

CW3E Atmospheric River Outlook: 22 Dec 2023

Pair of Atmospheric Rivers Forecast to Make Landfall along US West Coast

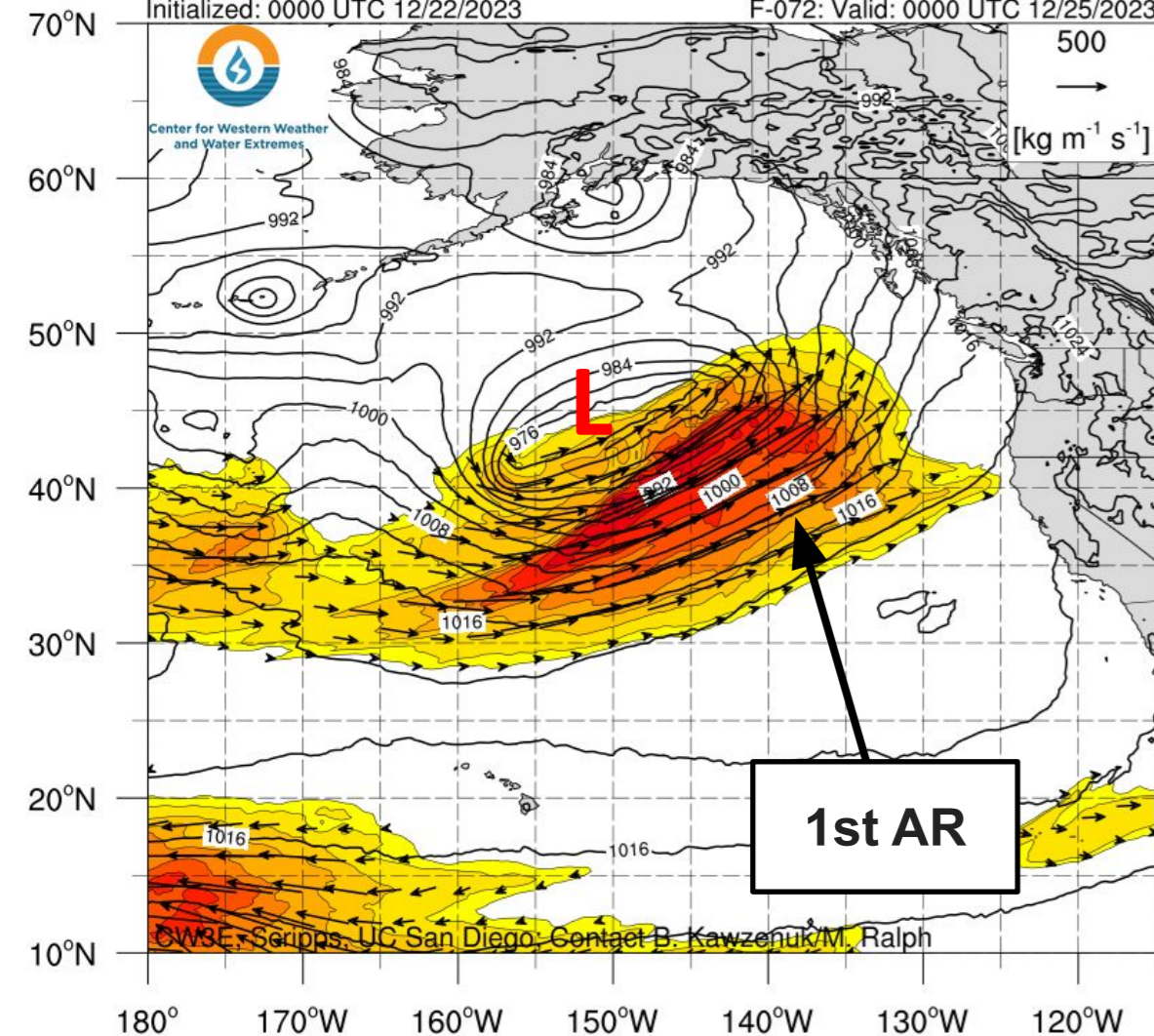
- A pair of Atmospheric Rivers (AR) are forecast to make landfall in the Pacific Northwest (PNW) early Mon 25 Dec and continue through Wed 27 Dec.
- The GEFS control run is forecasting AR1 to AR2 conditions (based on Ralph et al. 2019 AR scale) for the first AR period and AR2 to AR3 conditions for the second AR period for the PNW.
- The GEFS control run is forecasting up to AR1 for the first AR period and AR1 to AR2 conditions for the second AR period for Northern CA.
- There is uncertainty in the AR landfall timing, duration and possible break in AR conditions in the GEFS, ECMWF EPS and West-WRF Ensembles.
- The National Weather Service (NWS) Weather Prediction Center (WPC) is currently forecasting 3-day precipitation totals ≥ 2 " with highest precipitation totals over the Olympic Peninsula and CA/OR border.
- The WPC Excessive Rainfall Outlook (ERO) indicates a Marginal Risk (level 1 of 4, at least 5%) of exceeding flash flood guidance for the Olympic Peninsula for the 24-hour period ending at 4 AM Tue 26 Dec.
- The NWS Climate Prediction Center's Day 8-14 Hazard Outlook shows risks of heavy precipitation for Northern and Central CA from 29 Dec 2023 through 2 Jan 2024 with the surface low and the associated frontal boundary and potential third AR at the end of next week.

CW3E AR Outlook: 22 Dec 2023

GFS IVT Init 00Z Wed 22 Dec 2023

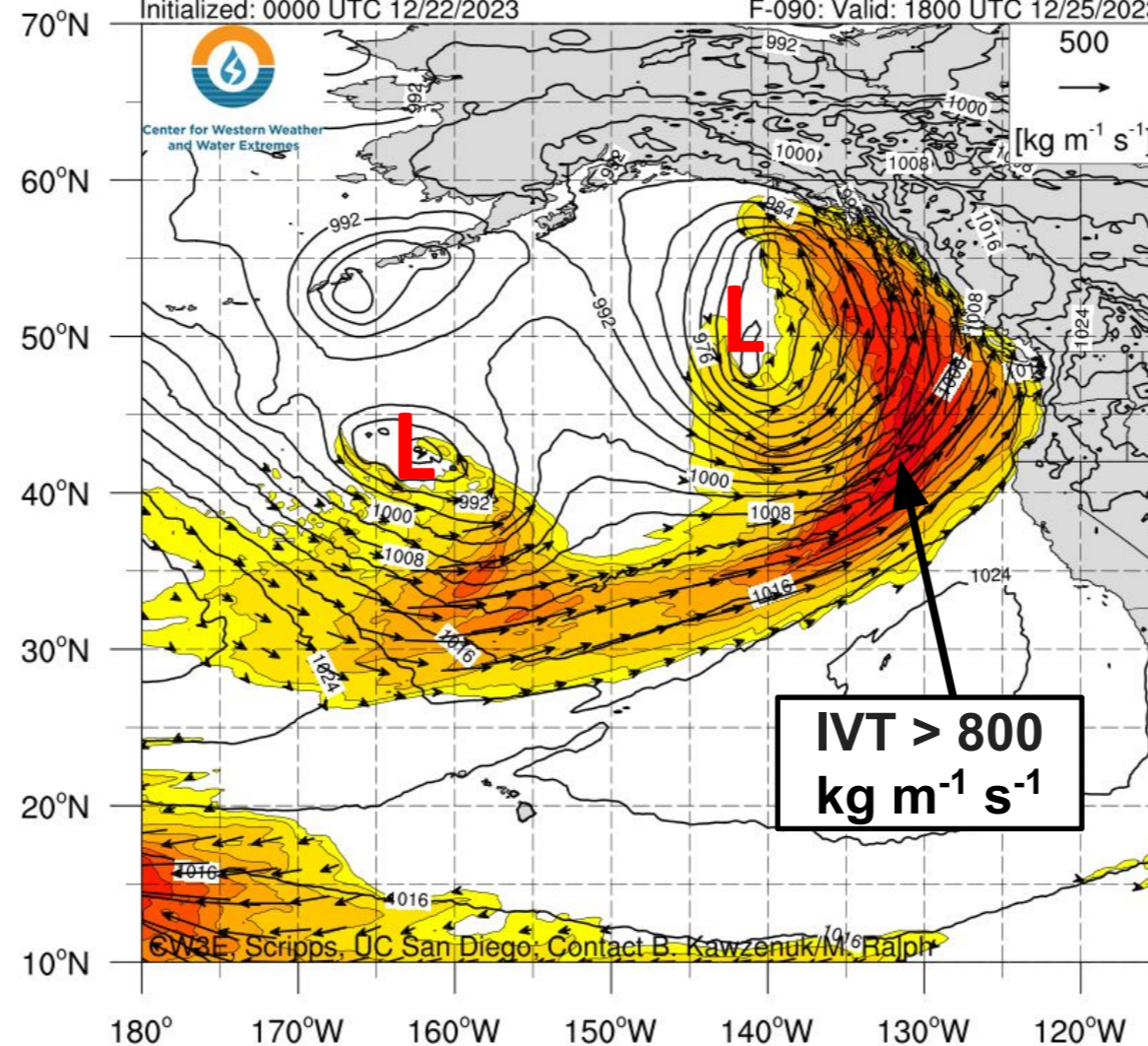
A) 4PM PT Sun 24 Dec 2023

NCEP GFS IVT ($\text{kg m}^{-1} \text{s}^{-1}$; shaded), IVT Vector, and SLP (hPa; contours)
Initialized: 0000 UTC 12/22/2023 F-072: Valid: 0000 UTC 12/25/2023



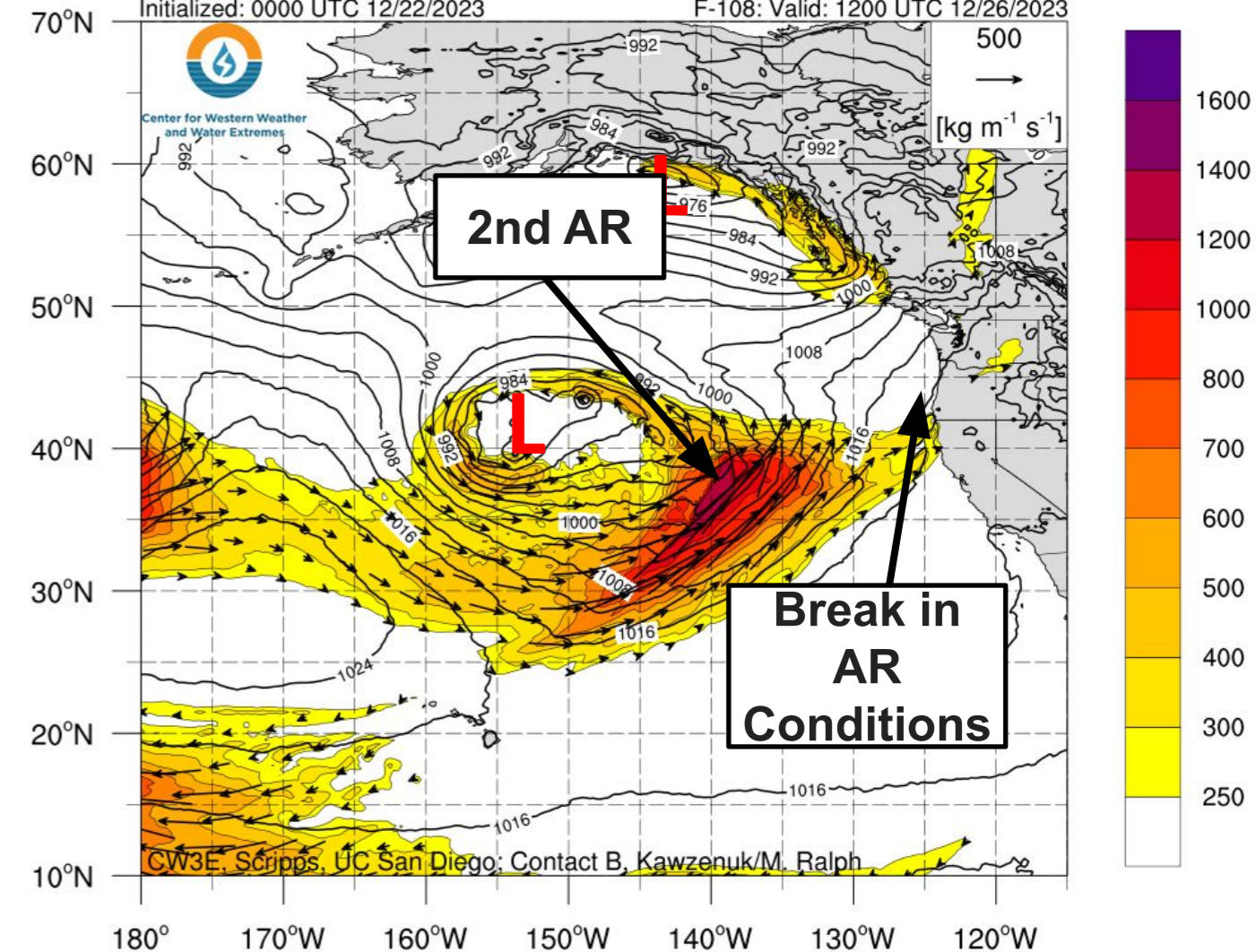
B) 10AM PT Mon 25 Dec 2023

NCEP GFS IVT ($\text{kg m}^{-1} \text{s}^{-1}$; shaded), IVT Vector, and SLP (hPa; contours)
Initialized: 0000 UTC 12/22/2023 F-090: Valid: 1800 UTC 12/25/2023



C) 4AM PT Tue 26 Dec 2023

NCEP GFS IVT ($\text{kg m}^{-1} \text{s}^{-1}$; shaded), IVT Vector, and SLP (hPa; contours)
Initialized: 0000 UTC 12/22/2023 F-108: Valid: 1200 UTC 12/26/2023

