

# **CW3E Event Summary: 26 Feb – 2 Mar 2022**

---

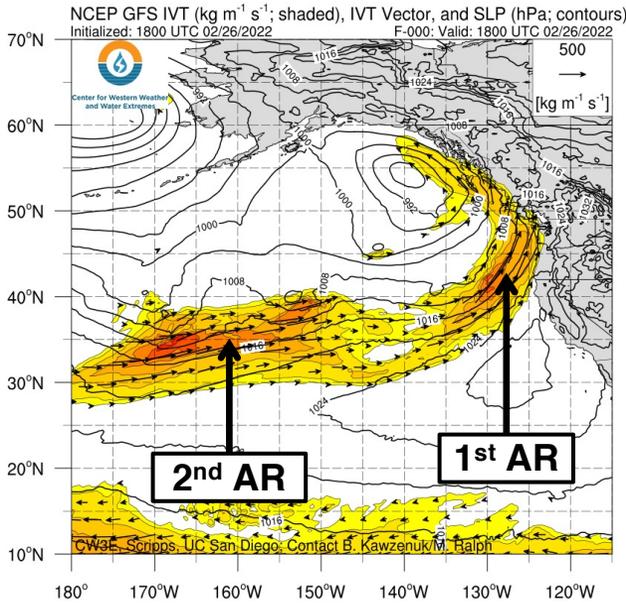
## **Atmospheric Rivers Produce Heavy Rainfall and Flooding in the Pacific Northwest**

- Multiple atmospheric rivers (ARs) impacted the Pacific Northwest between 26 Feb and 2 Mar
- An AR 4 (based on the Ralph et al. 2019 AR Scale) was observed in coastal Oregon, where AR conditions persisted for more than 72 consecutive hours and maximum IVT values exceeded  $750 \text{ kg m}^{-1} \text{ s}^{-1}$
- Inland penetration of the second AR led to AR 2 conditions in south-central Washington and north-central Oregon
- More than 10 inches of total precipitation fell in parts of the Olympic Peninsula, Northern Oregon Coast Ranges, and Washington Cascades
- The second AR produced several feet of snow in the higher elevations of the Washington Cascades and the Rocky Mountains in northern Idaho and Montana
- Heavy rain associated with the second AR caused flooding throughout western Washington
- Rain-on-snow exacerbated flooding and created an elevated risk of avalanches along the western slopes of the Cascades

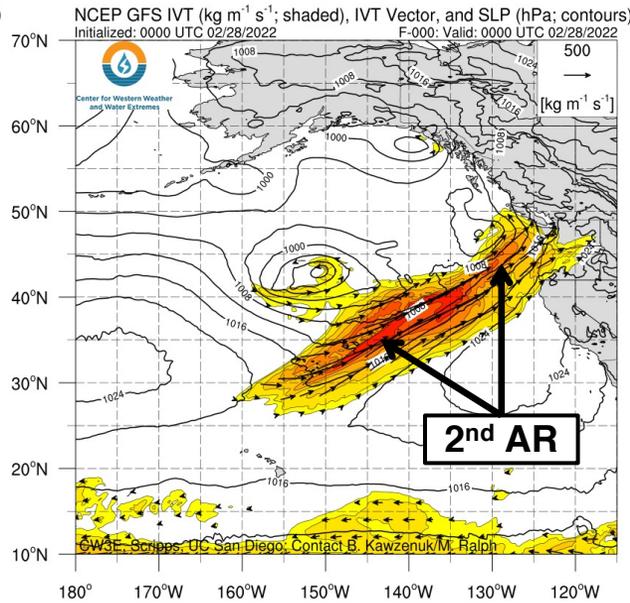
# CW3E Event Summary: 26 Feb – 2 Mar 2022

