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# AR-AFSv2: Enhancing Near-Real-Time Atmospheric River Forecasts for the 2025–2026 Winter Season in the US West Coast

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OMD/NWS/NOAA

AR Recon Workshop 6/30/2026

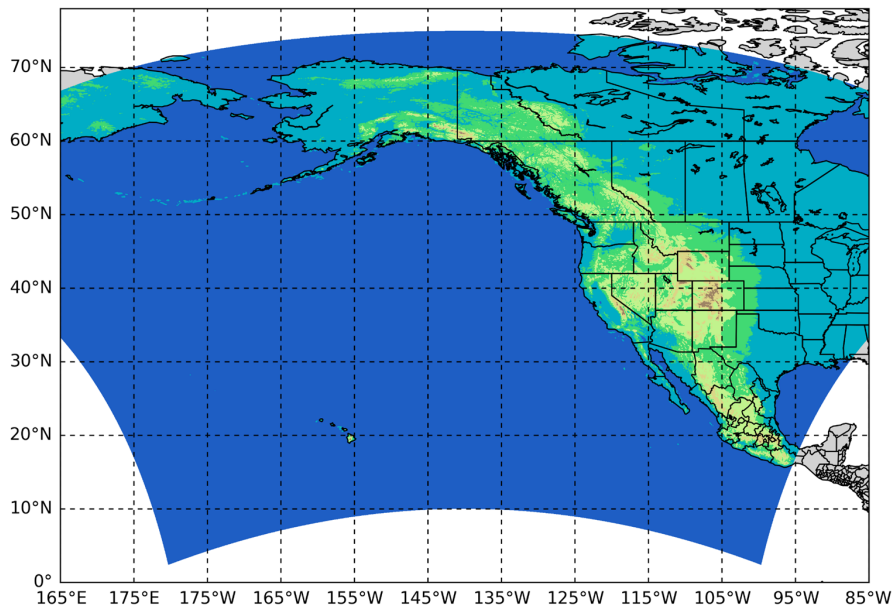


# Outline



- AR-AFS Configuration, Setup, and Near-Real Time Experiments
- AR-AFS VS. GFS Performance Evaluation
- Ocean Coupled AR-AFS
- New Physics Experiments (In Progress)
- Summary & Future Work

# AR-AFSv2 (Atmospheric River Analysis and Forecast System)



## Model Configuration:

- 3 km horizontal grid spacing
- 82 vertical levels
- Domain: 2°N-75°N, 165°E-85°W
- FV3 dynamic core, IC/BC from Operational GFSv16
- AR-AFS upgrades in alignment with the HAFS upgrades

## Physics Options (Based on HAFSv2)

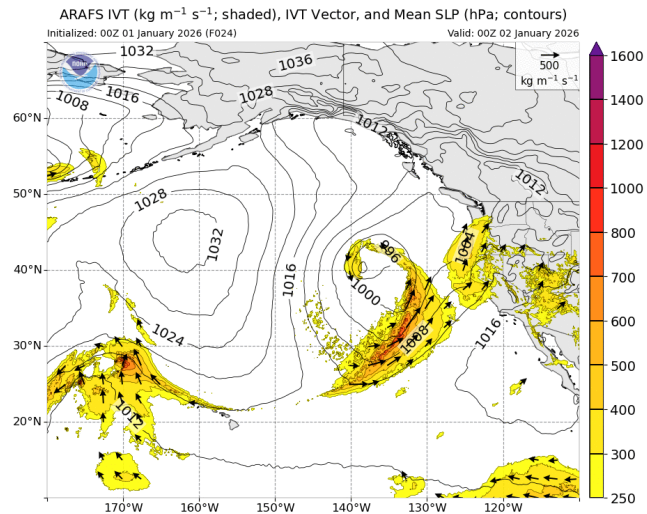
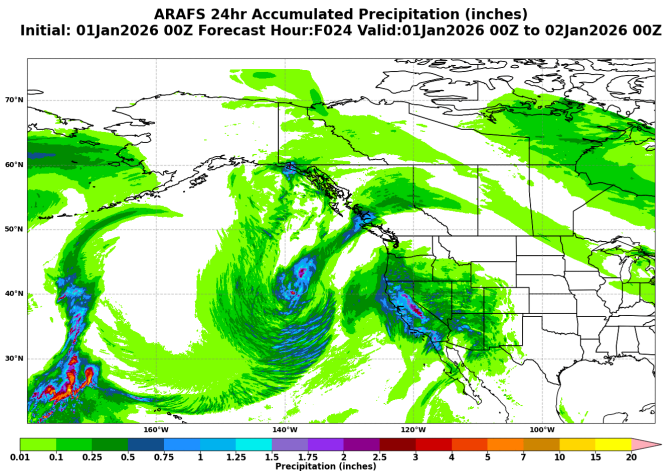
- Thompson Microphysics
- TEDMF PBL
- GFS surface layer parameterization
- Noahmp LSM
- RRTMG radiation