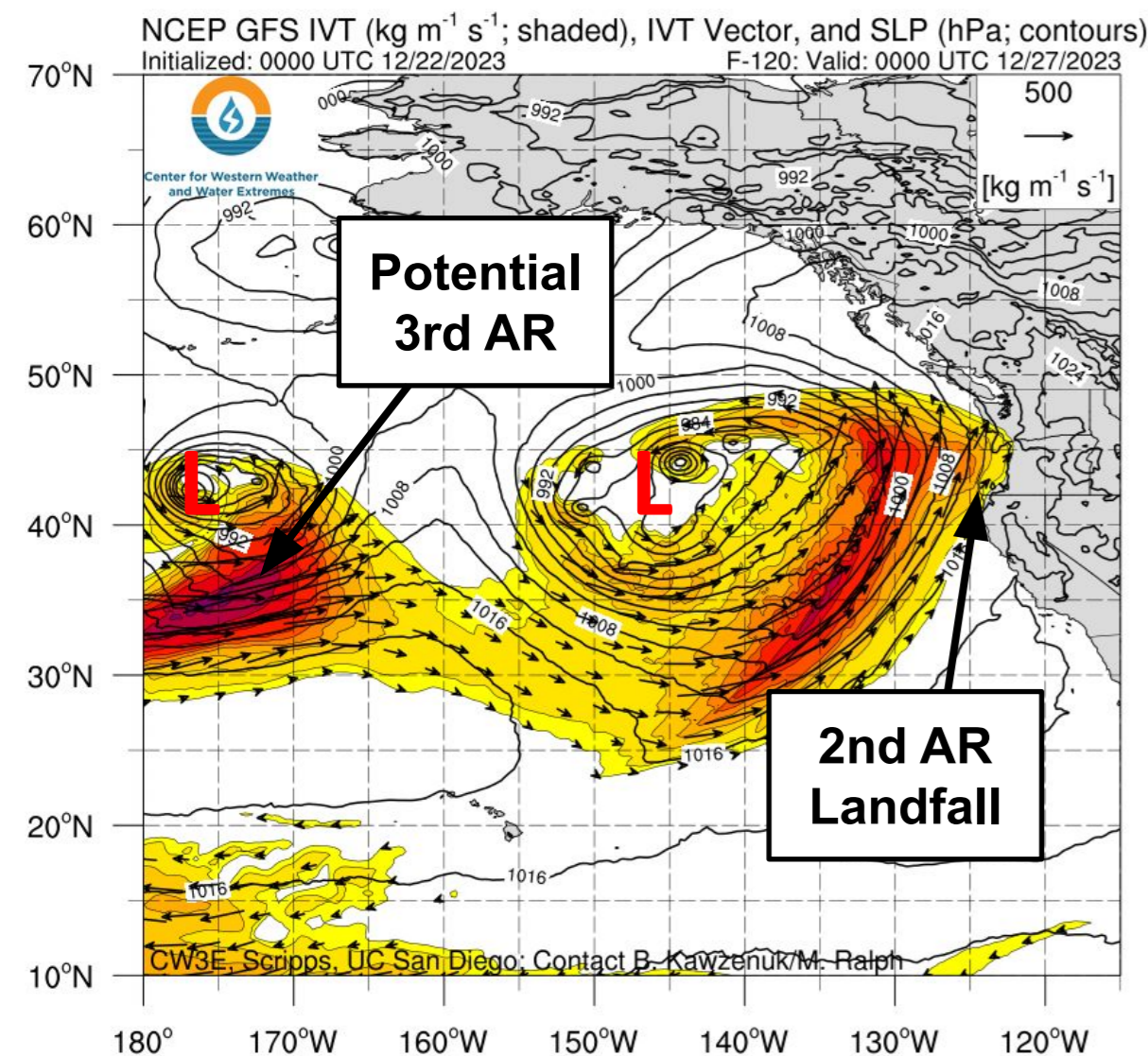


- The first AR and associated low pressure system are forecast to progress toward the USWC through the weekend, making landfall into the PNW early Mon 25 Dec (Figure A and B).
- The GFS is forecasting $\text{IVT} > 800 \text{ kg m}^{-1} \text{s}^{-1}$ in the core of the AR as it makes landfall into the PNW (Figure B).
- An inverted trough behind the first low pressure system leads to a break in AR conditions early on Tue 26 Dec (Figure C).

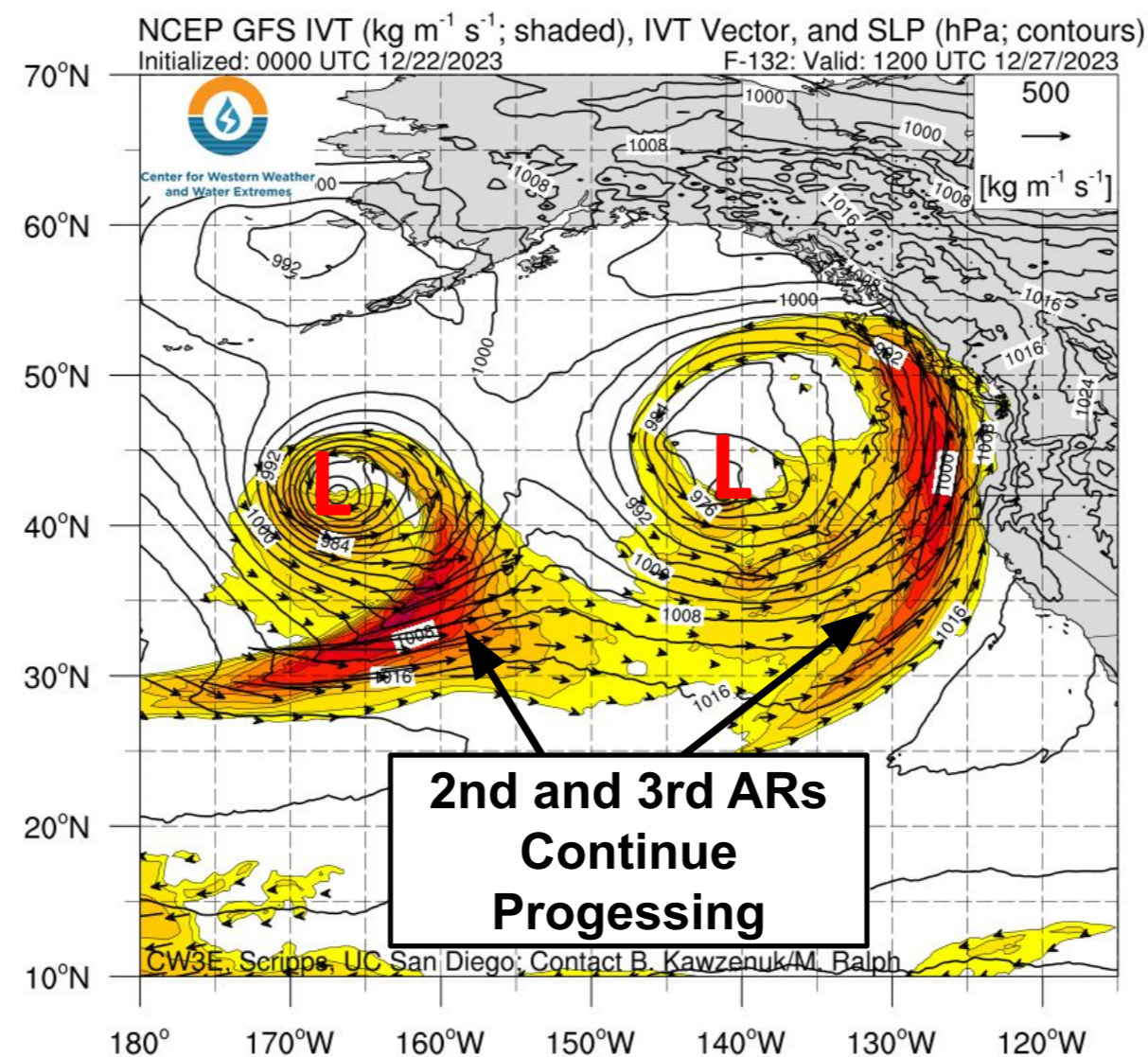
CW3E AR Outlook: 22 Dec 2023

GFS IVT Init 00Z Wed 22 Dec 2023

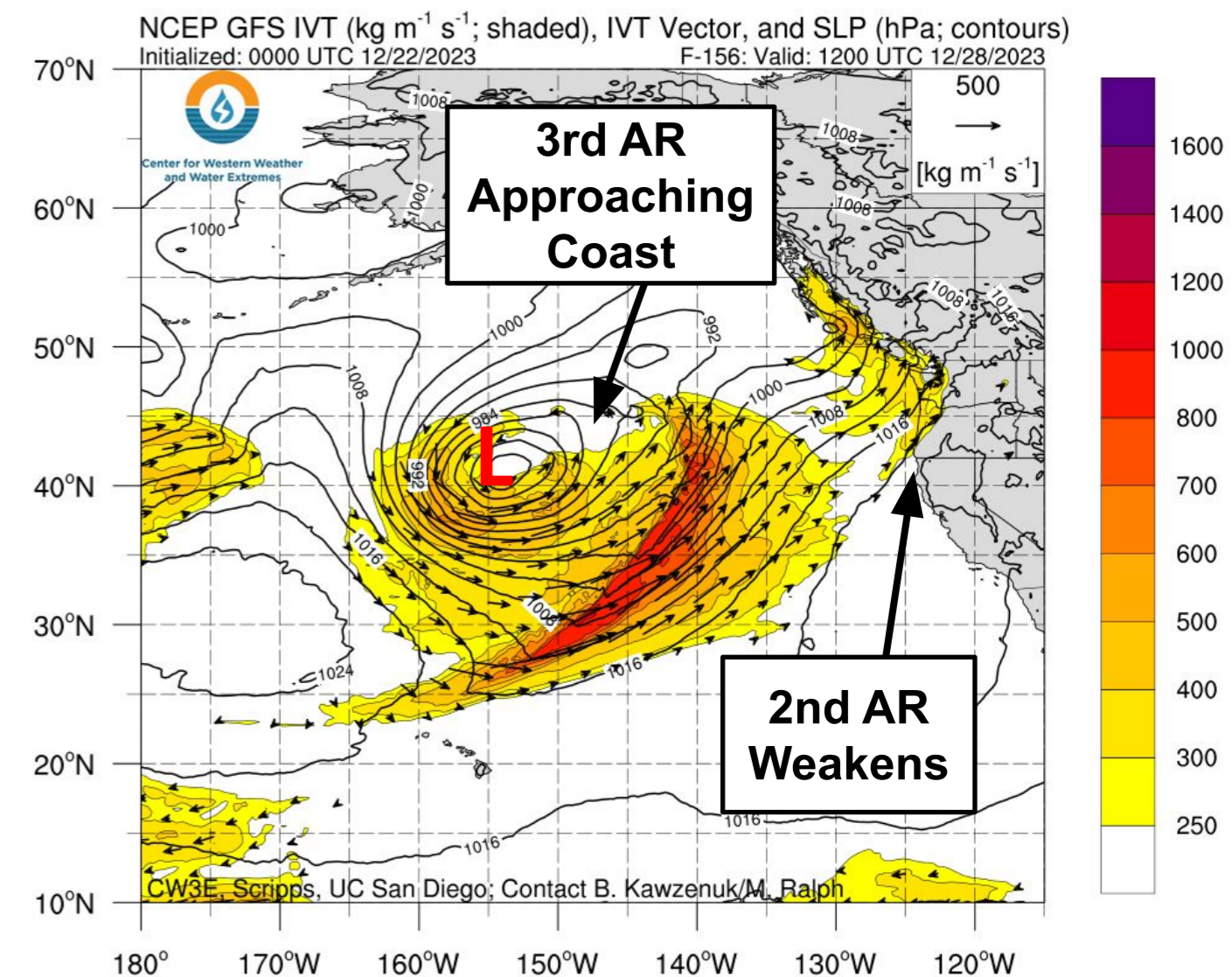
D) 4PM PT Tue 26 Dec 2023



E) 4AM PT Wed 27 Dec 2023



F) 4AM PT Thu 28 Dec 2023



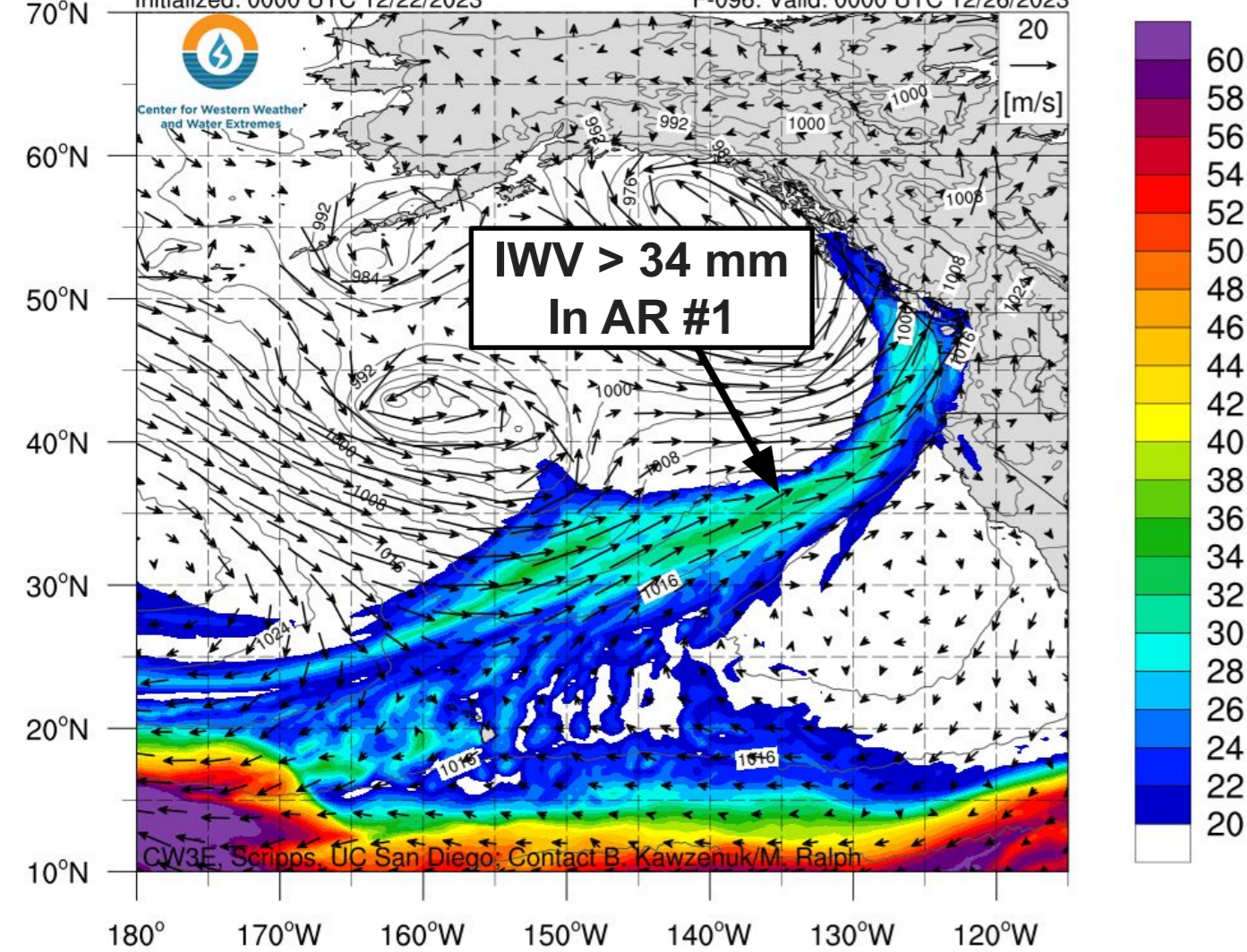
- The second AR is forecast to make landfall over the PNW on Tue 26 Dec and continue through Wed 27 Dec as the parent cyclone associated with the second AR persists in the Gulf of Alaska (Figures D and E).
- By this forecast period, a tertiary AR (that developed in the Central North Pacific on 25 Dec) is forecast to be progressing toward the North American West Coast (Figures E and F).