## GFS IVT/SLP Analyses

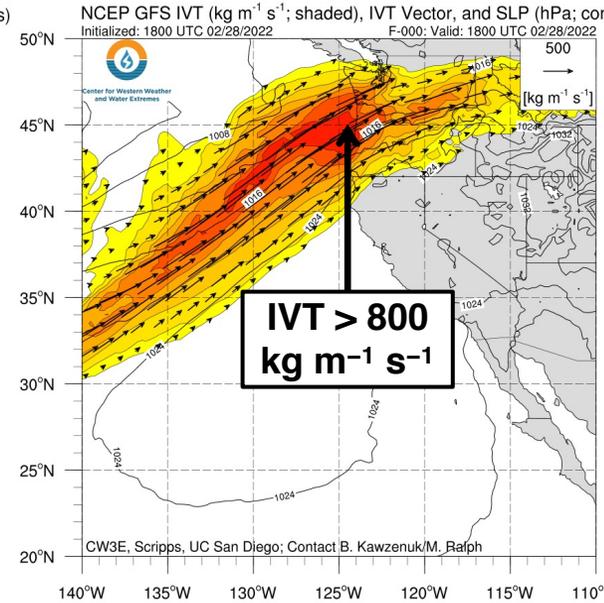
A) Valid: 10 AM PT 26 Feb



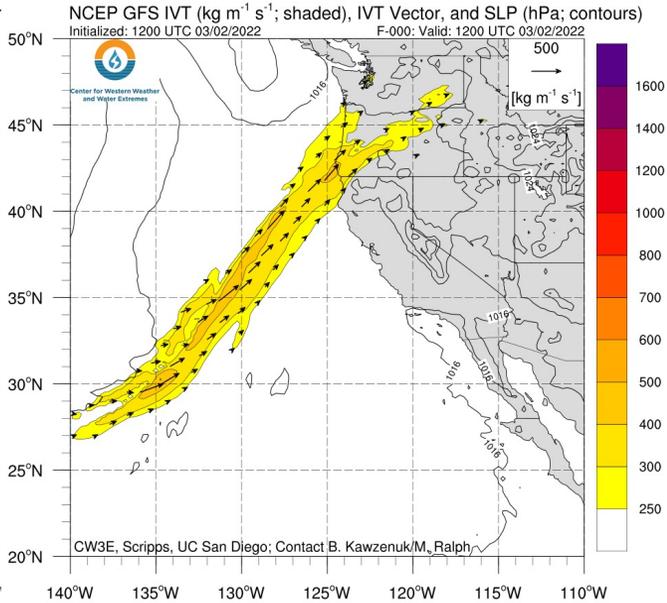
B) Valid: 4 PM PT 27 Feb



C) Valid: 10 AM PT 28 Feb



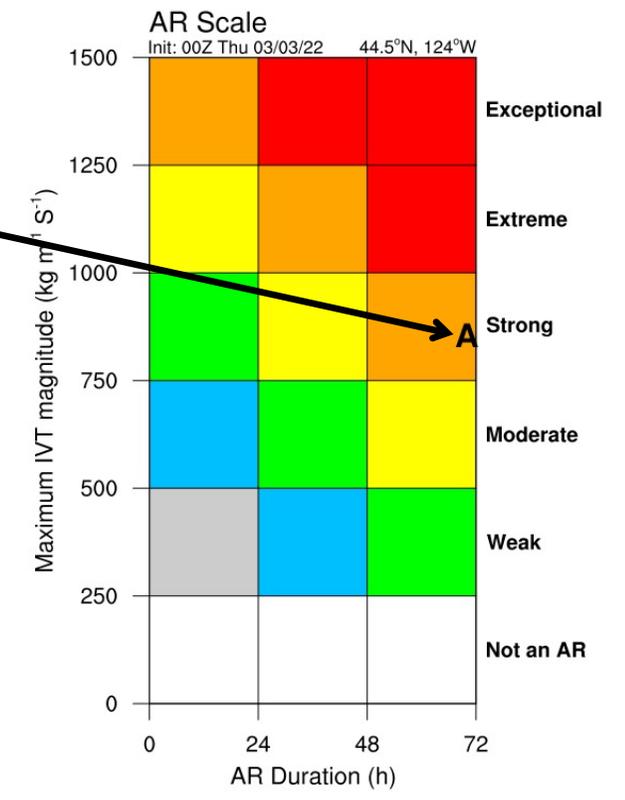
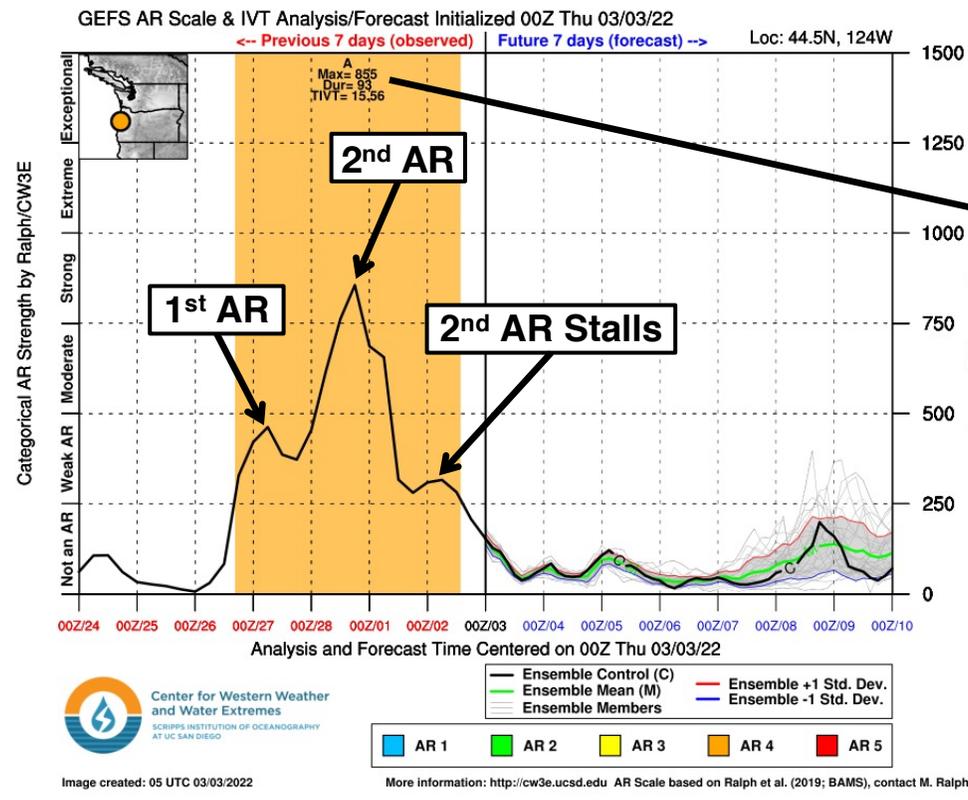
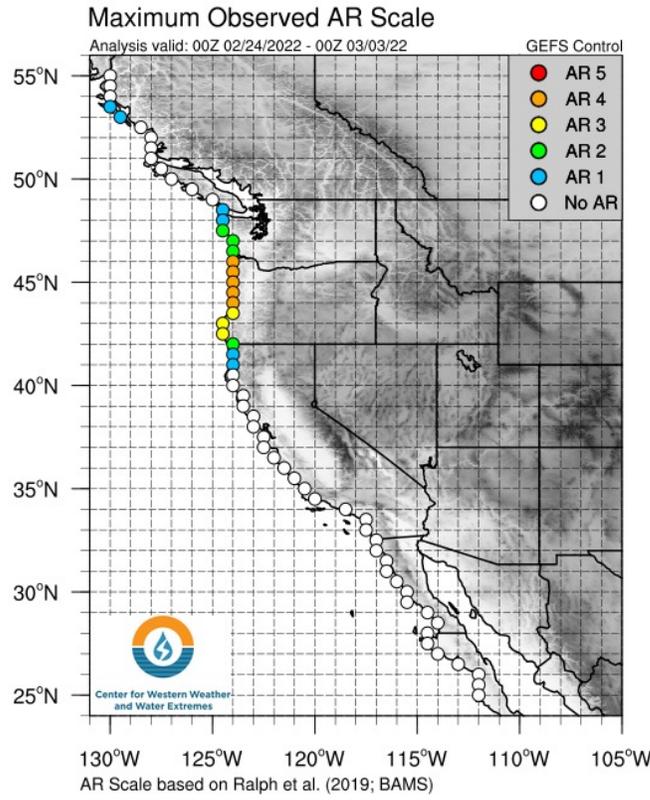
D) Valid: 4 AM PT 2 Mar



