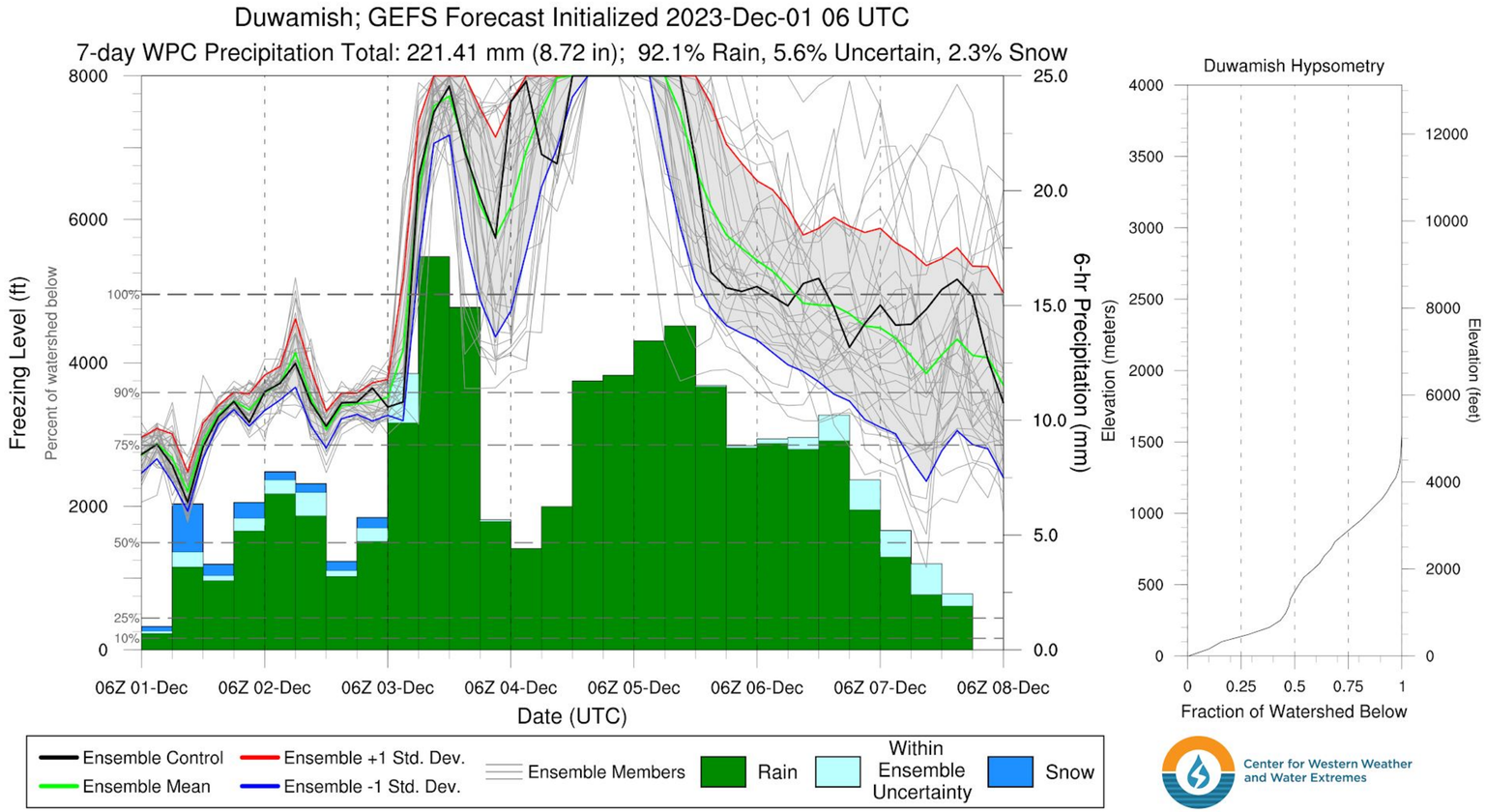


- River stages across the Pacific Northwest are forecast to steadily rise as a result of the heavy precipitation associated with these ARs
- The NWRFC is currently forecasting nine stream gages to exceed minor flood stage and eight stream gages to exceed moderate flood stage, primarily in western WA
- The Chehalis River near Ground Mound (left) and the Snoqualmie River near Carnation (right) are both forecast to reach moderate flood stage with peak river stage on 6 Dec