CW3E AR Outlook: 22 Dec 2023

GFS IWV Init 00Z Wed 22 Dec 2023

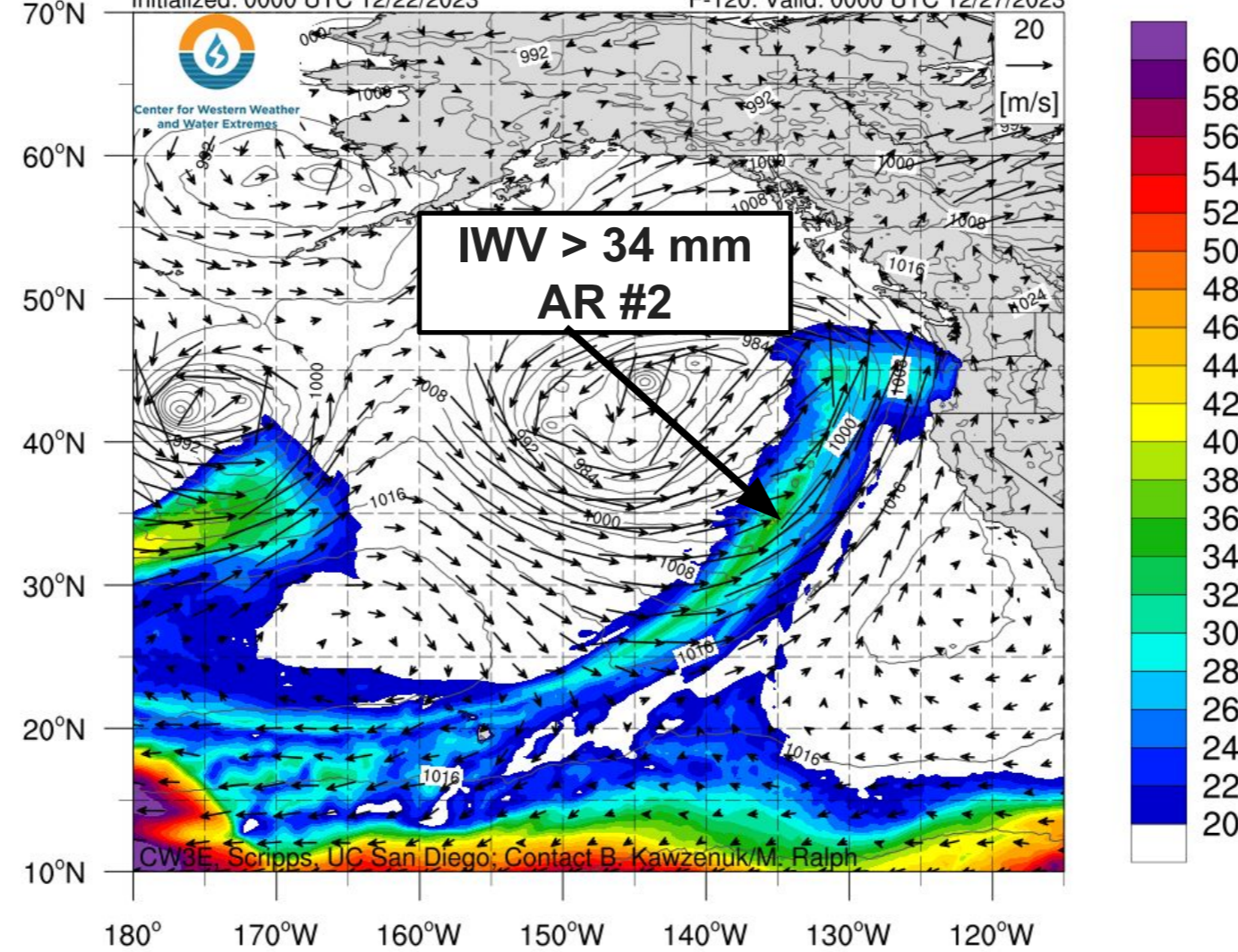
4PM PT Mon 25 Dec 2023

NCEP GFS IWV (mm; shaded), 850-hPa Wind (vectors), and SLP (hPa; contours)
Initialized: 0000 UTC 12/22/2023 F-096: Valid: 0000 UTC 12/27/2023



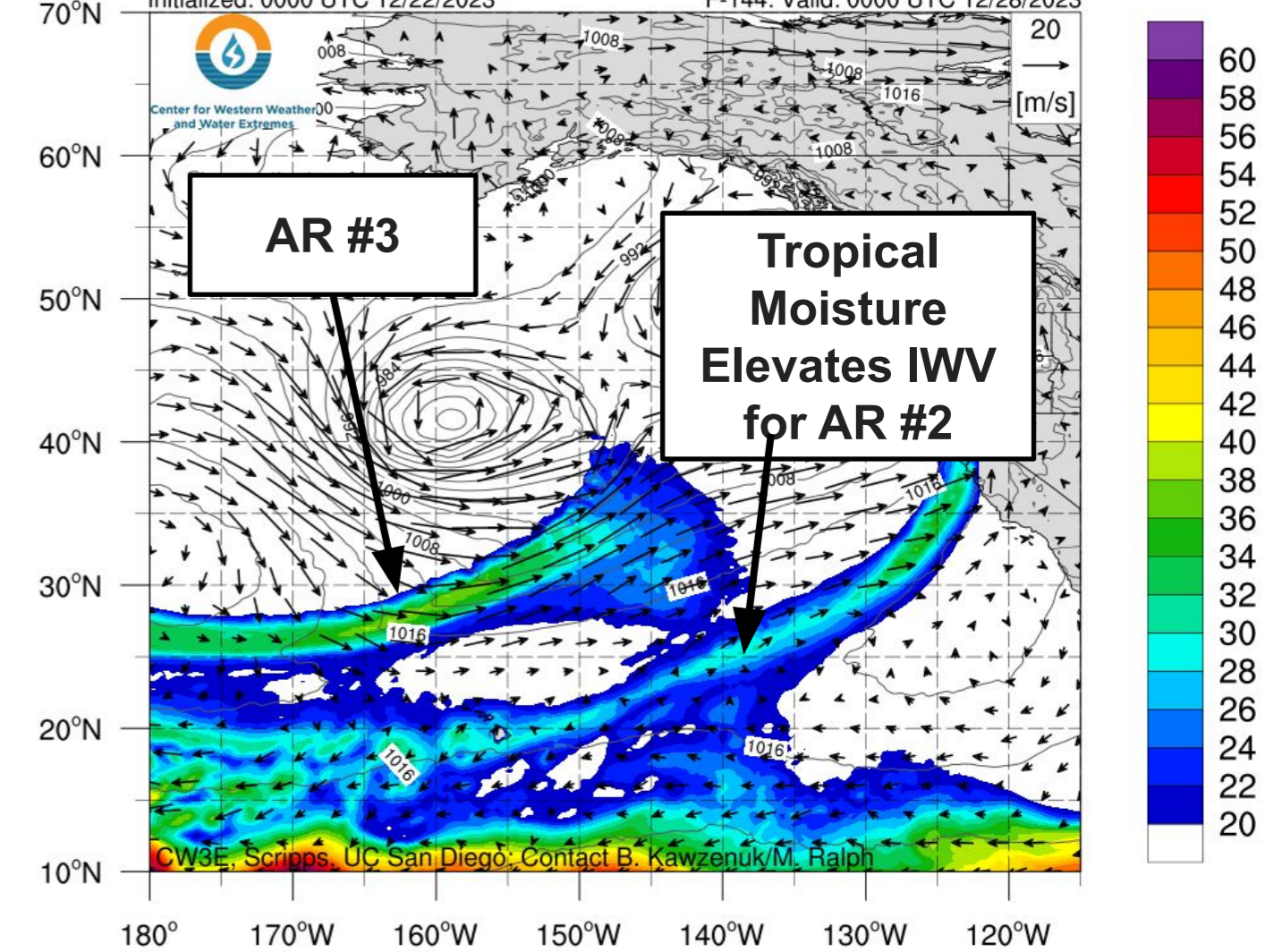
4PM PT Tue 26 Dec 2023

NCEP GFS IWV (mm; shaded), 850-hPa Wind (vectors), and SLP (hPa; contours)
Initialized: 0000 UTC 12/22/2023 F-120: Valid: 0000 UTC 12/27/2023



4PM PT Wed 27 Dec 2023

NCEP GFS IWV (mm; shaded), 850-hPa Wind (vectors), and SLP (hPa; contours)
Initialized: 0000 UTC 12/22/2023 F-144: Valid: 0000 UTC 12/28/2023

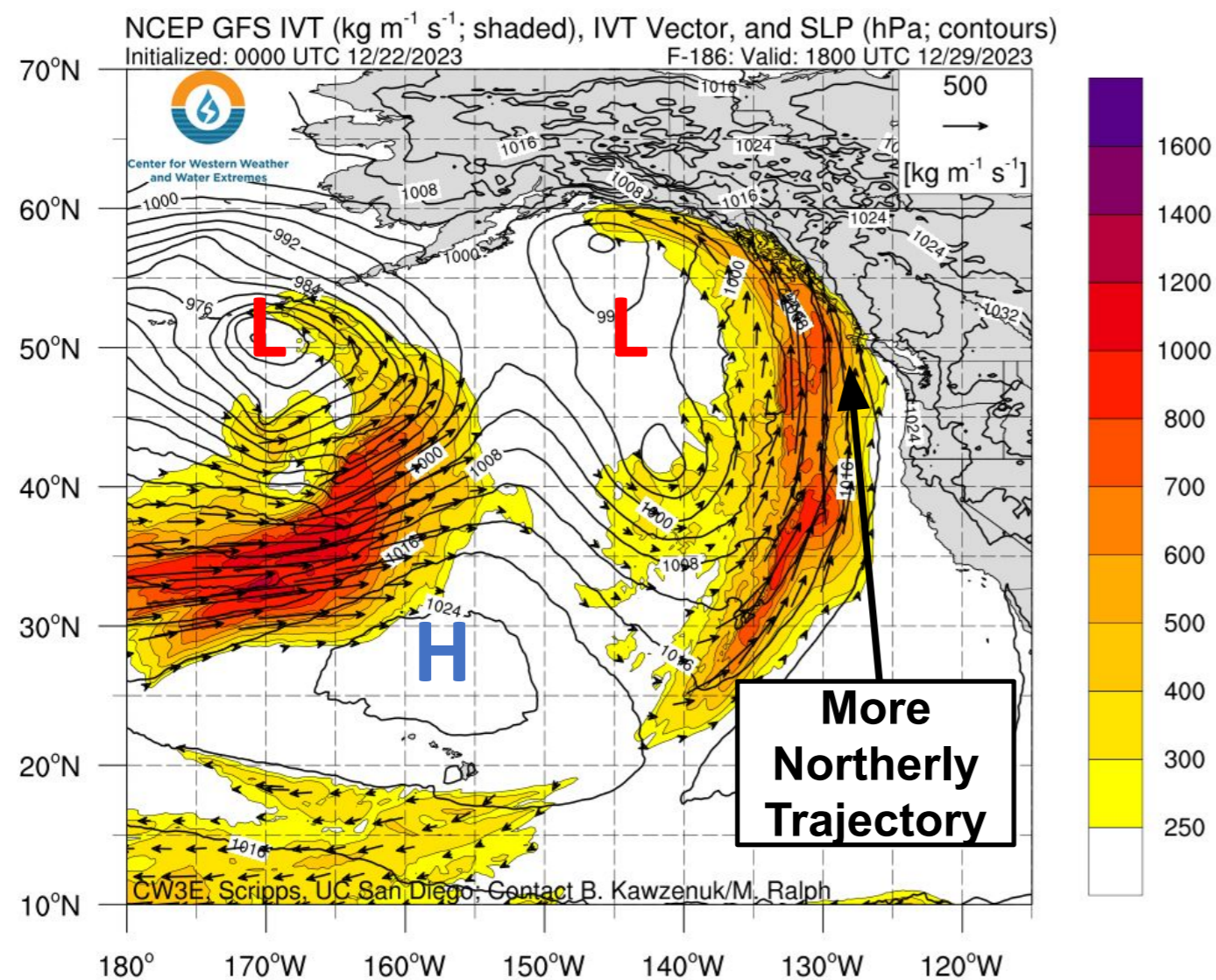


- The first and second ARs are forecast to be associated with a robust tropical moisture export (TME) extending from north of Hawaii, with Integrated Water Vapor (IWV) > 34 mm in the core of the AR.
- Elevated IWV continues in the core through the duration of the event, tapping into moisture from the Central Pacific.