## Configurations for model experiments

Experiment	AR-AFSv2 (Exp4/ <b>NRT</b> )	AR-AFS_OCP (Exp5)	TEMPO	C3
Microphysics	Thompson	Thompson	TEMPO	Thompson
Convection	SAMF	SAMF	SAMF	C3
PBL	TEDMF	TEDMF	TEDMF	TEDMF
Surface layer	GFS	GFS	GFS	GFS
Land Surface Model	Noahmp	Noahmp	Noahmp	Noahmp
Vertical Layers	82	82	82	82
Ocean	None	MOM6 (1/12 deg., 55 Levels)	None	None

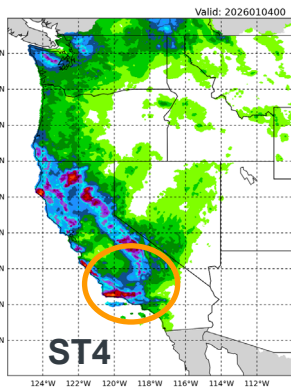
# NRT AR-AFS (v2) for the 2025-2026 Winter Season

- November 1, 2025 ~ March 31, 2026
- 1–5 day forecasts, 00Z and 12Z, 1350 cores X 4 hours/run, on NOAA Gaea system
- GFS IC and BC were obtained from NOMADS online
- Results available around 06Z and 18Z daily. Graphics for [IVT](#), [IWV](#), and [precipitation](#) were generated and published to web pages
- Model output was archived on HPSS
- IVT fields saved in NetCDF format

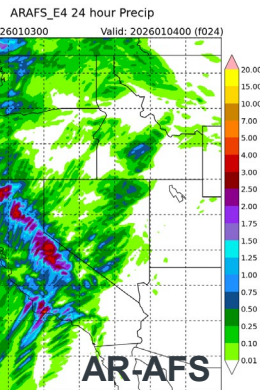
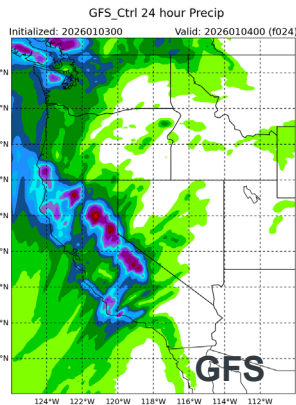


# 2025-2026 Winter Season Evaluation (2025 Nov 01 - 2026 Mar 31)

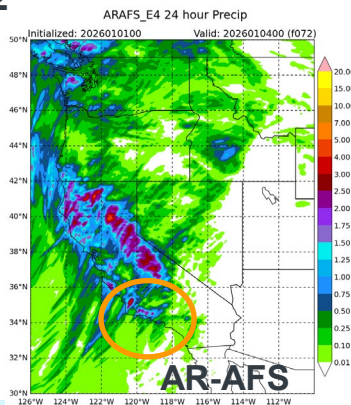
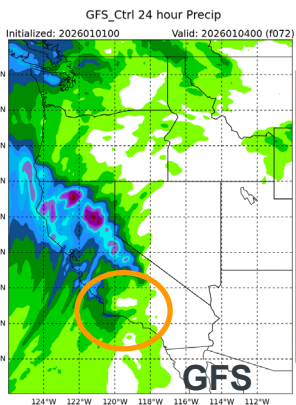
2026010400