- Two ARs developed over the North Pacific Ocean and made landfall in the Pacific Northwest on 26 Feb and 27 Feb (Figures A and B)
- The first AR brought weak AR conditions ( $IVT < 500 \text{ kg m}^{-1} \text{ s}^{-1}$ ) to coastal Washington and Oregon (Figure A)
- The second AR brought strong AR conditions ( $IVT > 750 \text{ kg m}^{-1} \text{ s}^{-1}$ ) to coastal Oregon (Figure C)
- As the second AR began to weaken, it stalled over coastal Oregon, prolonging AR conditions into 2 Mar (Figure D)

# CW3E Event Summary: 26 Feb – 2 Mar 2022

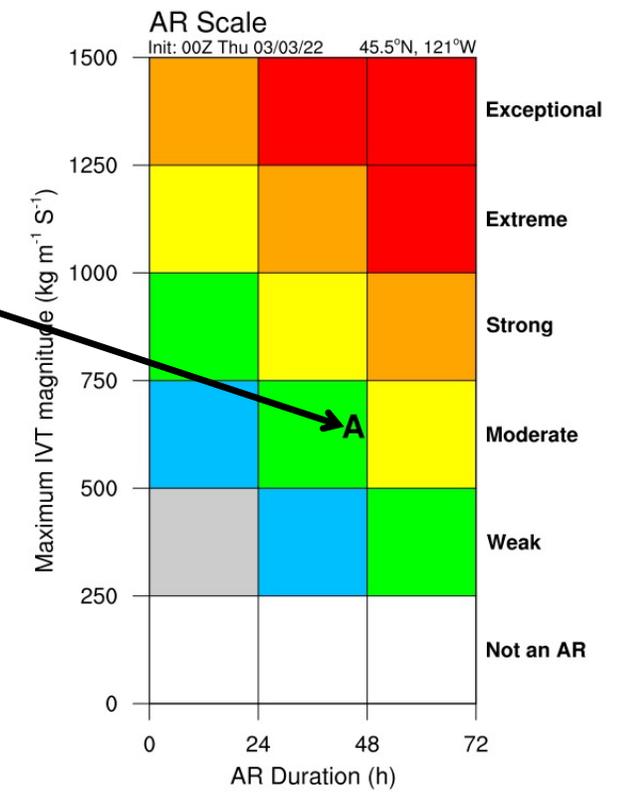
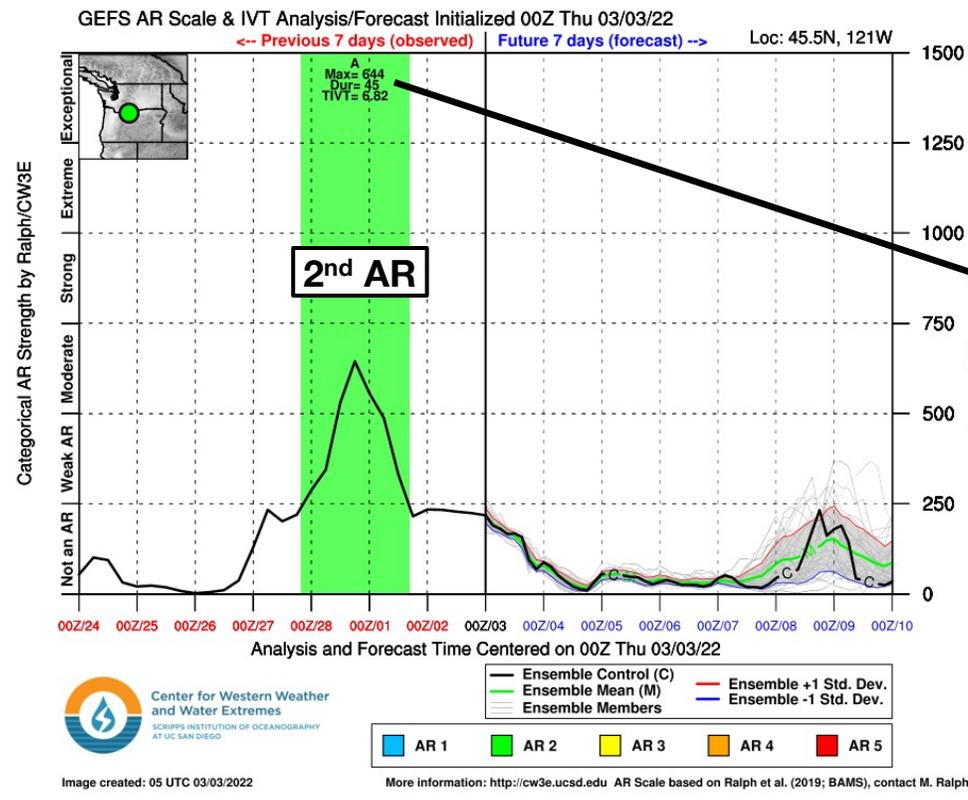
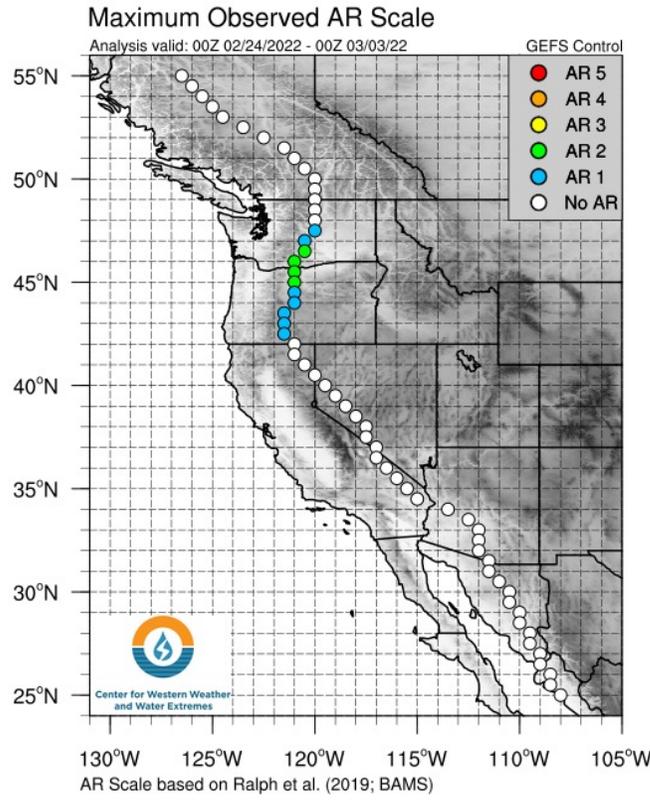
## GEFS Coastal AR Scale & IVT Analyses