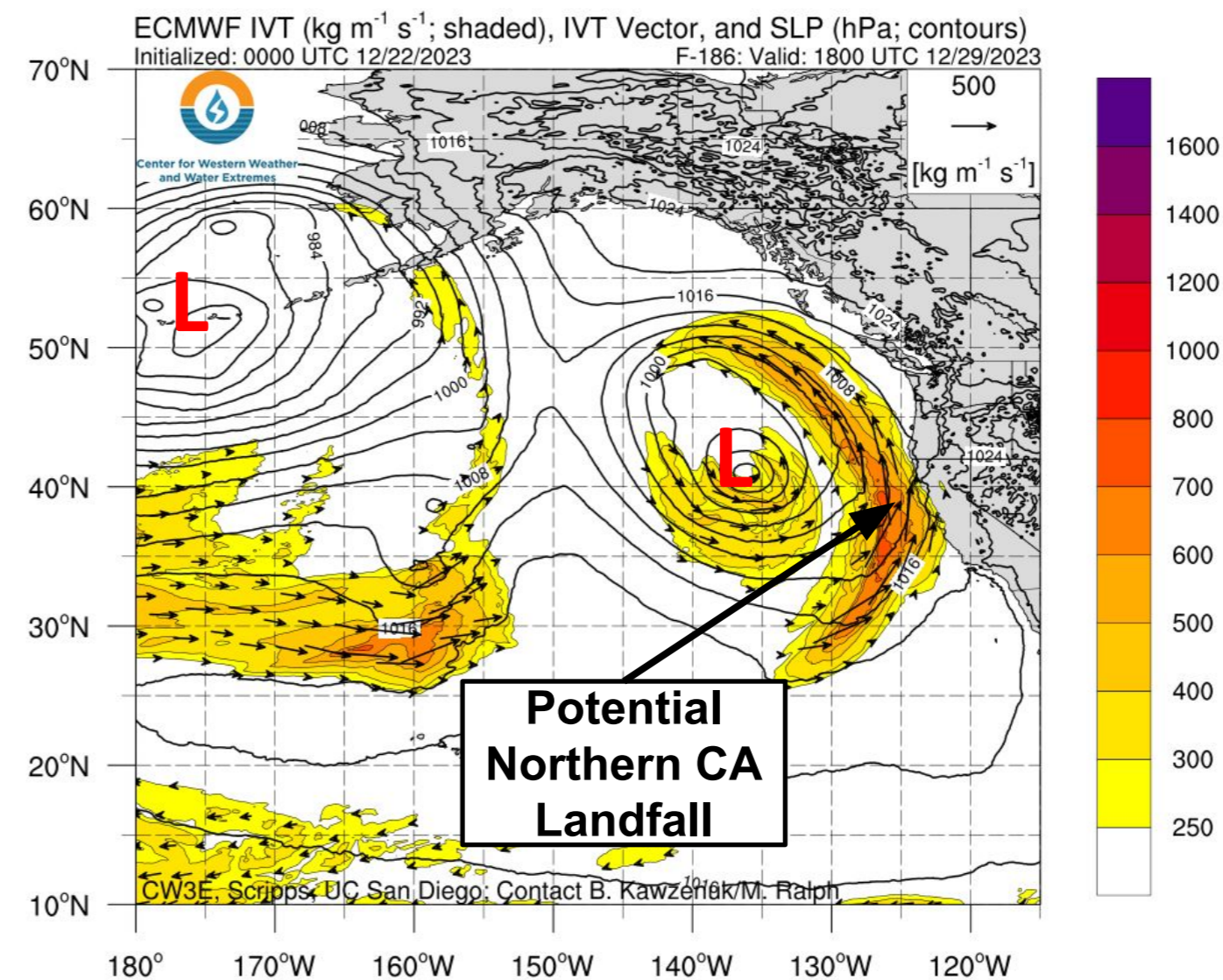
CW3E AR Outlook: 22 Dec 2023

GFS and ECMWF IVT: Init 00Z Wed 22 Dec 2023

GFS: Valid 10AM PT Fri 29 Dec 2023

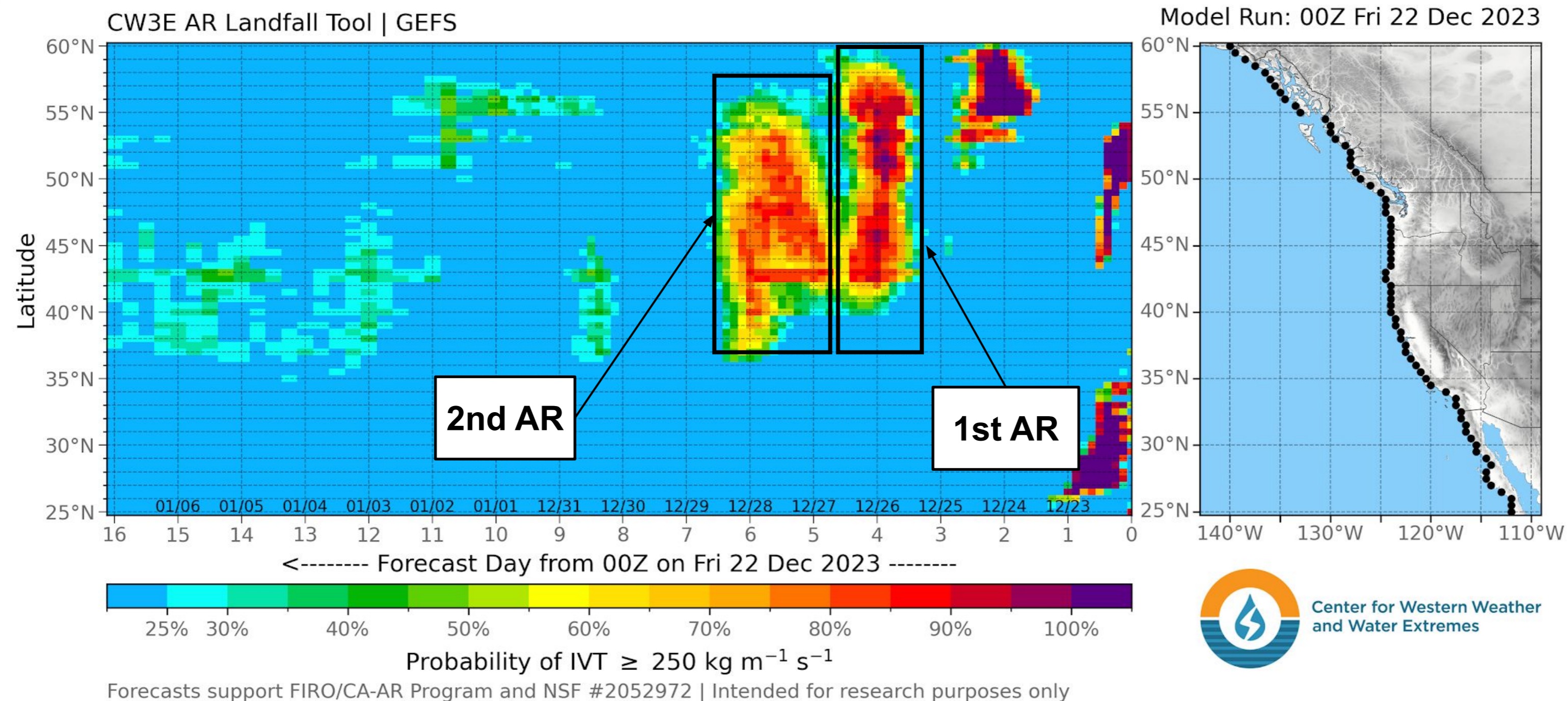


ECMWF: Valid 10AM PT Fri 29 Dec 2023



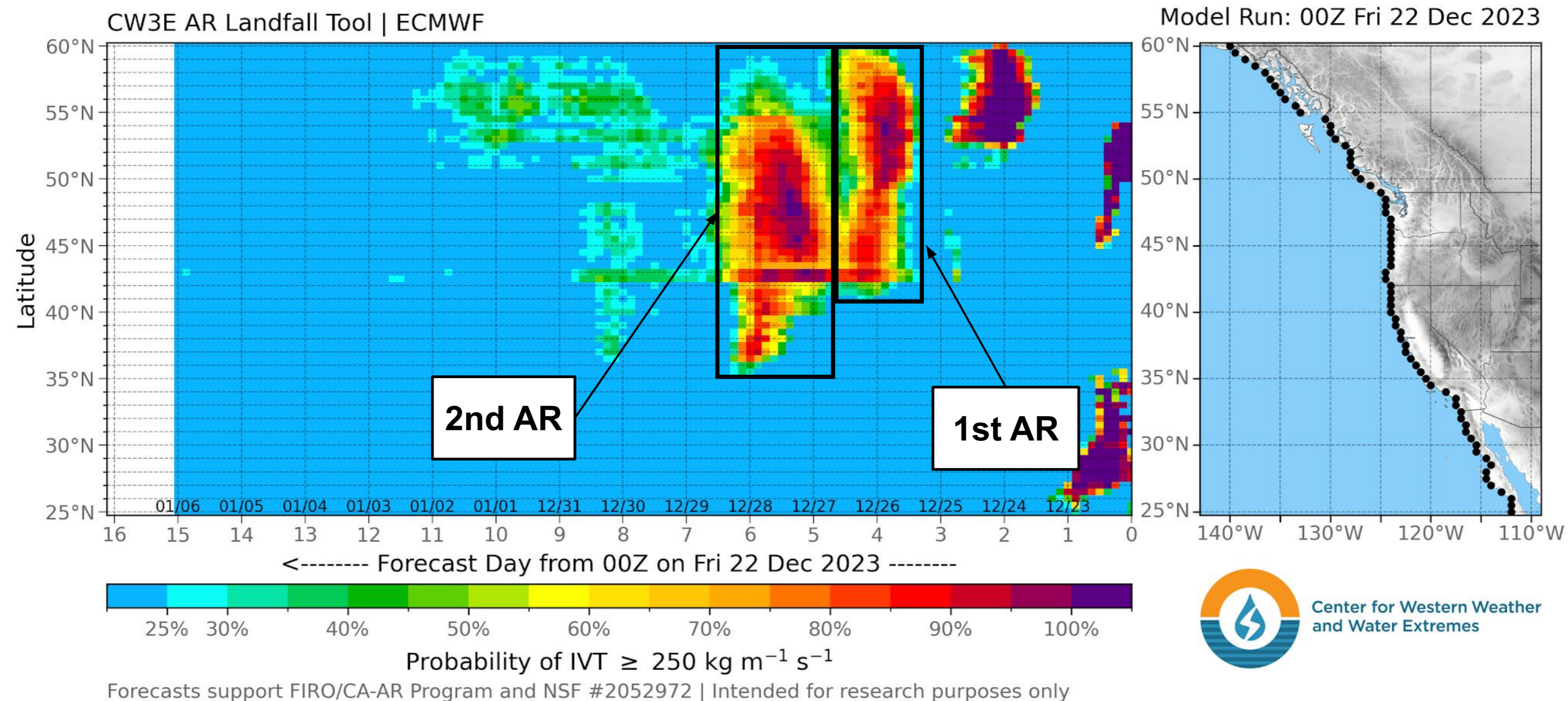
- The 00Z GFS and 00Z ECMWF are uncertain on the trajectory of the third AR at the end of next week.
- The GFS is currently forecasting a northerly landfall into S. AK and British Columbia while the ECMWF is forecasting a landfall in N. CA.