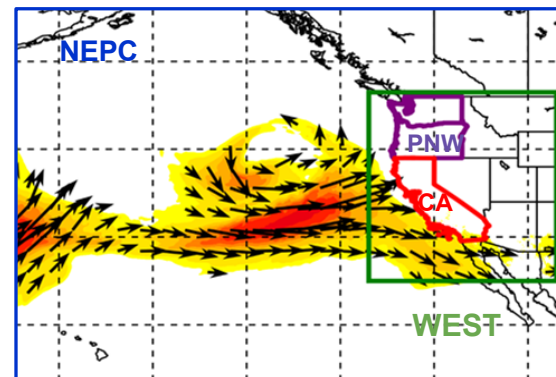
F24



F72



## Spatial domains for Verification



- WEST: US West Coast
- PNW: Washington and Oregon
- CA: California
- NEPC: the northeast Pacific
- Alaska

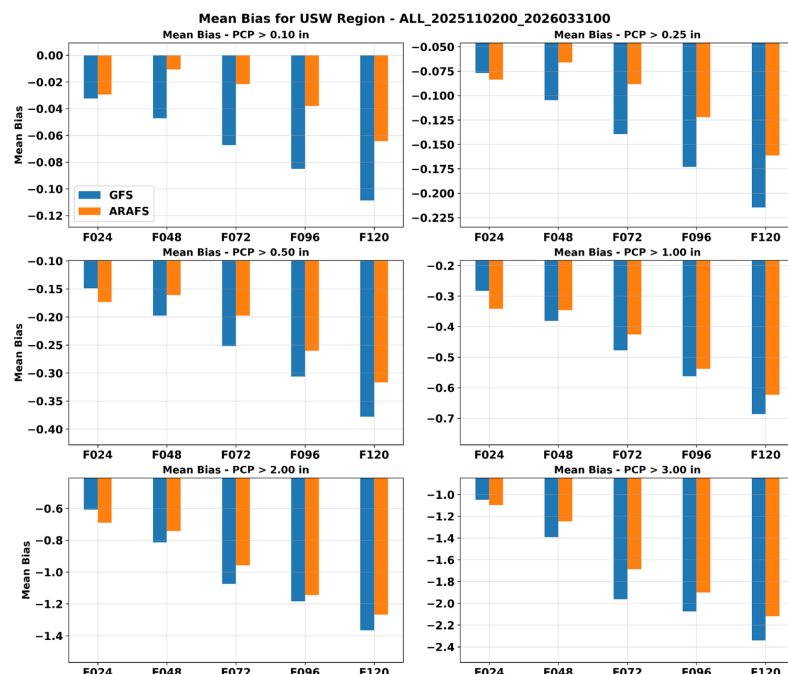
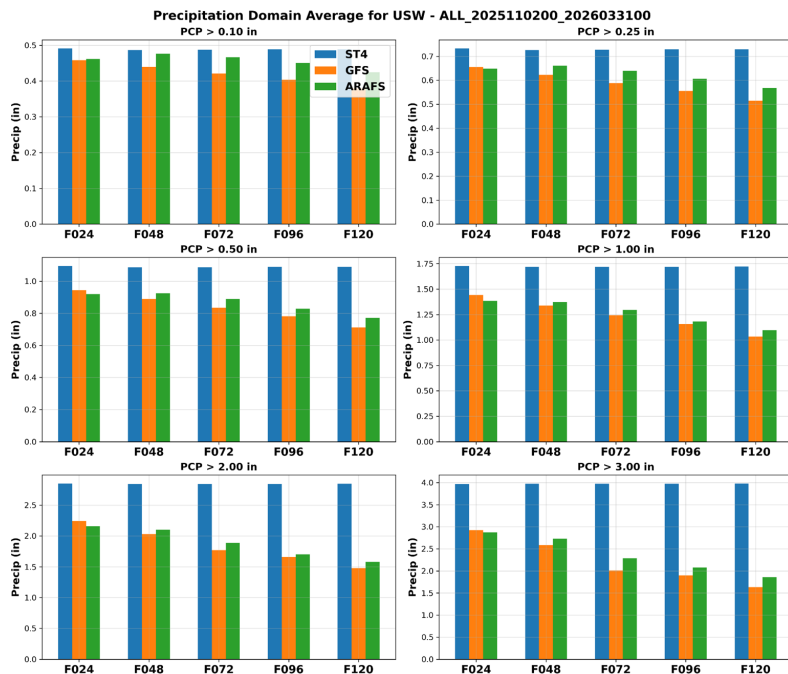


# 24-hour Precip accumulation AR-AFSv2 vs GFS

2025 Nov 01 - 2026 Mar 31 (WEST)

## Domain Mean

## Bias



Both GFS and AR-AFS exhibit underprediction of precipitation (ST4 obs), but AR-AFSv2 (NRT) demonstrates improvement, with reduced bias across various thresholds.