- These two ARs produced AR 3/AR 4 conditions (based on the Ralph et al. 2019 AR Scale) in coastal Oregon
- The lack of a break in AR conditions between the two ARs, as well as the stalling of the second AR, led to a very prolonged period of continuous AR conditions over coastal Oregon
- AR conditions persisted for 93 consecutive hours and a maximum IVT of  $855 \text{ kg m}^{-1} \text{ s}^{-1}$  was observed near Newport, OR

# CW3E Event Summary: 26 Feb – 2 Mar 2022

## GEFS Inland AR Scale & IVT Analyses

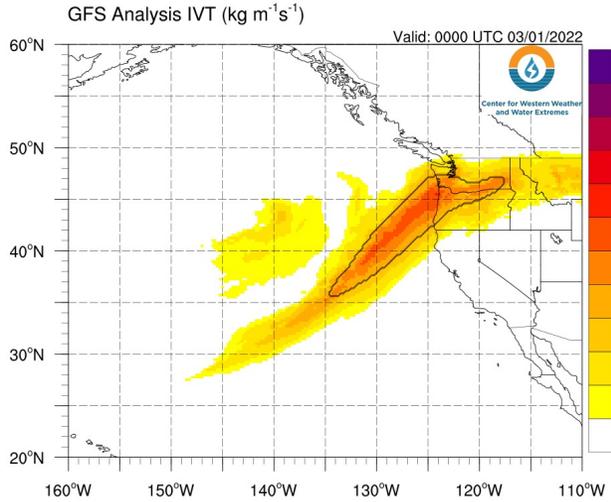


- Inland penetration of the second AR produced AR 2 conditions over south-central Washington and north-central Oregon
- A maximum IVT of  $644 \text{ kg m}^{-1} \text{ s}^{-1}$  and an AR duration of 45 hours was observed near The Dalles, OR

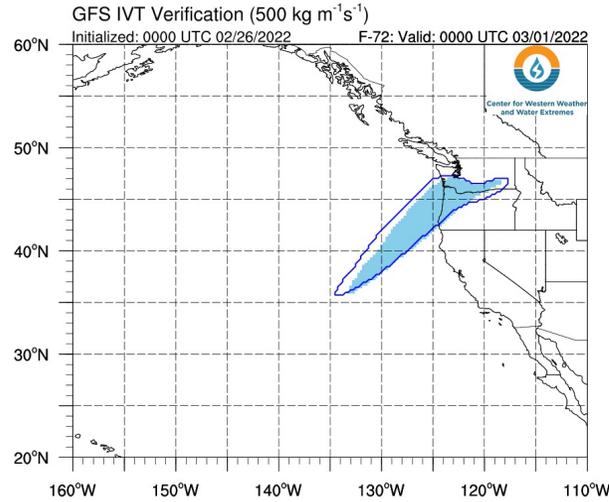
# CW3E Event Summary: 26 Feb – 2 Mar 2022

## GFS AR/IVT Forecast Verification: Valid 00Z 1 Mar

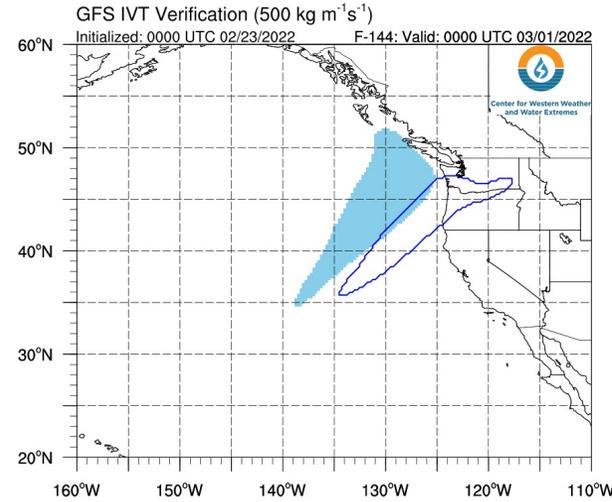
### Model Analysis



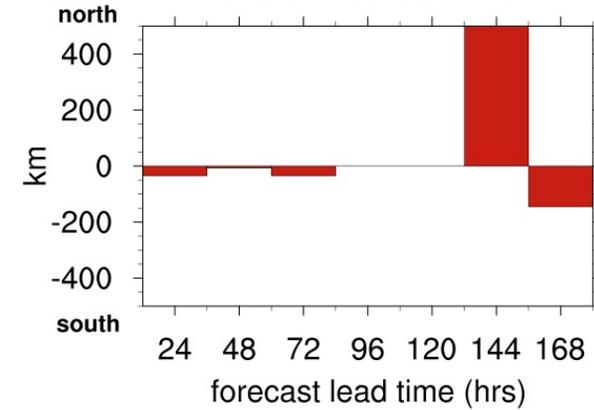
### 72-h Forecast



### 144-h Forecast



### Landfall Position Error



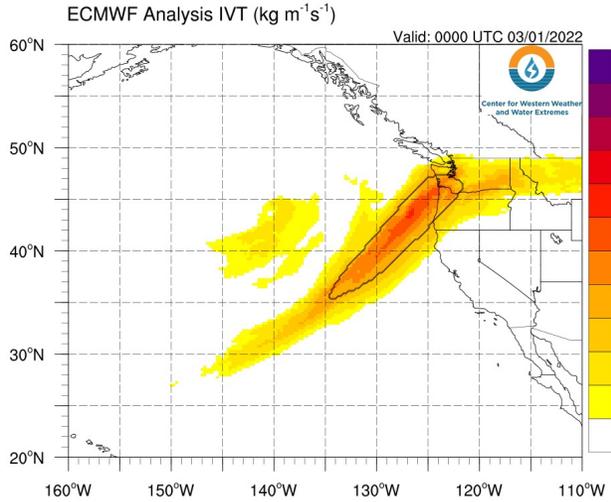
*Forecast objects shaded (unmatched objects in gray)  
Observed objects contoured (unmatched objects in black)  
Objects defined based on  $IVT > 500 \text{ kg m}^{-1} \text{ s}^{-1}$*