CW3E AR Outlook: 22 Dec 2023



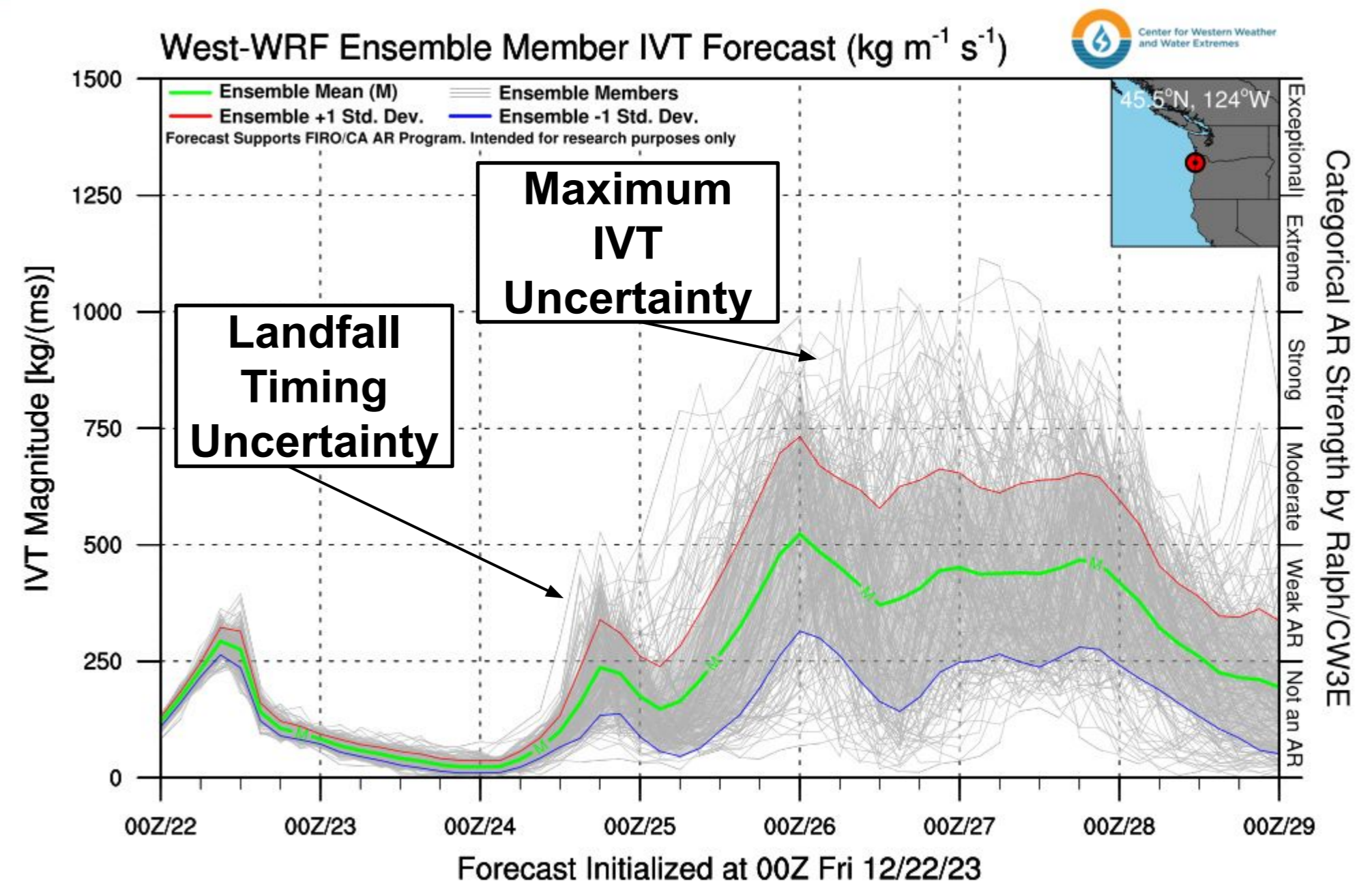
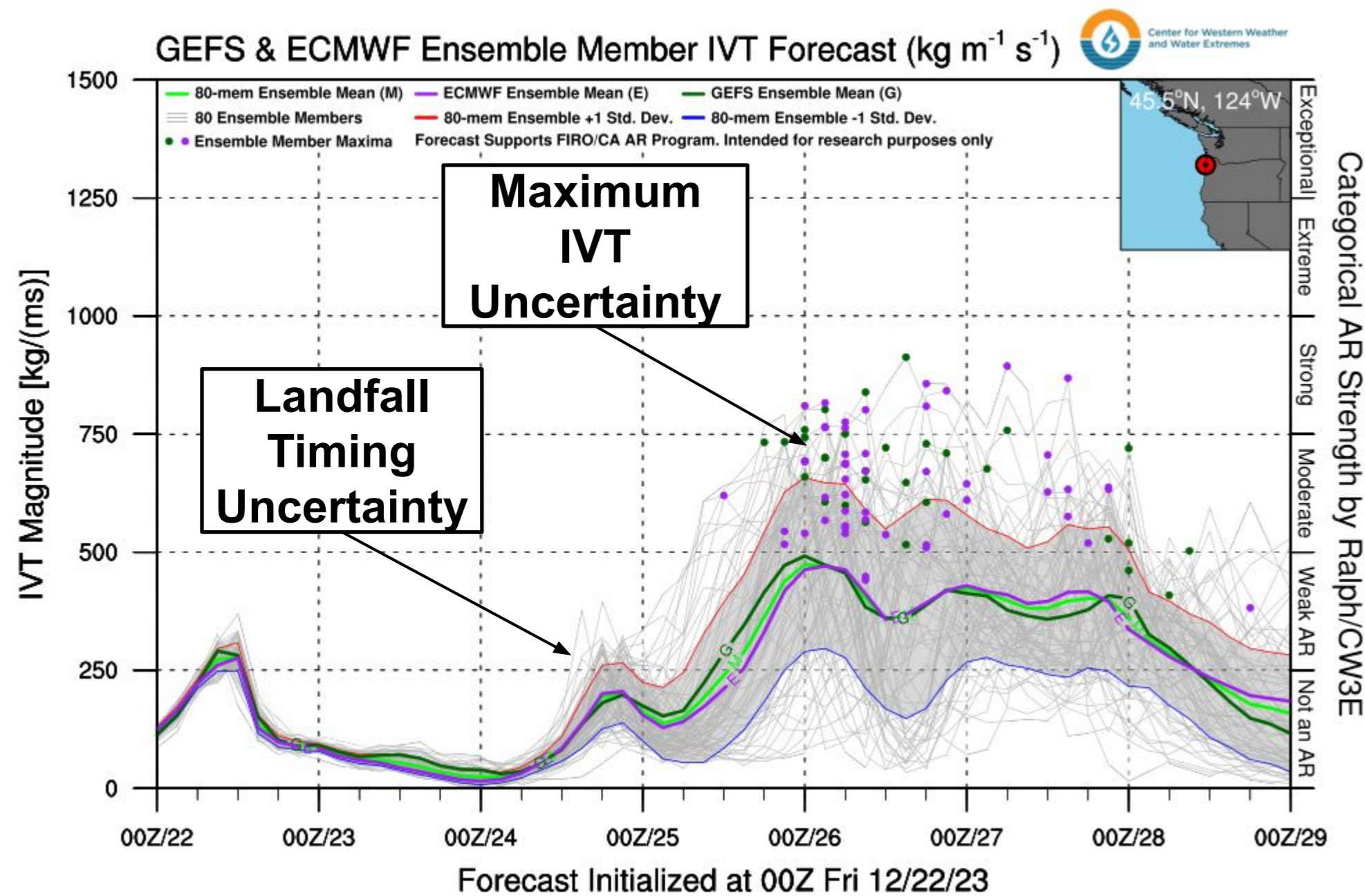
- The GEFS control is showing very high confidence ($>85\%$) in $IVT > 250 \text{ kg m}^{-1} \text{ s}^{-1}$ over the North American coast from British Columbia down through the CA/OR border during the first AR period from late Mon 25 Dec through early Tue 26 Dec.
- The GEFS control is also quite confident in ~ 36 hour period of $IVT > 250 \text{ kg m}^{-1} \text{ s}^{-1}$ with the second AR (preceded by a short break), with initial landfall over the PNW British Columbia and then with probabilities of $IVT > 250$ units extending into Northern California near the end of the period.

CW3E AR Outlook: 22 Dec 2023



- The ECMWF EPS control is forecasting two AR periods much like the GEFs control, although the EPS is showing higher confidence.
- The EPS is also showing higher confidence in no break in AR conditions for the regions from 43°N to 47°N in OR and WA.

CW3E AR Outlook: 22 Dec 2023



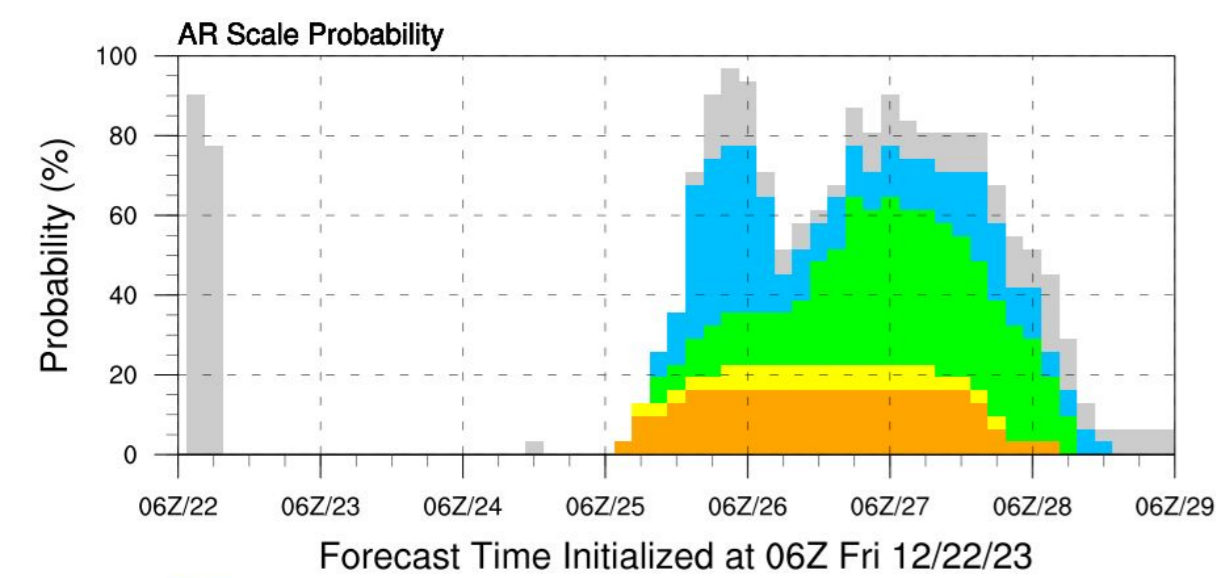
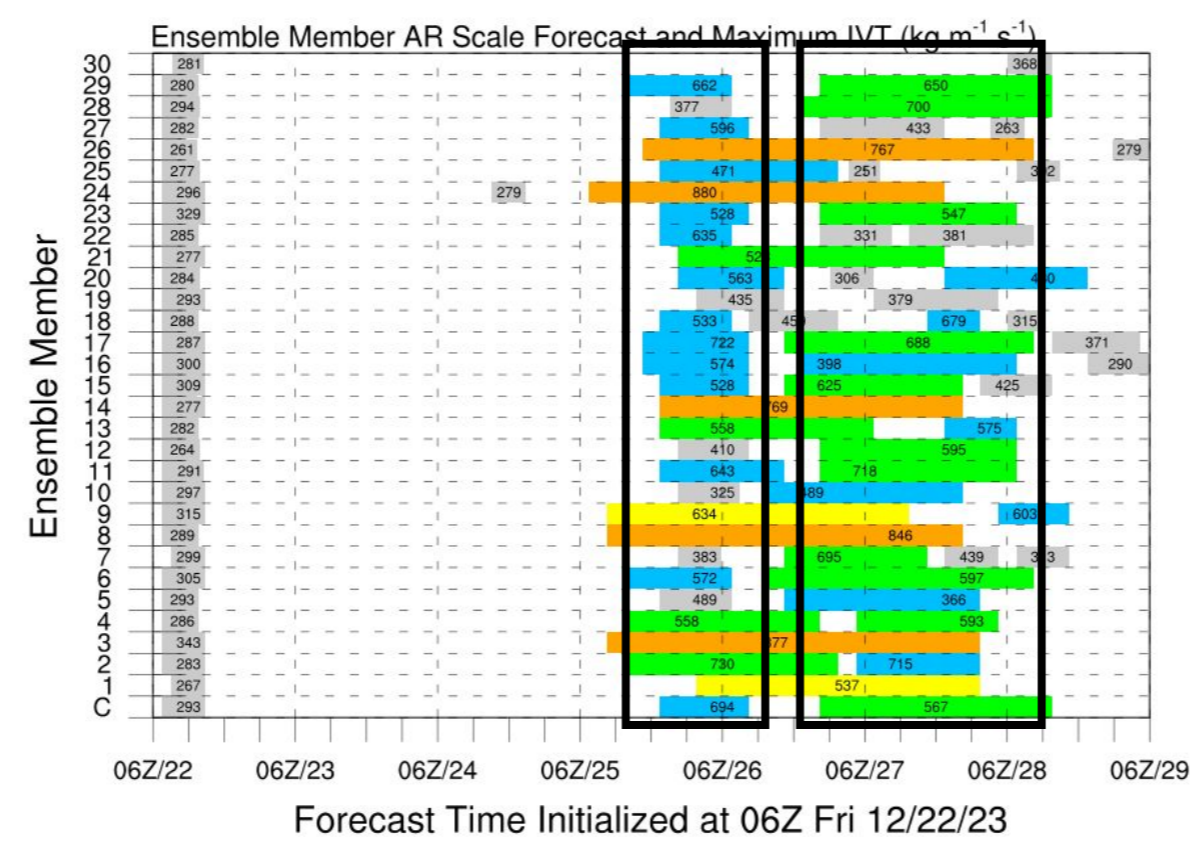
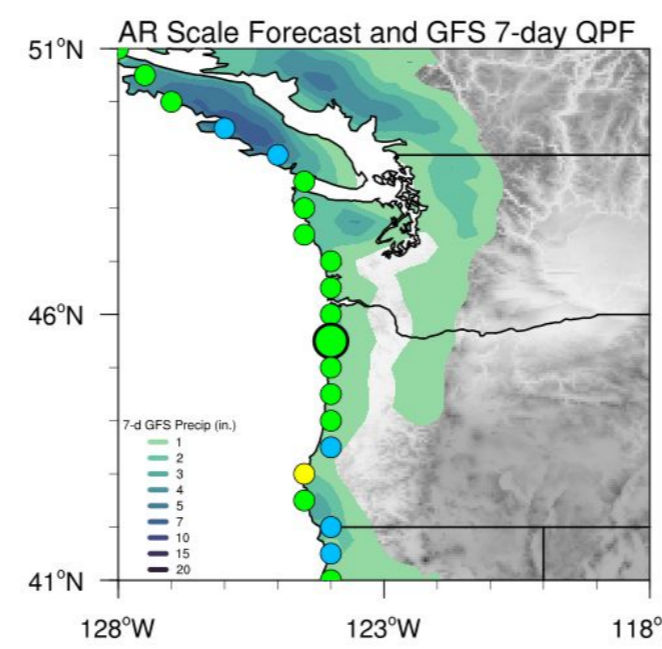
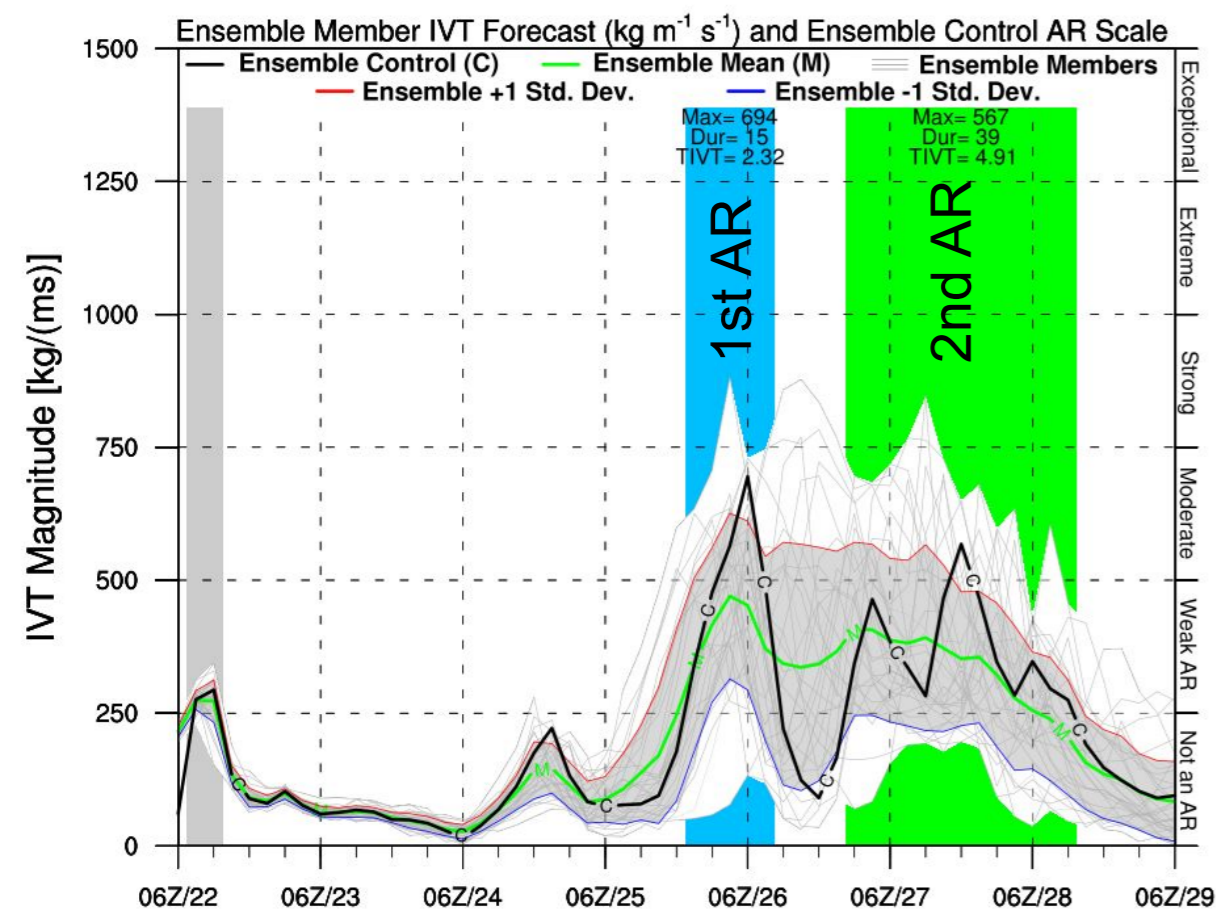
- IVT forecast plumes from the global models show considerable uncertainty in maximum IVT and AR duration. There is also uncertainty regarding if a break will occur between the ARs and how long the break will last.
- The West-WRF Ensemble similarly shows wide variability amongst its members in the IVT magnitude at landfall as well as the timing and peak of maximum IVT at this location. West-WRF mean and peak IVT is higher than either of the GEFS and ECMWF.