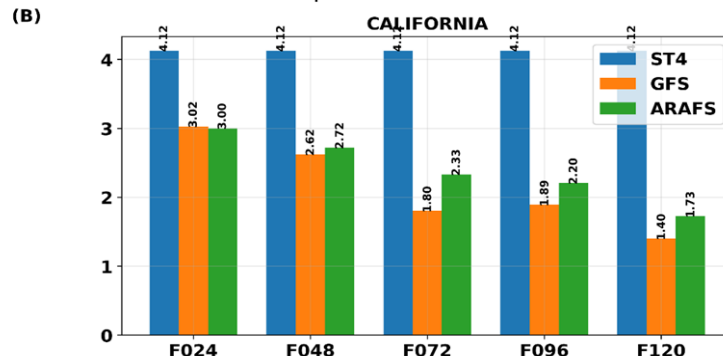
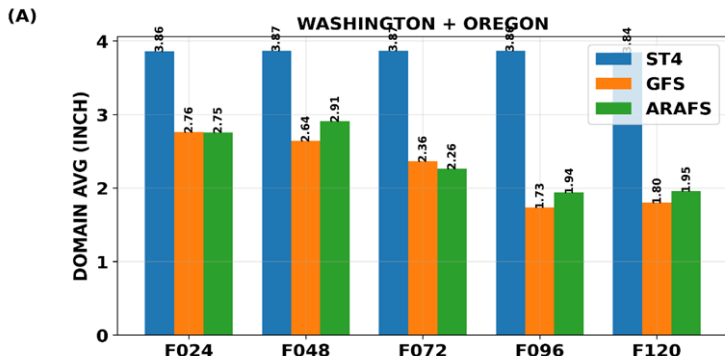
# 24-hour Precip accumulation AR-AFSv2 vs GFS

PNW

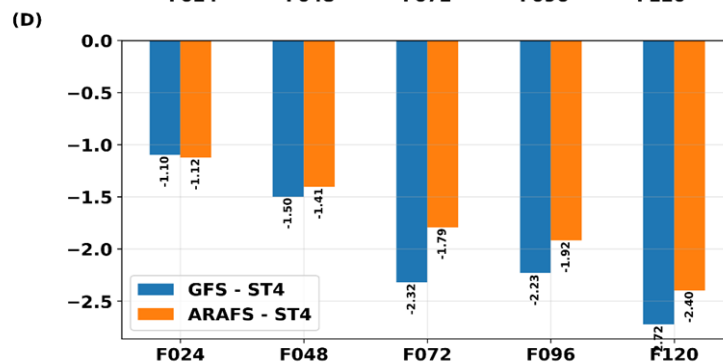
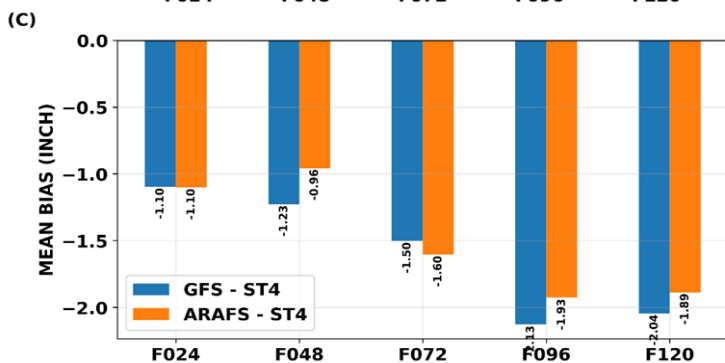
CA