- Using the Method for Object-Based Diagnostic Evaluation (MODE) with a  $500 \text{ kg m}^{-1} \text{ s}^{-1}$  IVT threshold shows the position and structure of the second AR were well forecasted by the GFS model at a 72-hour lead time
- The area of the forecasted AR object was slightly smaller than observed and did not extend quite as far inland
- Examination of the 144-hour GFS forecast shows that the forecasted AR object was much farther north and west, with landfall predicted to occur over British Columbia instead of northern Oregon
- Additionally, the orientation of the AR in the 144-hour forecast was more meridional compared to the observed AR

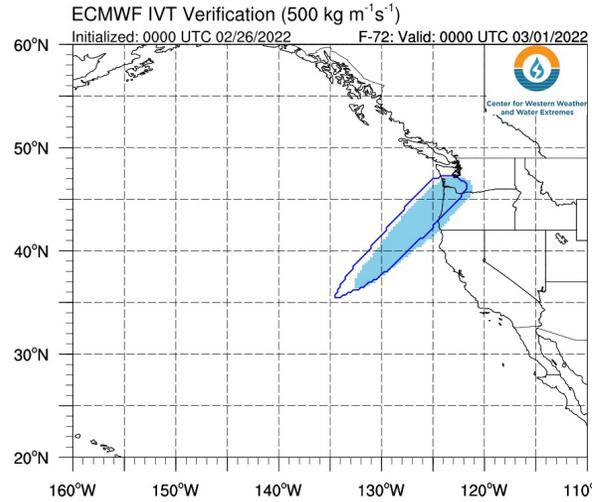
# CW3E Event Summary: 26 Feb – 2 Mar 2022

## ECMWF AR/IVT Forecast Verification: Valid 00Z 1 Mar

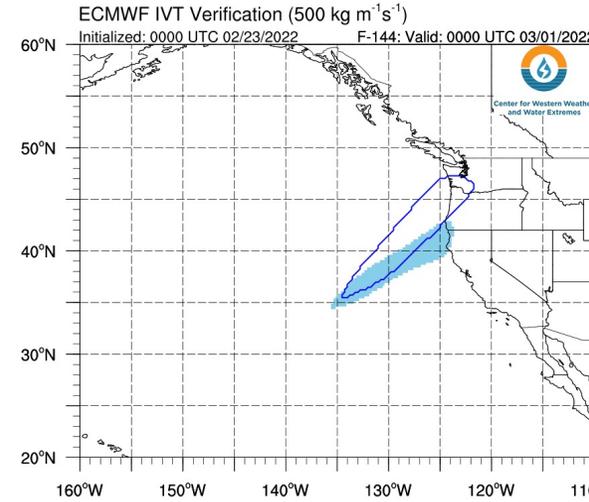
### Model Analysis



### 72-h Forecast

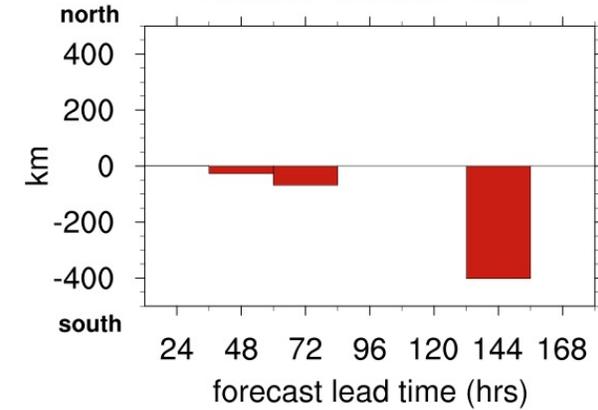


### 120-h Forecast



*Forecast objects shaded (unmatched objects in gray)  
Observed objects contoured (unmatched objects in black)  
Objects defined based on  $IVT > 500 \text{ kg m}^{-1} \text{ s}^{-1}$*