CW3E AR Outlook: 22 Dec 2023

GEFS 7-day AR Scale and IVT Forecast

GEFS Ensemble Initialized: 06Z Fri 12/22/23

Location: 45.5°N 124°W



- The GEFS control is forecasting two AR periods for the point at 45.5° N, 124.0° W (coastal OR).
- 30/31 (97%) GEFS ensemble members are forecasting at least AR1 conditions at during either AR period.
- 24/31 (77%) of the members (including the control) are forecasting at least AR1 conditions during the first AR period.
- 26/31 (84%) of the members (including the control) are forecasting at least AR1 conditions during the second AR period.
- 7/31 (23%) of the members (including the control) are not forecasting a break in AR conditions at this point.
- There is uncertainty in the duration of AR conditions amongst GEFS members.



AR 1 (blue) AR 2 (green) AR 3 (yellow) AR 4 (orange) AR 5 (red)

Image created: 12 UTC 12/22/2023

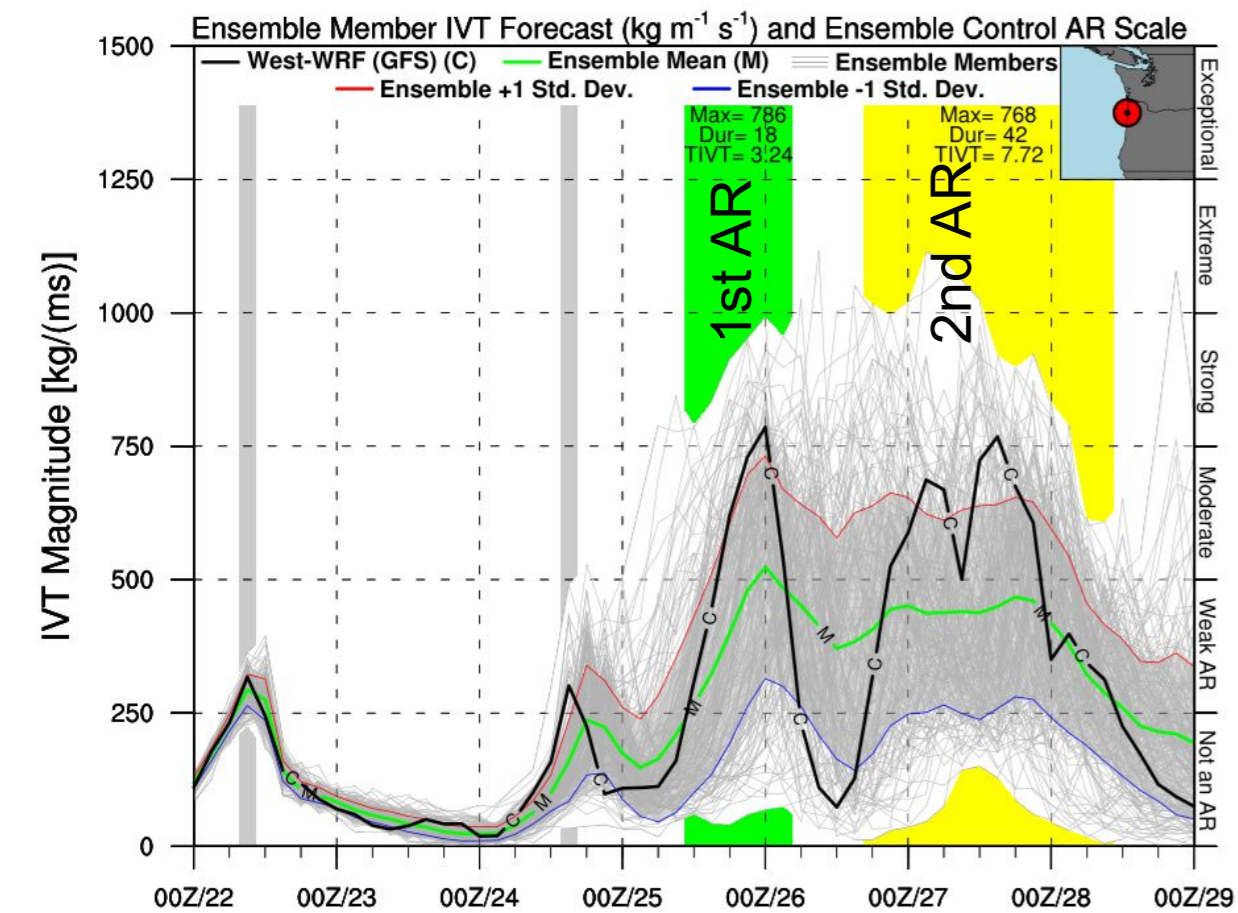
More information: <http://cw3e.ucsd.edu> AR Scale based on Ralph et al. (2019; BAMS), contact M. Ralph

CW3E AR Outlook: 22 Dec 2023

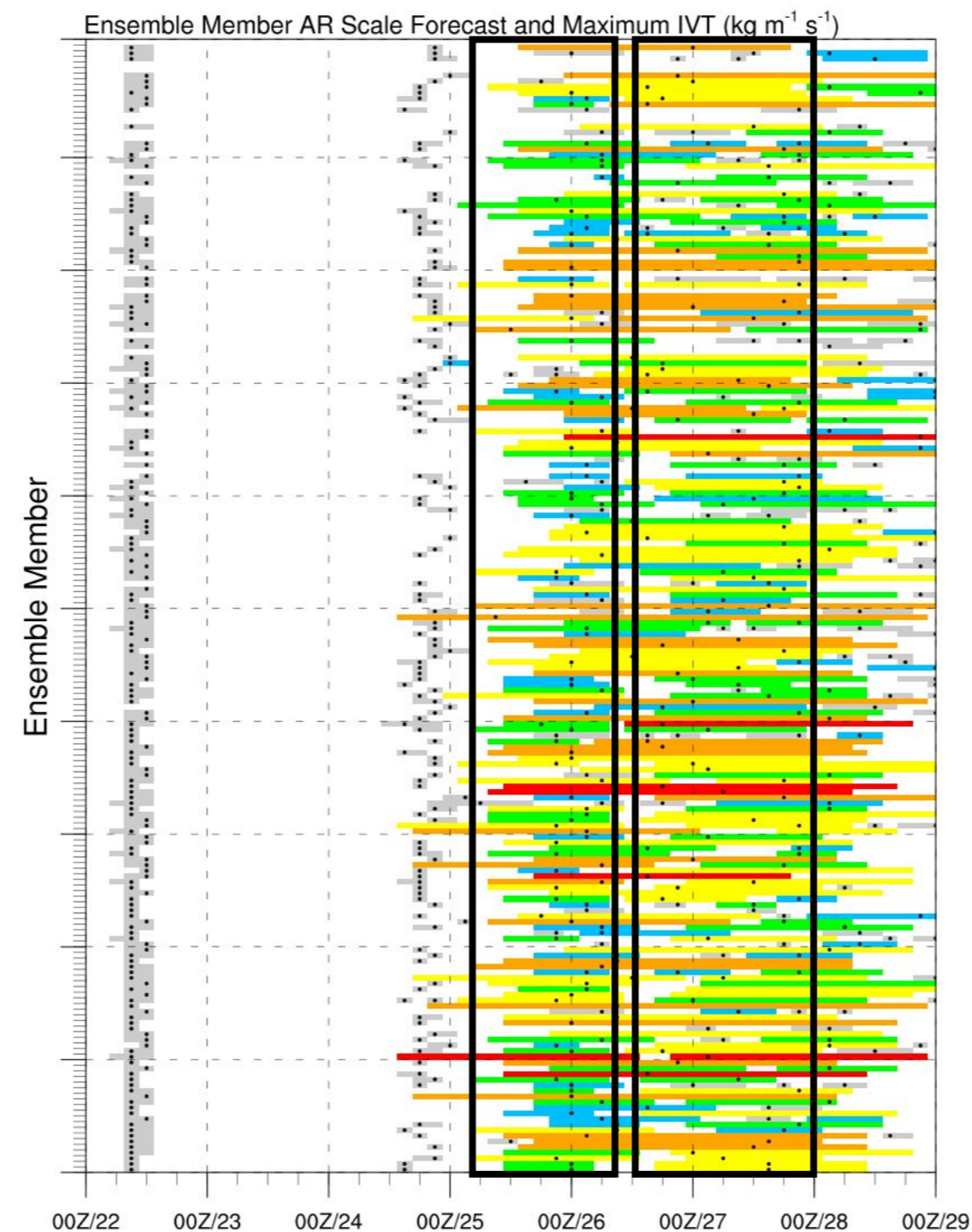
West-WRF Ensemble 7-day AR Scale and IVT Forecast

West-WRF Ensemble Initialized: 00Z Fri 12/22/23

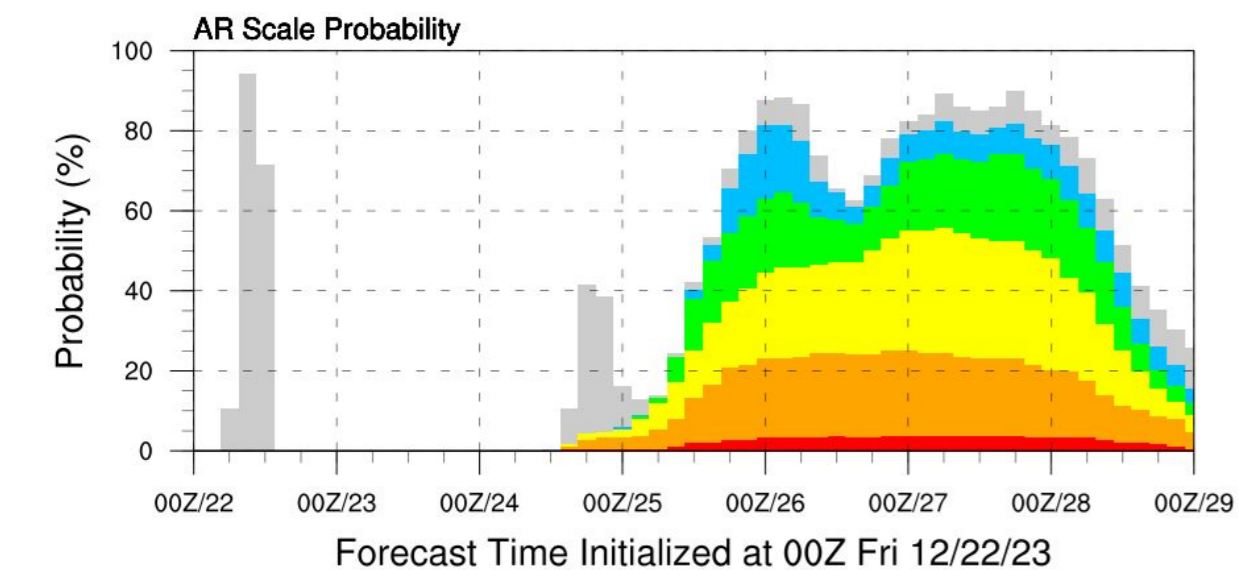
Location: 45.5°N 124°W



Categorical AR Strength by Ralph/CW3E



- The majority of West-WRF ensemble members are forecasting at least AR1 conditions for both AR periods at 45.5° N, 124.0° W.
- There is much uncertainty amongst West-WRF members in AR intensity and duration as well as whether or not there is a break in AR conditions at this location.
- There are several ensemble members forecasting AR4 to AR5 conditions at this location through both AR periods