POOLED OVER ALL VALIDATION DATES: 2025110200 TO 2026033100 | ST4 > 3 INCH

Domain Mean



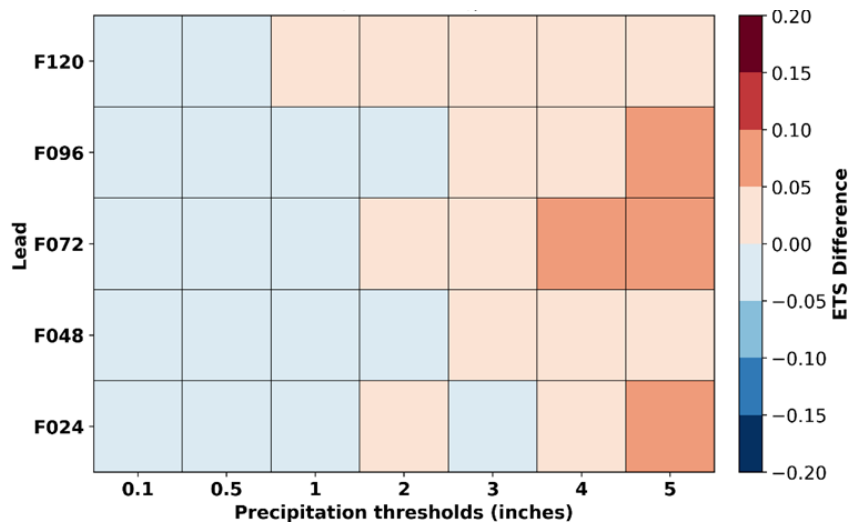
Bias



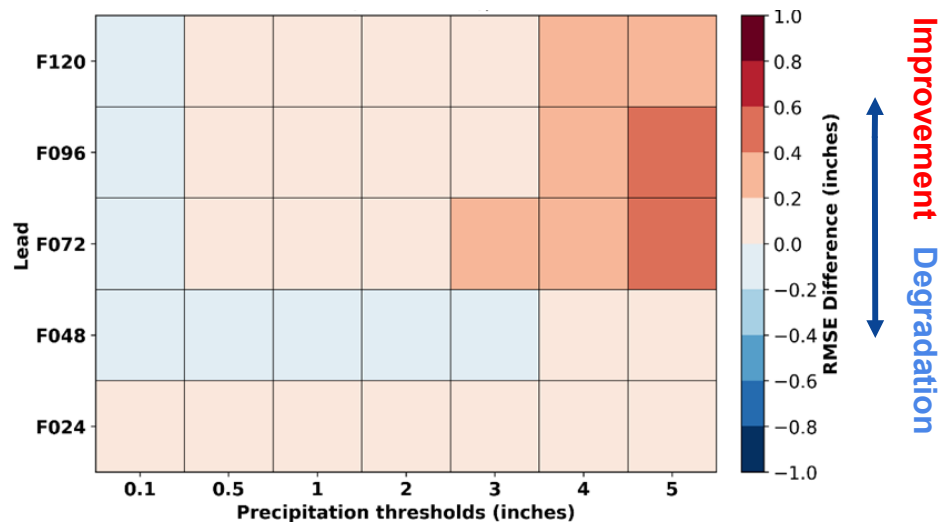
# 24-hour Precip accumulation AR-AFSv2 vs GFS

2025 Nov 01 - 2026 Mar 31 (US WEST)

Equitable Threat Score (ETS) (ARAFS-GFS)



Root Mean Square Error (RMSE) (GFS-ARAFS)