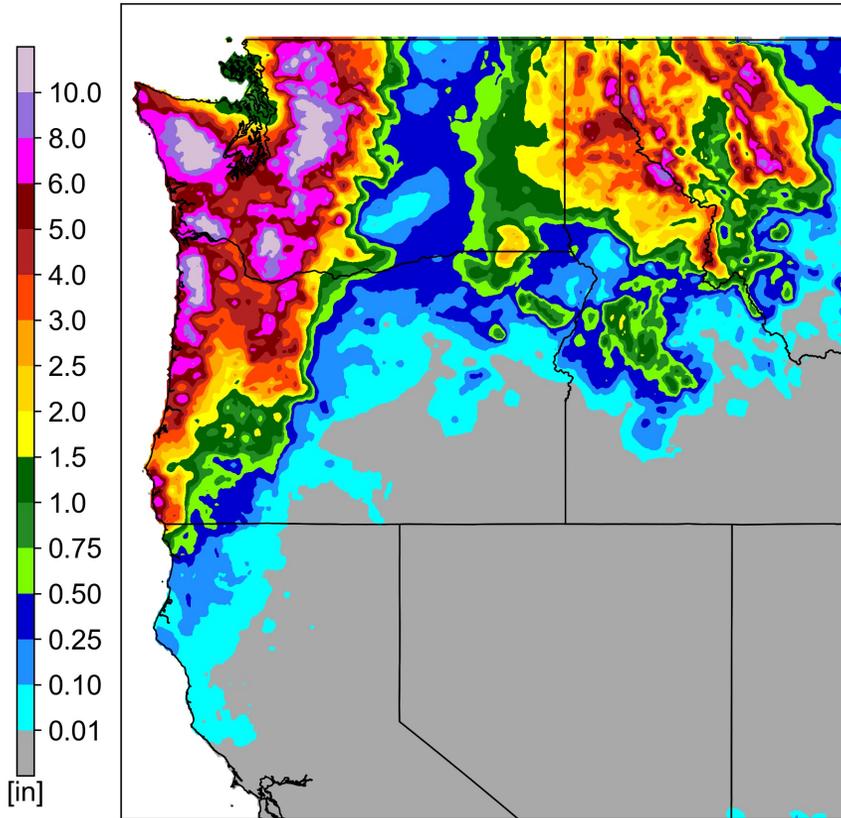
### Landfall Position Error



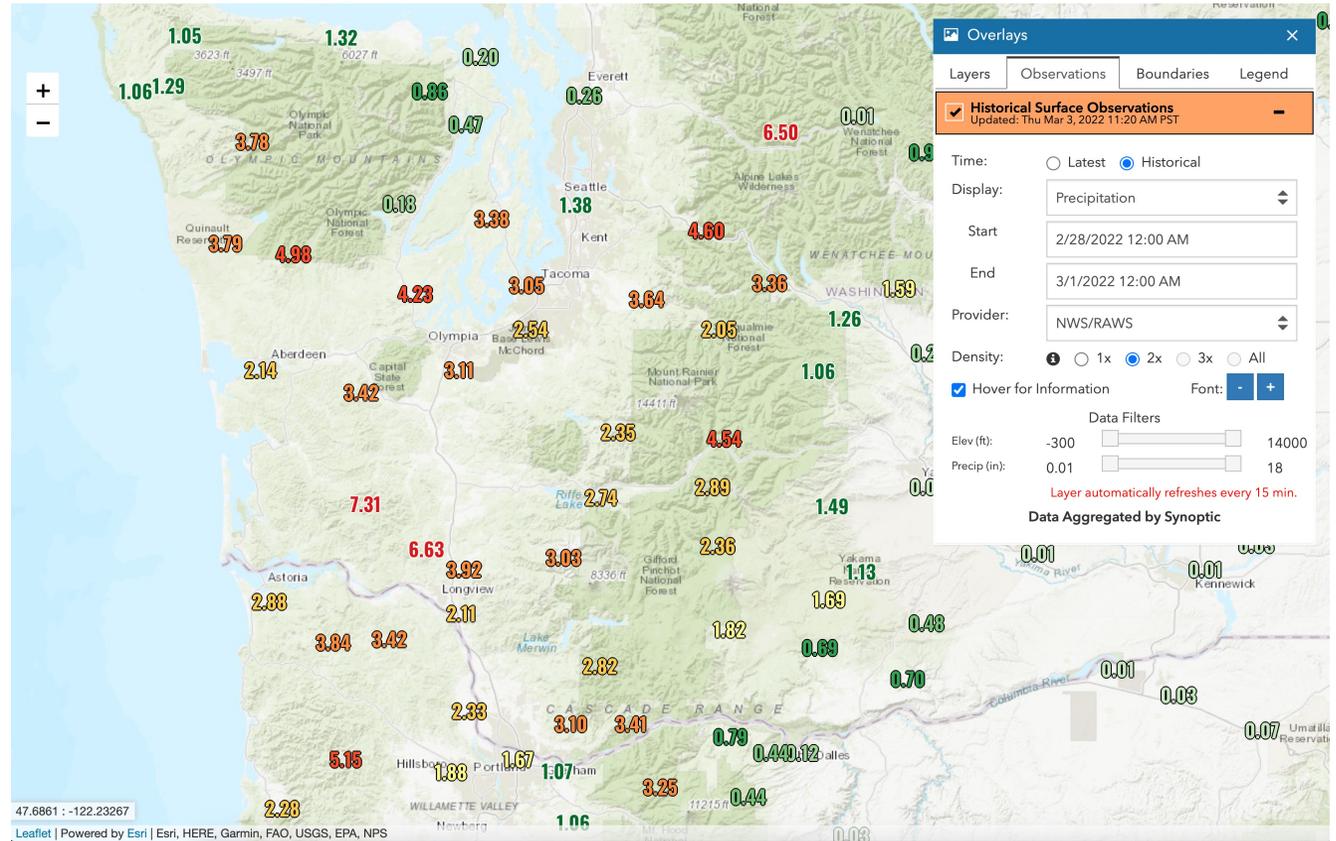
- The position and structure of the second AR were well forecasted by the ECMWF model at a 72-hour lead time, but the timing of AR landfall was slightly earlier than observed
- Examination of the 144-hour ECMWF forecast shows that the forecasted AR object was much farther south, with landfall predicted to occur near the Oregon–California border
- Additionally, the orientation of the AR in the 144-hour forecast was more zonal compared to the observed AR

# CW3E Event Summary: 26 Feb – 2 Mar 2022

**NCEP Stage IV 120-h QPE**  
Valid: 4 AM PT 26 Feb – 3 Mar



**Observed Precipitation: Valid 12 AM PT 28 Feb – 12 AM PT 1 Mar**

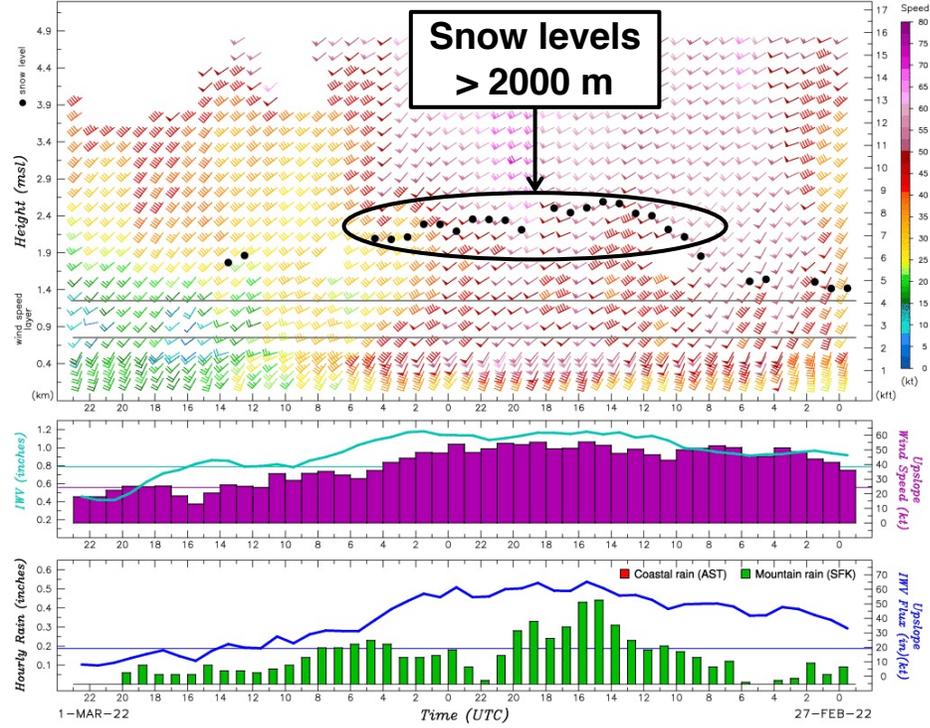


Source: NWS Western Region Headquarters

- These ARs produced heavy precipitation in the Pacific Northwest, particularly in the Olympic Mountains, the Northern Oregon Coast Ranges, and the Washington Cascades, where more than 10 inches fell during a 5-day period
- The most intense precipitation occurred on 28 Feb, resulting in numerous daily precipitation records in Washington and Oregon
- Olympia Airport and Seattle-Tacoma International Airport recorded their 2<sup>nd</sup> and 3<sup>rd</sup> wettest February days, respectively
- Inland penetration of the second AR also produced heavy precipitation (> 5 inches) in the Rocky Mountains in northern Idaho and Montana