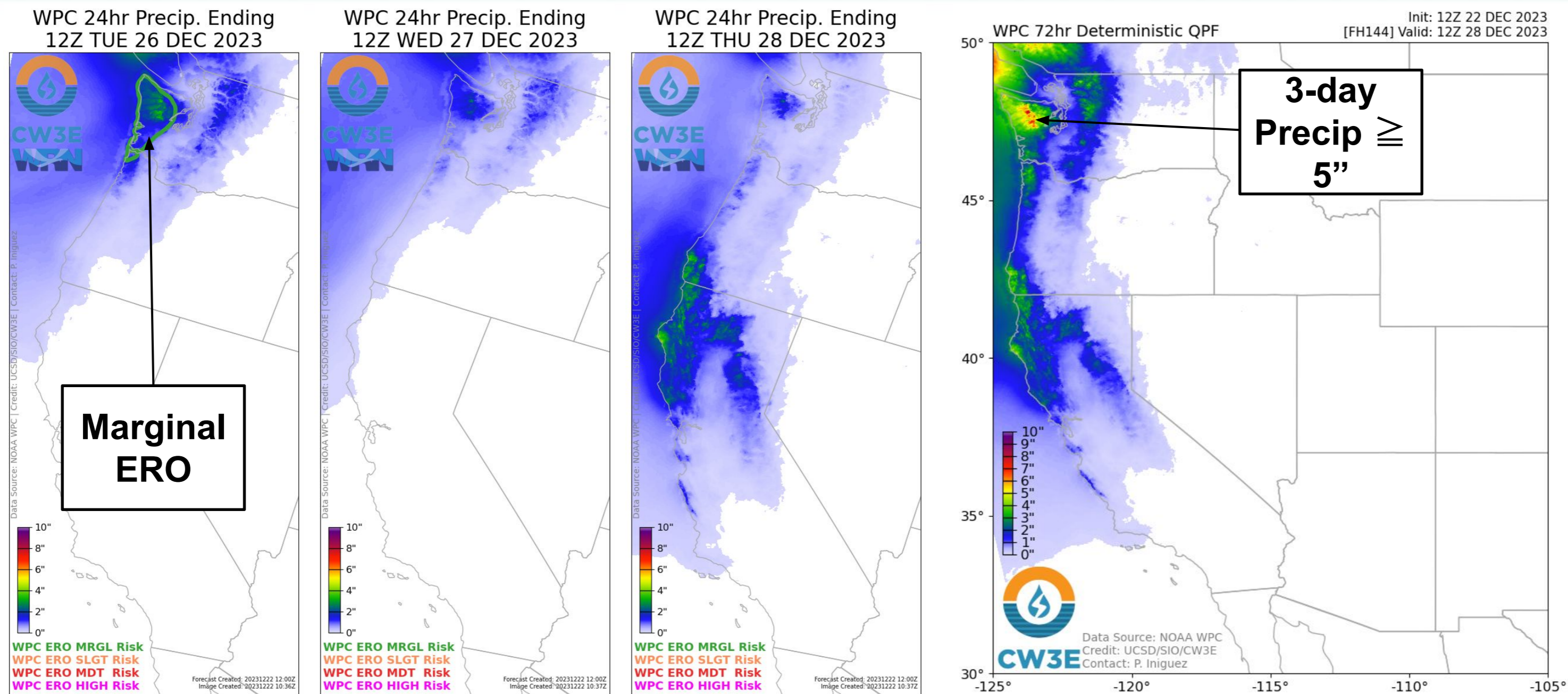


AR 1 AR 2 AR 3 AR 4 AR 5

Image created: 14 UTC 12/22/2023

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

CW3E AR Outlook: 22 Dec 2023

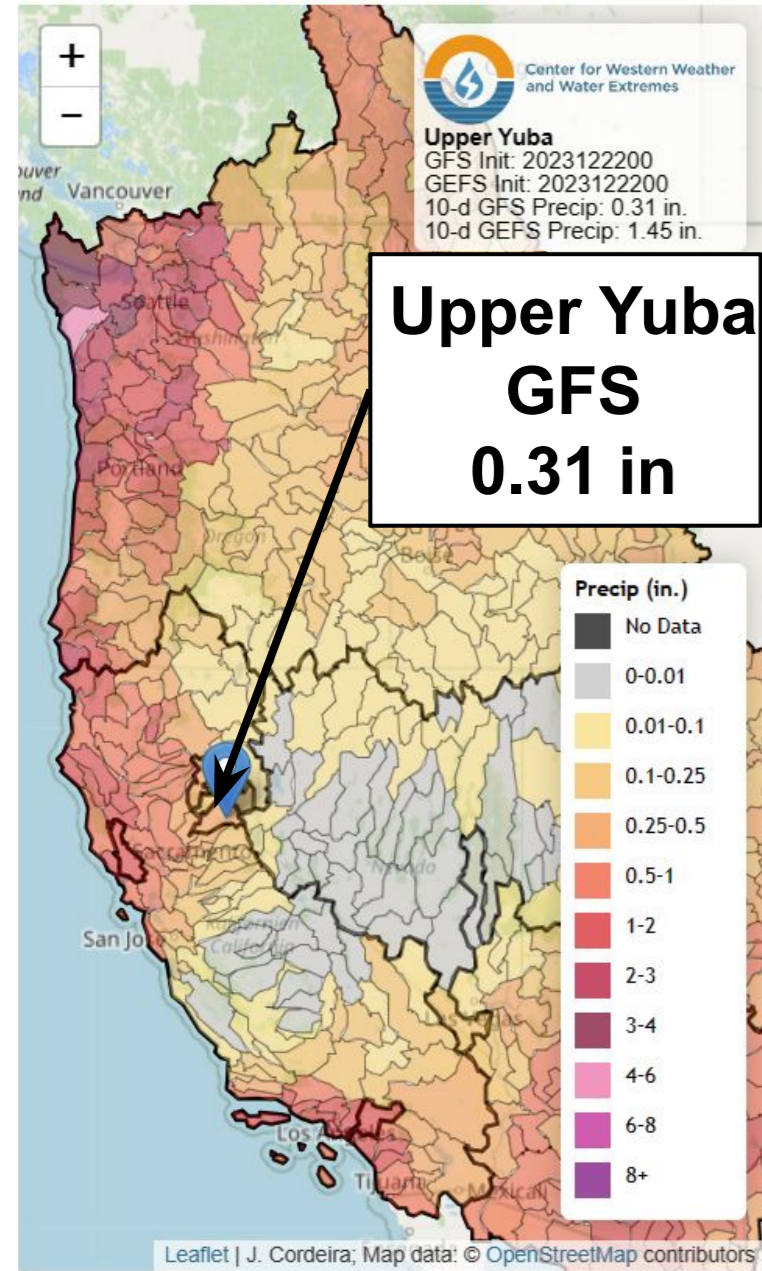


- The NWS WPC is forecasting precipitation totals ≥ 1 inches for regions along the PNW and Northern CA coasts and into the Cascades during the 24-hour periods ending at 12Z on 26, 27, and 28 Dec.
- NWS WPC 3-day precipitation totals are forecast to exceed 2 inches for the PNW and Northern CA coasts with the highest precipitation totals ≥ 5 inches over the Olympic Peninsula.
- The WPC Excessive Rainfall Outlook (ERO) indicates a Marginal Risk (level 1 of 4, at least 5%) of exceeding flash flood guidance across the Olympic Peninsula for the 24-hour period ending at 4 AM on Dec 26.

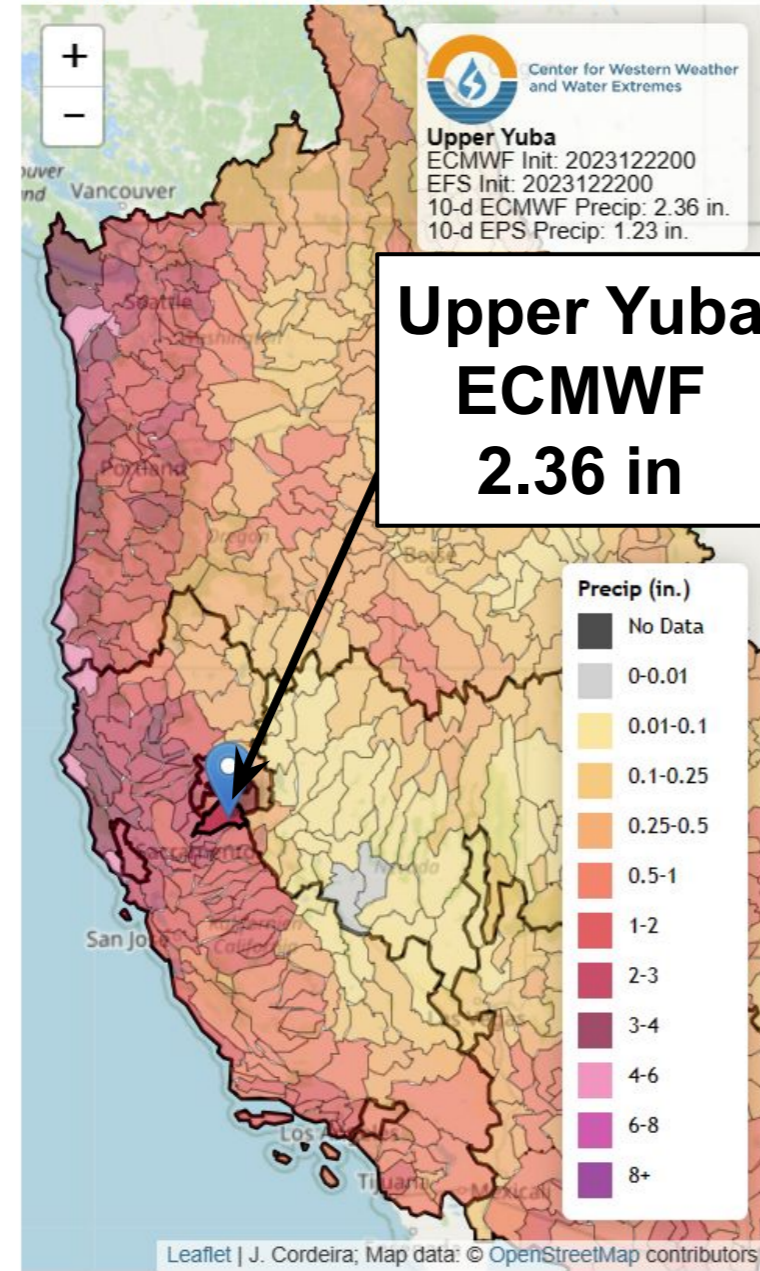
CW3E AR Outlook: 22 Dec 2023

10-day Watershed Precipitation Forecasts (Initialized 00Z 22 Dec)

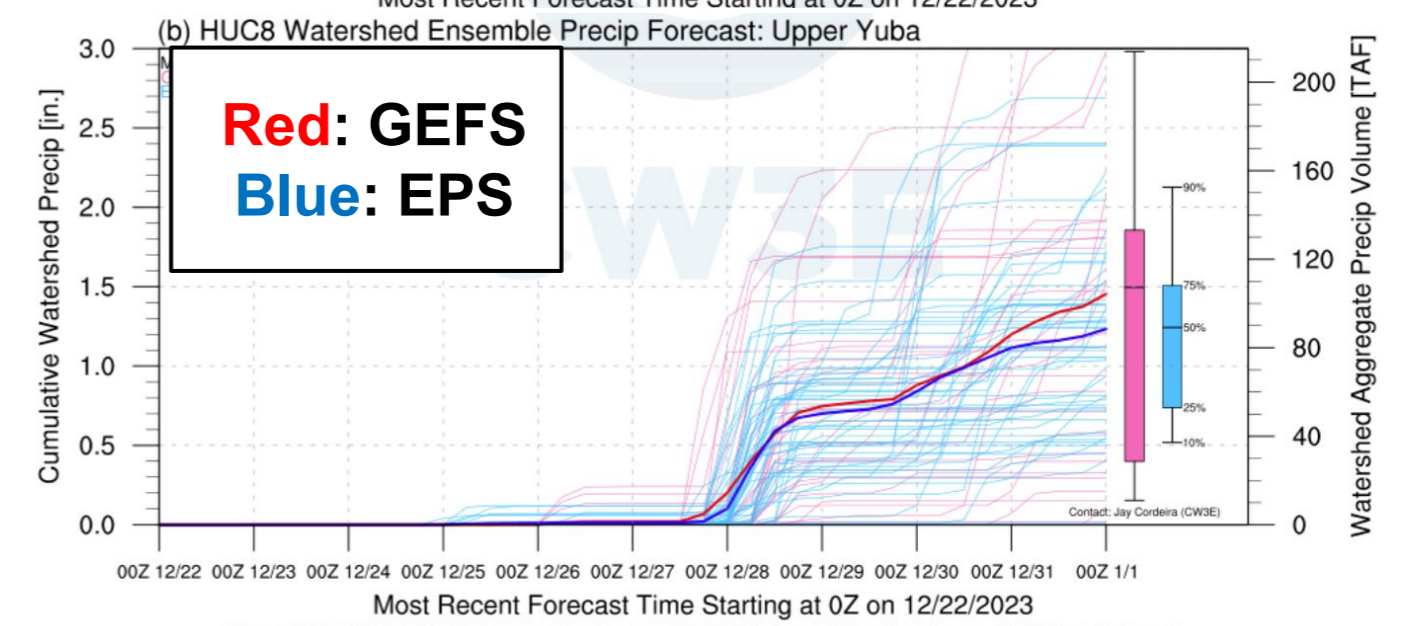
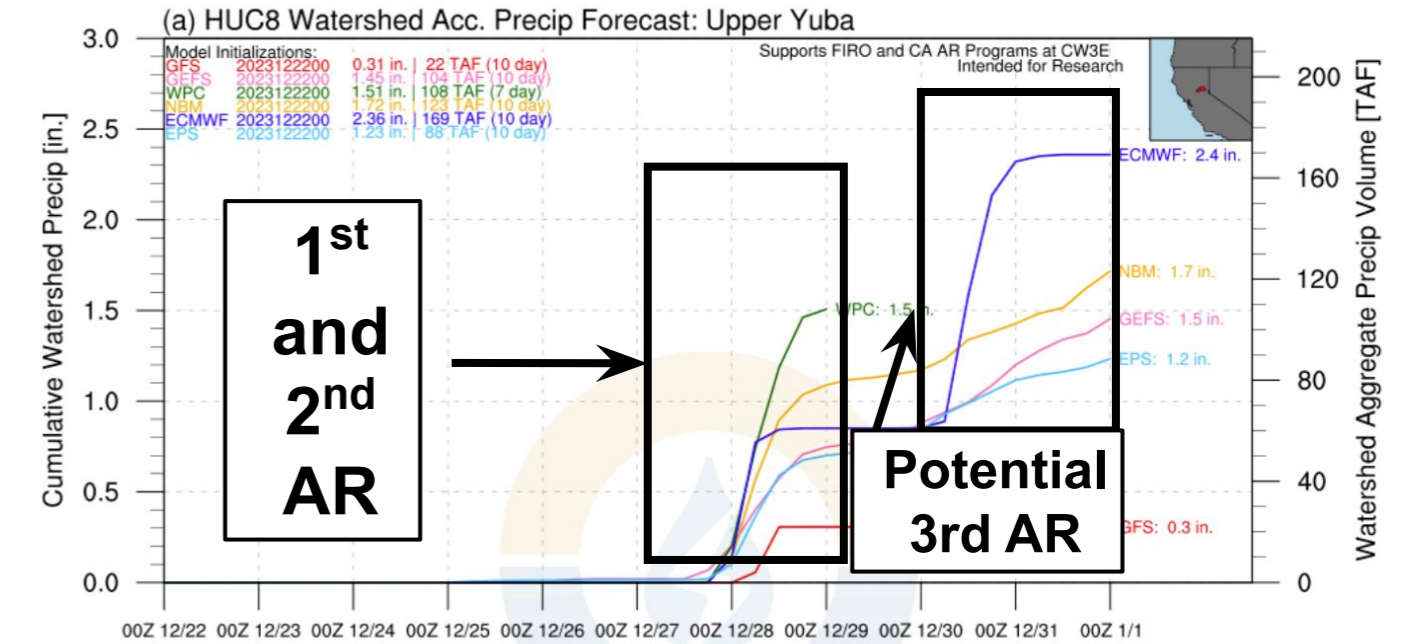
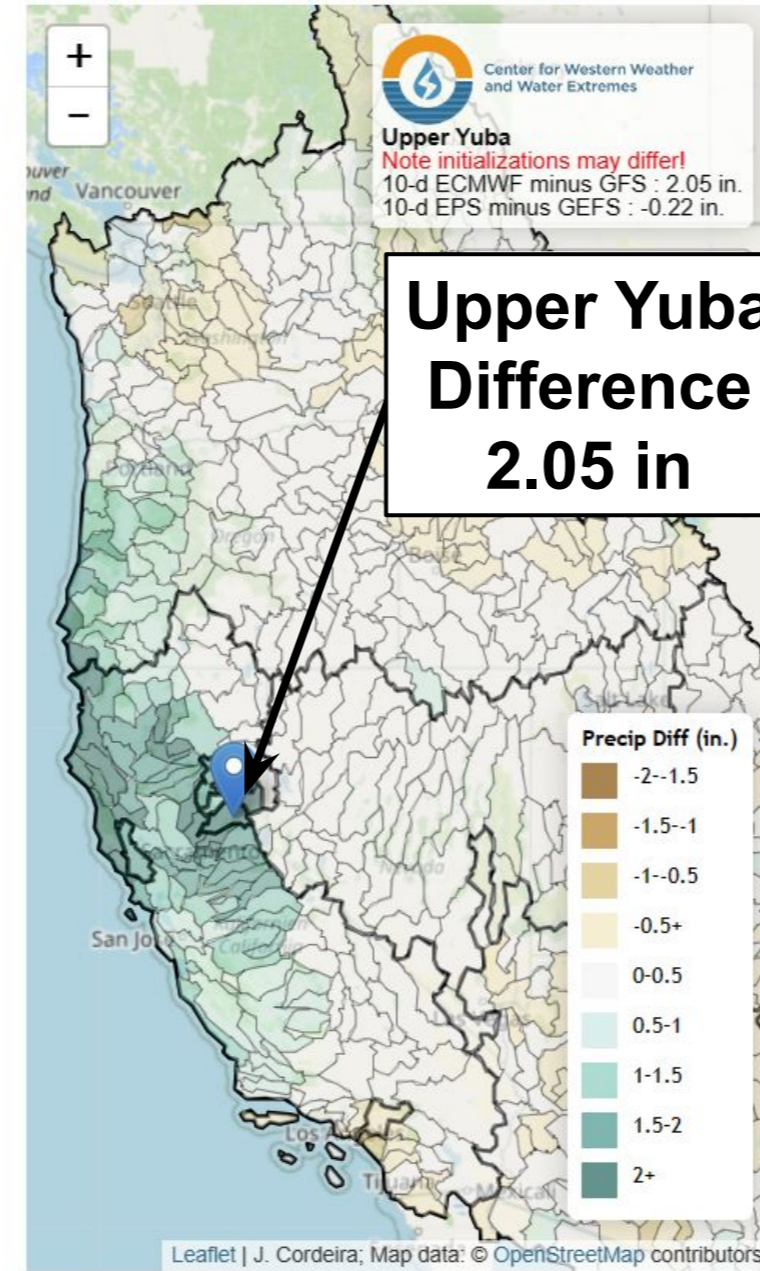
10-day GFS/GEFS Precipitation Forecasts