CW3E AR Outlook: 1 Dec 2023

Freezing Level Forecast





- Low freezing levels during the first AR will allow for significant snowfall accumulations below 4,000 in the Cascades
- Once the second AR arrives however, the warmer air accompanying the system will cause freezing levels to rise substantially
- Heavy rain falling on fresh snowpack will likely increase the risk of flooding, particularly on the western side of the WA Cascades

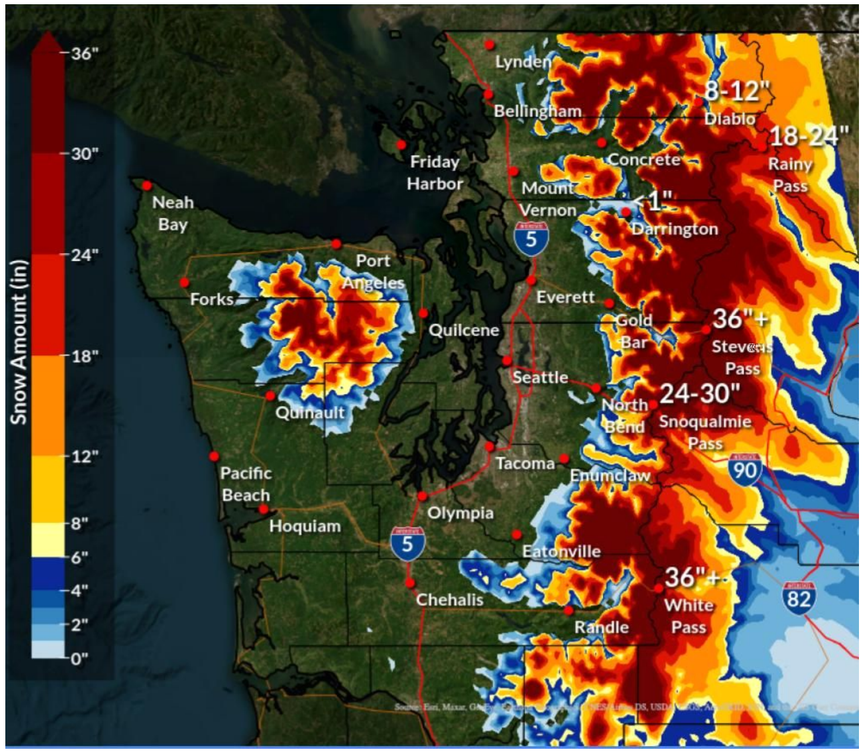
CW3E AR Outlook: 1 Dec 2023

AMBASSADOR™ WRN WEATHER-READY NATION