# CW3E Event Summary: 26 Feb – 2 Mar 2022

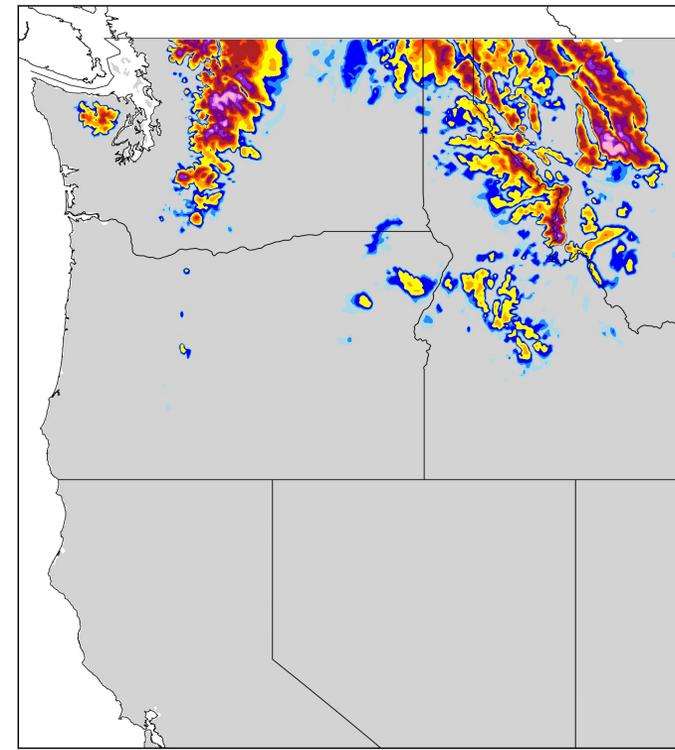
NOAA Physical Sciences Laboratory  
Coastal Atmospheric River Monitoring and Early Warning System



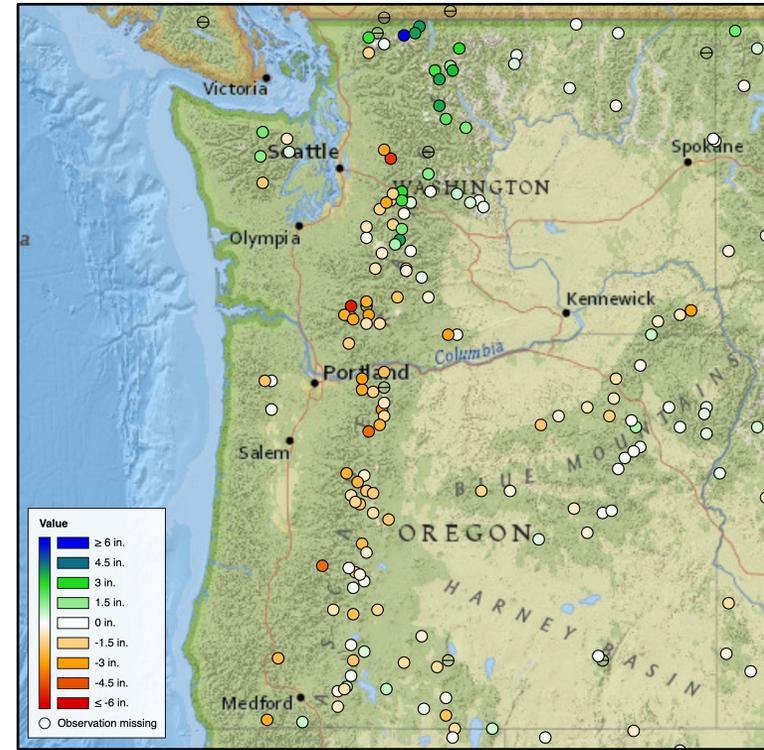
Astoria, OR (AST)  
46.1569 N, 123.8830 W, 3 m  
South Fork, OR (SFK)  
45.59530 N, 123.48360 W, 678 m

Upslope Direction = 230 deg  
AST 48-hr precip: 0.00 in  
SFK 48-hr precip: 6.60 in