10-day ECMWF/EFS Precipitation Forecast



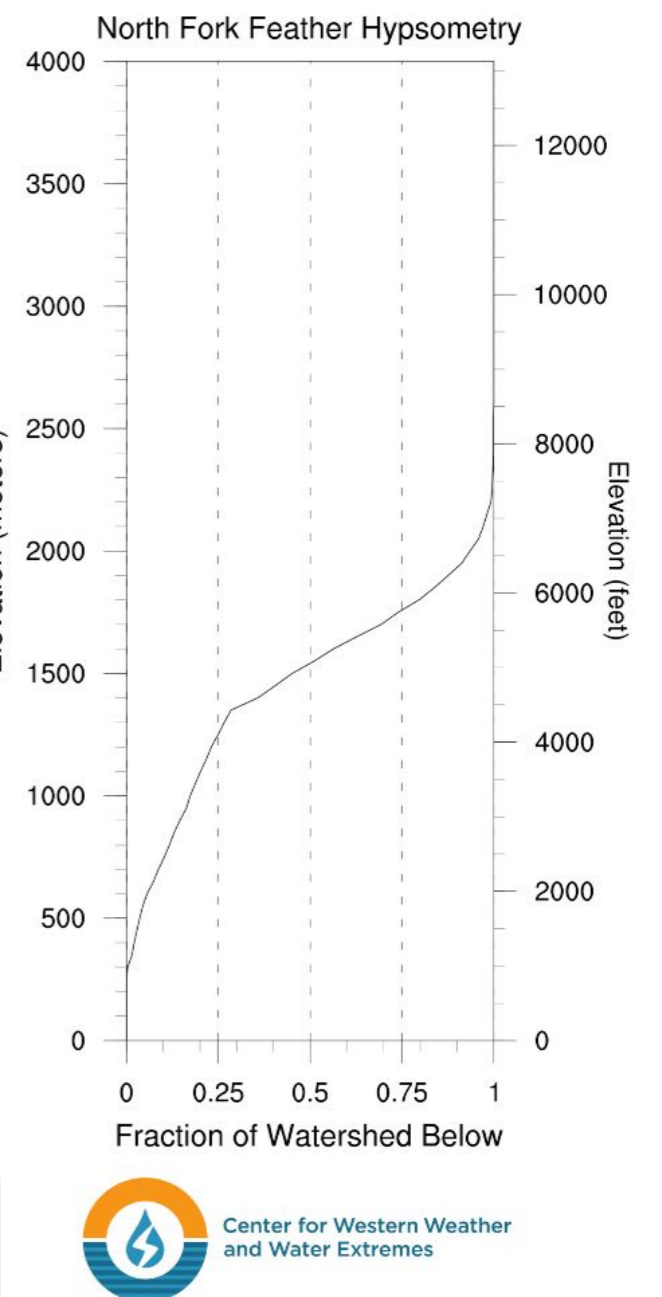
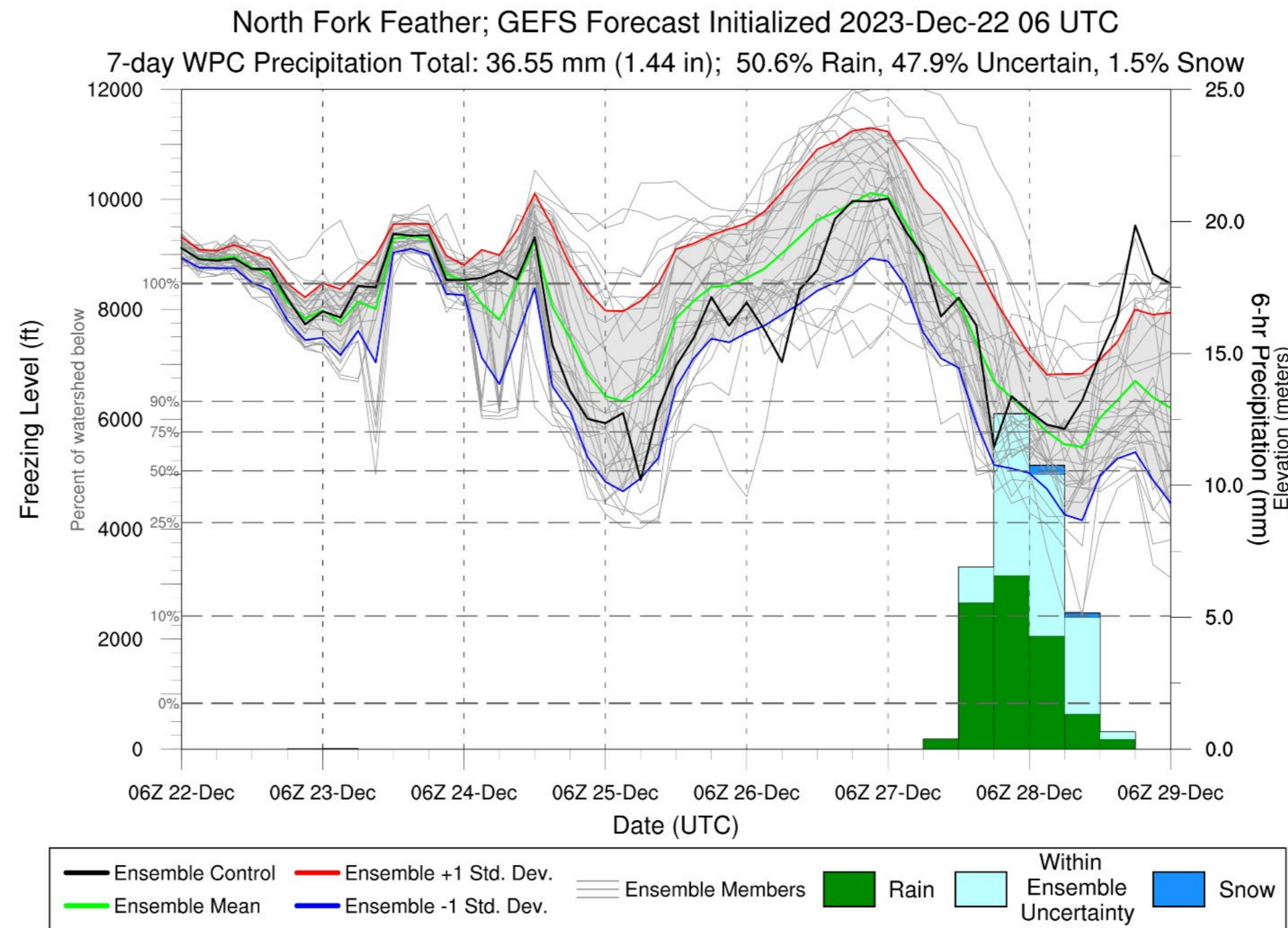
10-day Difference Precipitation Forecast



- The 00Z ECMWF and 00Z GFS are forecasting similar 10-day watershed precipitation totals in the PNW. Primary forecast differences are in Northern and Central CA where the ECMWF is forecasting more precipitation, though this is associated with the potential third AR.
- The 00Z ECMWF is forecasting 2.36" of mean areal precipitation in the Chetco watershed over the next 10 days, while the 00Z GFS is forecasting 0.31" over the same watershed. Both ensembles' members are showing uncertainty in the 10-day precipitation totals

CW3E AR Outlook: 22 Dec 2023

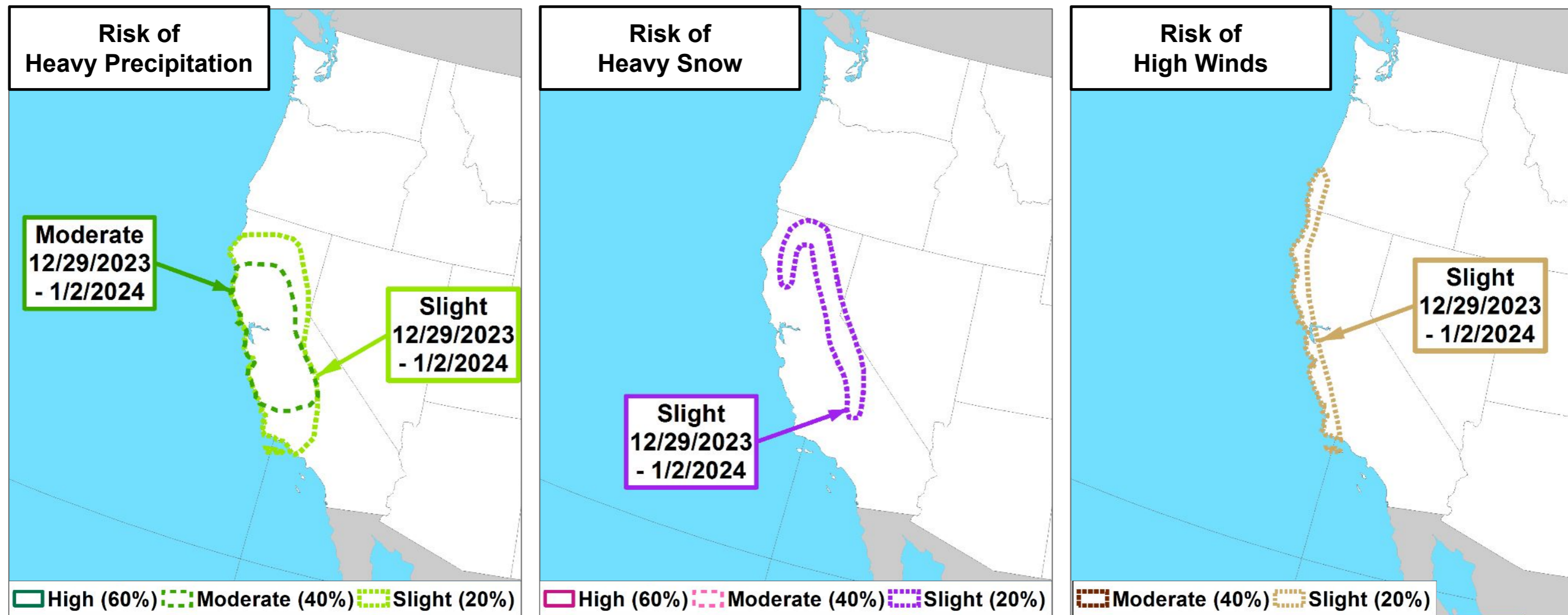
Freezing Level Forecast



- The freezing levels are forecast to fall back to ~6000 feet, creating uncertainty in the precipitation type in the N. Sierras leading to greater potential for a rain-on-snow event.
- There is uncertainty in the forecasted freezing levels through the duration of this AR.

CW3E AR Outlook: 22 Dec 2023

Climate Prediction Center 8-14 Day Hazard Outlooks



- Looking further into the forecast, the NWS Climate Prediction Center (CPC) is indicating the potential for heavy precipitation and strong winds in the 29 Dec to 2 Jan period with a possible third AR.

<https://www.cpc.ncep.noaa.gov/products/predictions/threats/threats.php>