NWS Snow Forecast - Friday thru Saturday

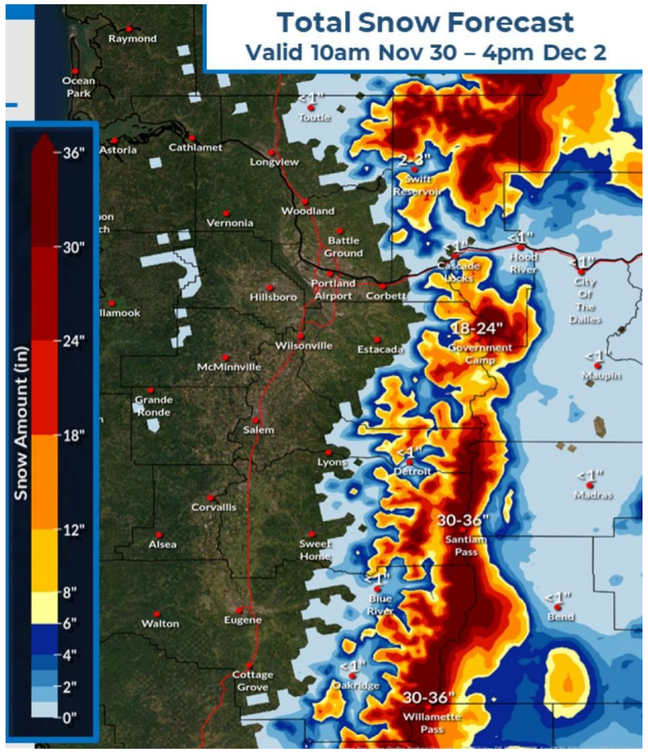
NWS Seattle WA

Olympic Peninsula and Northern Cascades



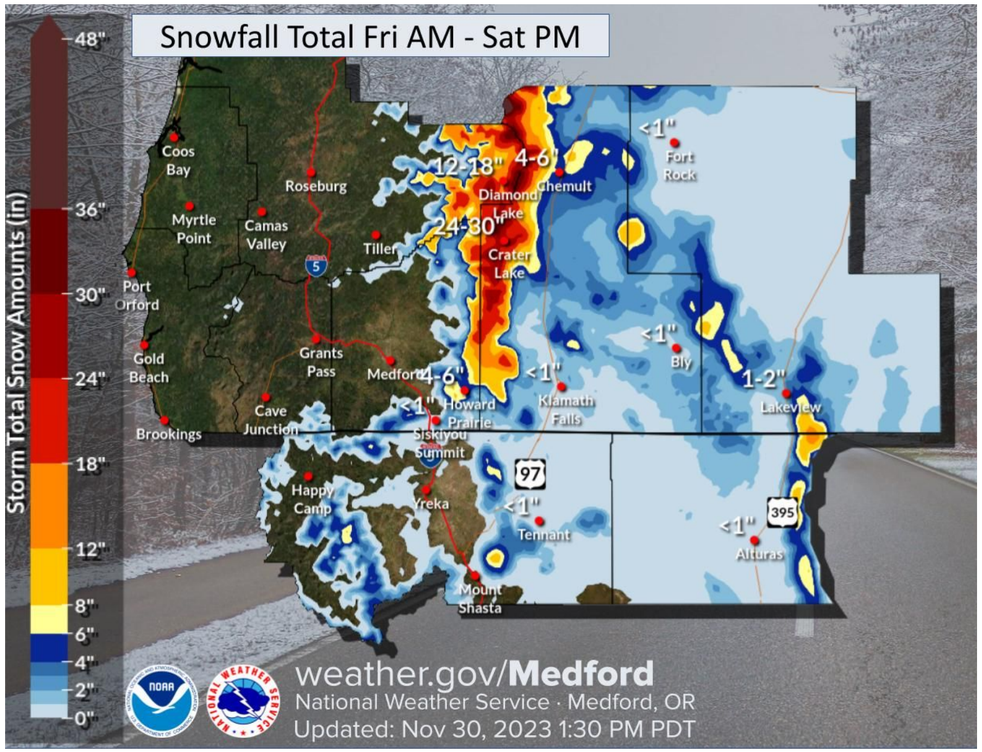
NWS Portland OR

Central Cascades



NWS Medford OR

Southern Cascades



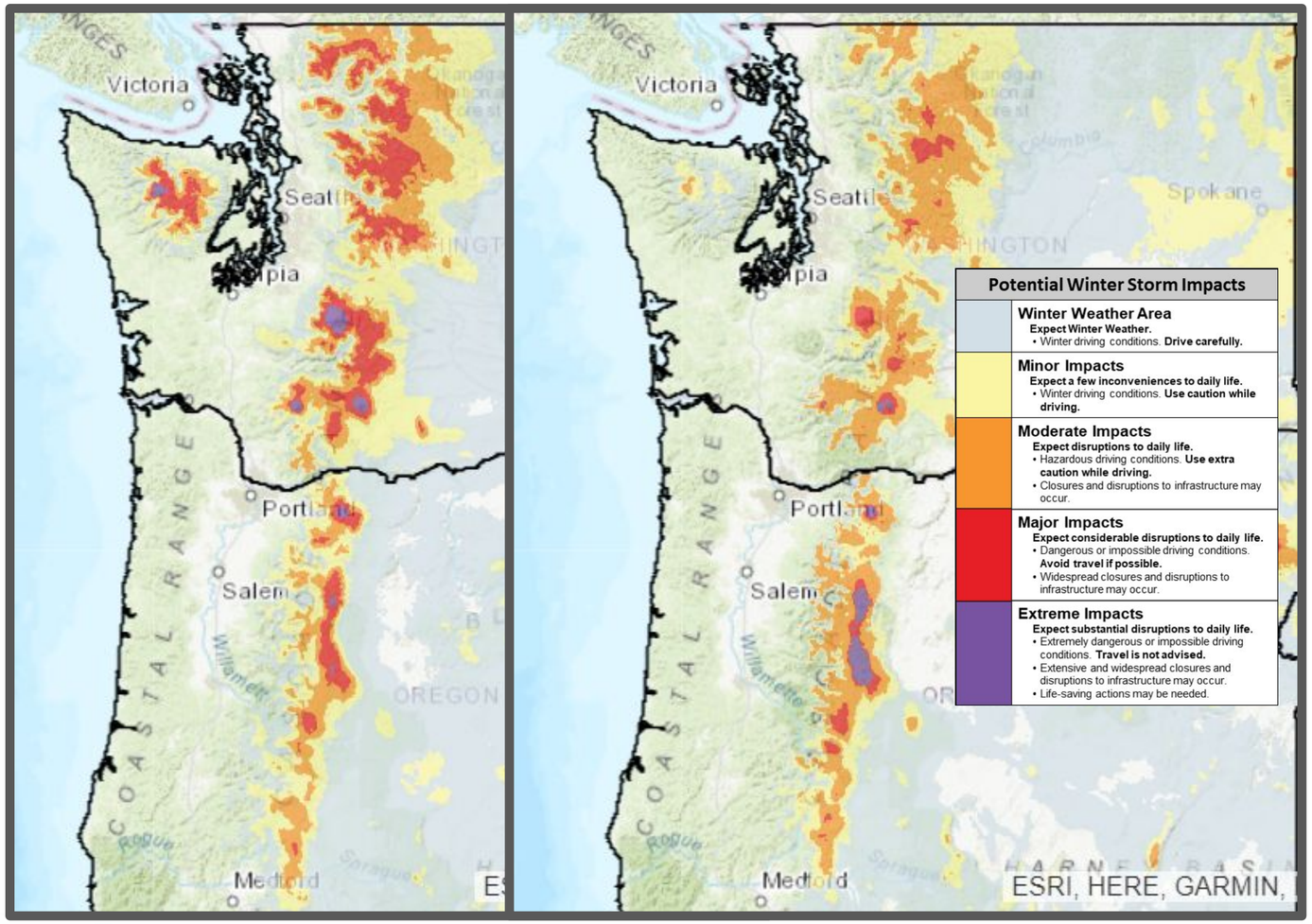
- NWS offices throughout the Pacific Northwest are forecasting at least 1-3 feet of snowfall in the Olympic Mountains, northern Cascades (left), central Cascades (center), and southern Cascades (right) through late Saturday in association with the first AR