## 72-h Interpolated Snowfall Valid: 4 AM PT 27 Feb – 2 Mar



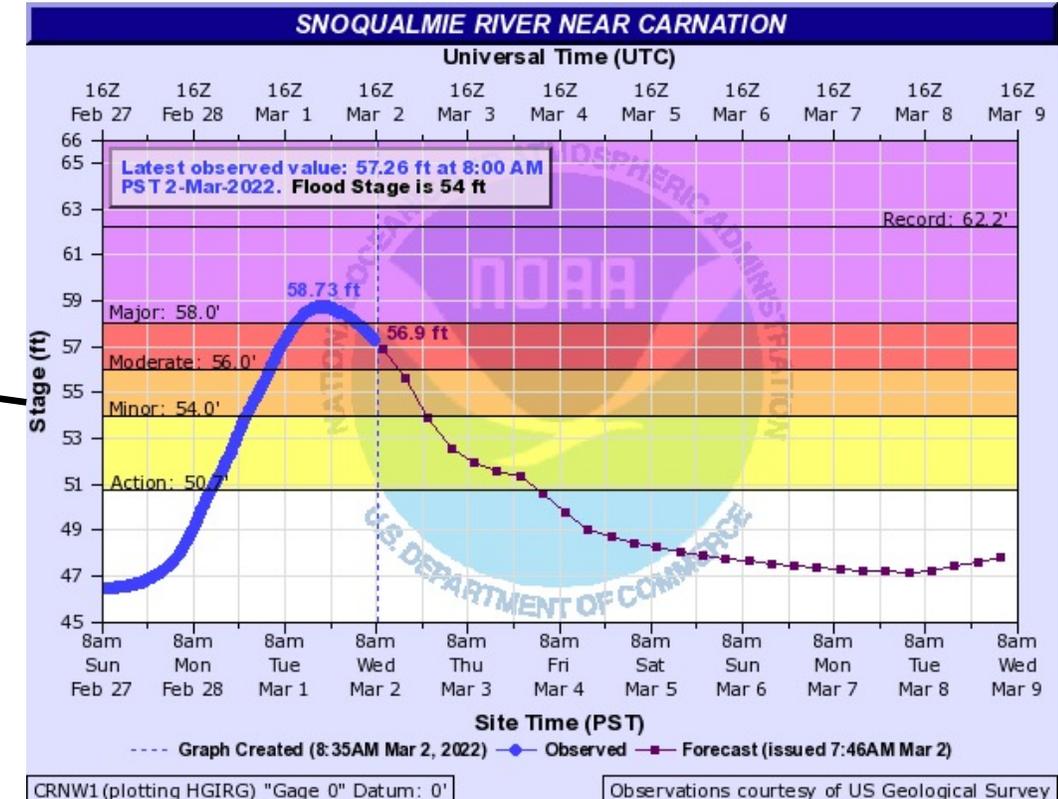
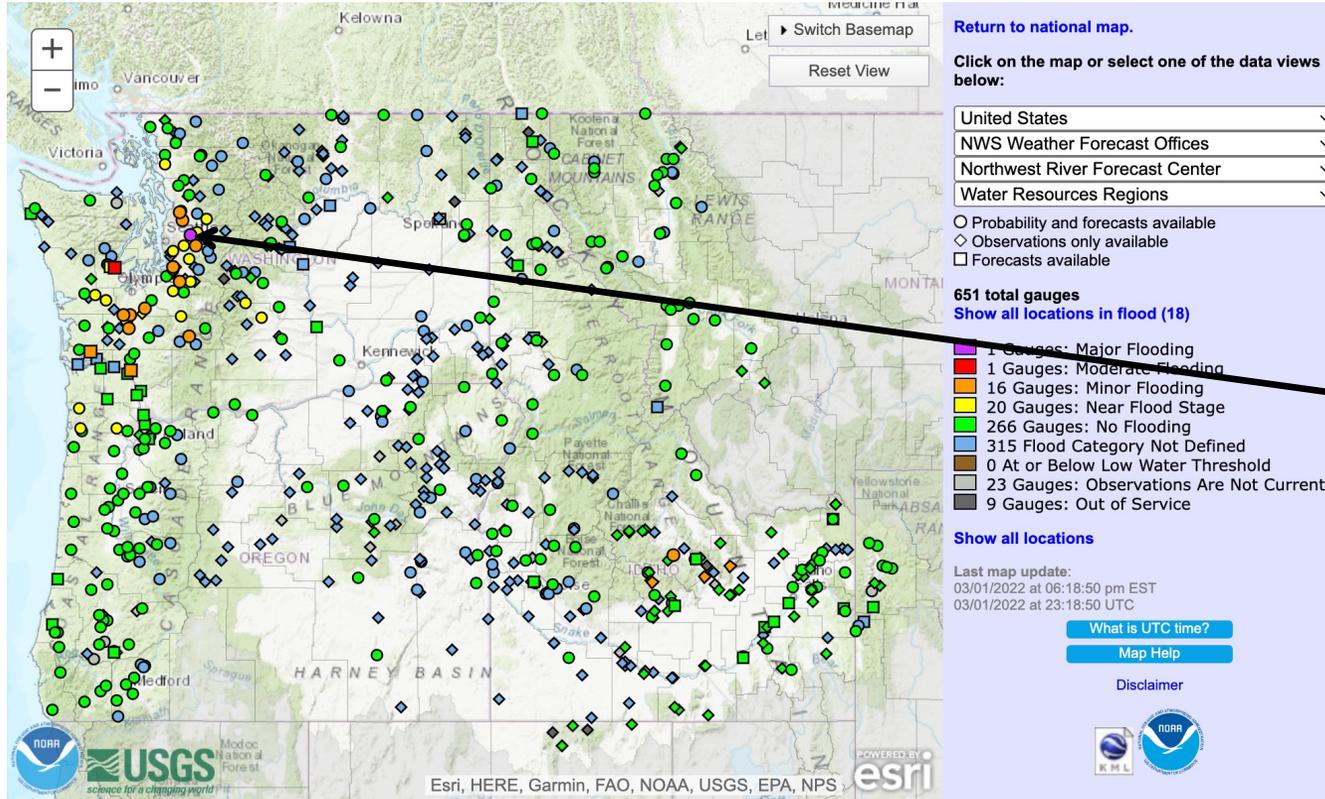
## 3-day SWE Change Valid: 27 Feb – 2 Mar (End of Day)



Source: NRCS Water and Climate Center

- High freezing levels limited snowfall accumulations below 6,000 ft during the second AR
- Estimated snowfall from the second AR exceeded 3 feet in some higher-elevation areas in the Washington Cascades, the Bitterroot Mountains, and the Lewis Range (northwestern Montana)
- Many SNOTEL sites below 6,000 ft reported significant decreases in snow water content and snow depth during the second AR
- Heavy rainfall on existing snowpack likely increased surface runoff and exacerbated the flooding at lower elevations

# CW3E Event Summary: 26 Feb – 2 Mar 2022



Source: NOAA/NWS Advanced Hydrologic Prediction Service

- Heavy rain during the second AR produced widespread riverine flooding in western Washington
- The Snoqualmie River (near Carnation, WA) rose above major flood stage (58.0 ft) on 1 Mar, reaching a peak stage height of 58.73 ft
- This is the highest stage height observed at this location since Dec 2015

# CW3E Event Summary: 26 Feb – 2 Mar 2022

## SR-7 Near Warner's Creek



Source: WSDOT

## US-101 Near Shelton, WA



Source: WSDOT

## Interstate 90



Source: WSDOT

- Intense rainfall during the second AR caused flooding and slides in western Washington
- Flooding closed several miles of SR-7 near Warner's Creek in Lewis County, WA
- A landslide blocked all travel lanes on US-101 near Shelton, WA
- A natural avalanche slide occurred on Interstate 90 near Snoqualmie Pass
- Sections of Interstate 90 and US-2 were closed due to heavy snowfall the night of 27 Feb and a high risk of avalanche activity on 28 Feb