CW3E AR Outlook: 1 Dec 2023

Winter Storm Severity Index

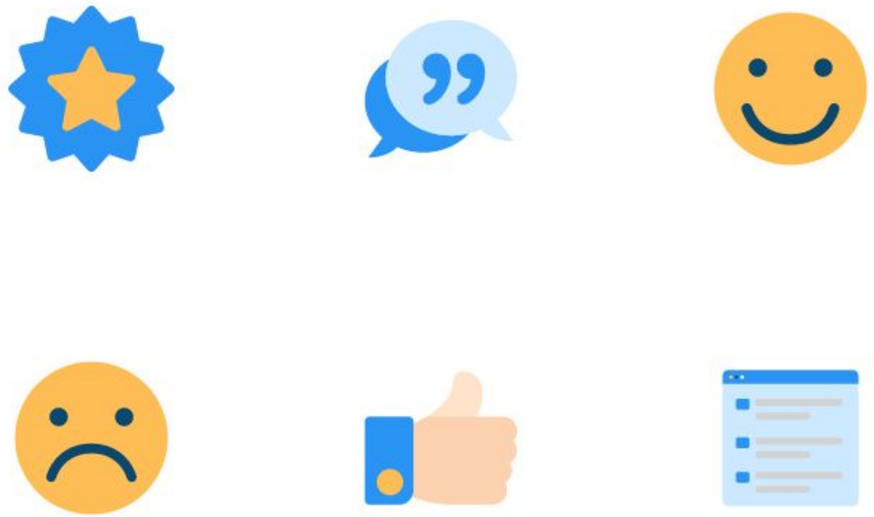
4 AM 1 Dec - 4 AM 2 Dec

4 AM 2 Dec - 4 AM 3 Dec



- NWS Winter Storm Severity Index products for the forecast period between 4 AM PT 1 Dec through 4 AM PT 3 Dec have indicated major to extreme impacts in the highest elevations of the Olympic Mountains and Cascades
- High forecast snowfall totals are the primary forecast variable influencing the broad region of major to extreme WSSI along the Cascades
- Major to extreme impacts are primarily forecast for the highest elevations of the Olympic Peninsula and Washington Cascades between 4 AM PT 1-2 Dec
- The primary region of major to extreme impacts is forecast farther south in the Oregon Cascades between 4 AM PT 2-3 Dec

CW3E AR Outlook: 28 Nov 2023



We value your feedback! Please complete this short survey to help us improve these outlooks.