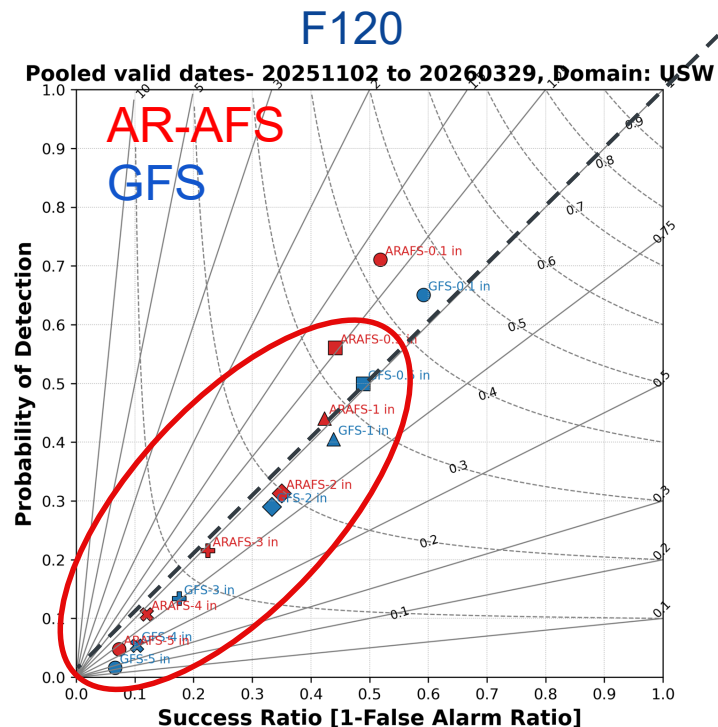
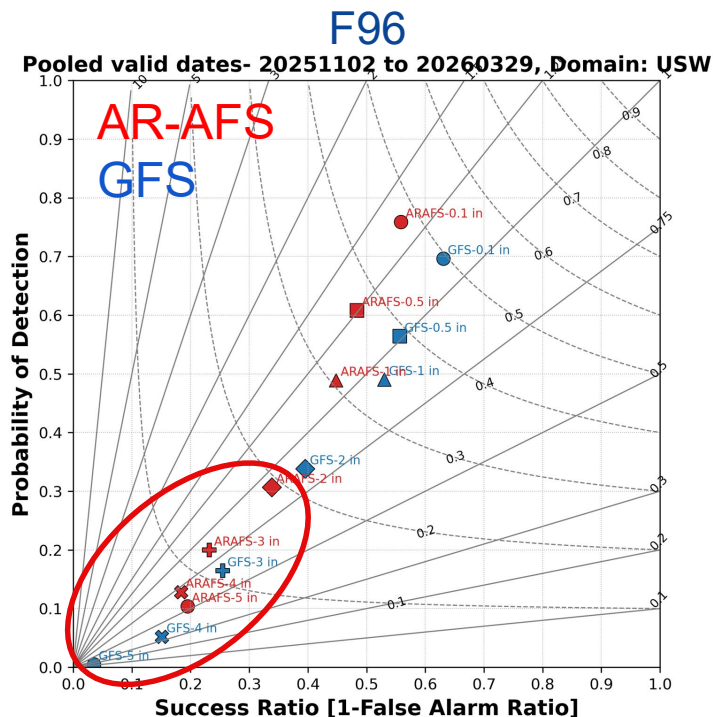
Improvement ↑  
Degradation ↓

AR-AFSv2 (NRT) improves significantly (with a higher ETS) at higher threshold (>2 in), especially at long lead times (F72, F96, F120).

AR-AFSv2 (NRT) improves significantly (with a smaller RMSE, up to 10% decrease) at higher thresholds compared to GFS.

# 24-hour Precip accumulation AR-AFSv2 vs GFS

2025 Nov 01 - 2026 Mar 31 (US WEST)



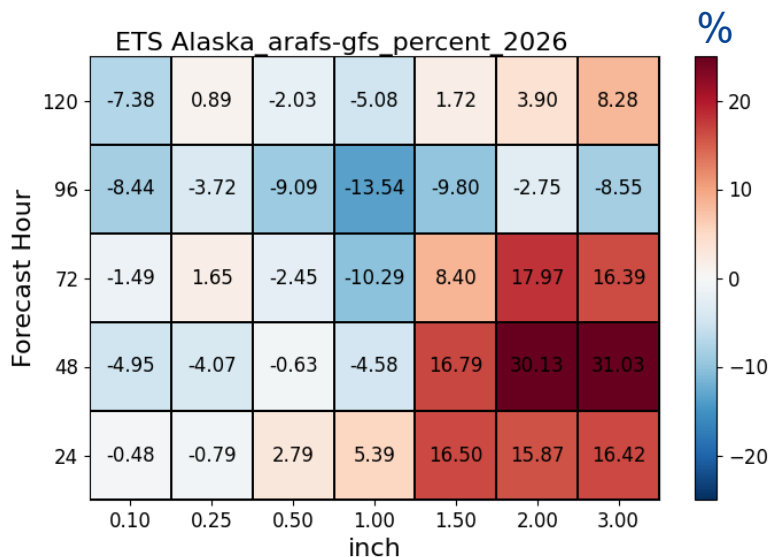
AR-AFS has better ETS (further away from left bottom corner) and frequency bias (closer to diagonal line) when threshold is 2 inch or higher.

# 24-hour Precip accumulation AR-AFSv2 vs GFS

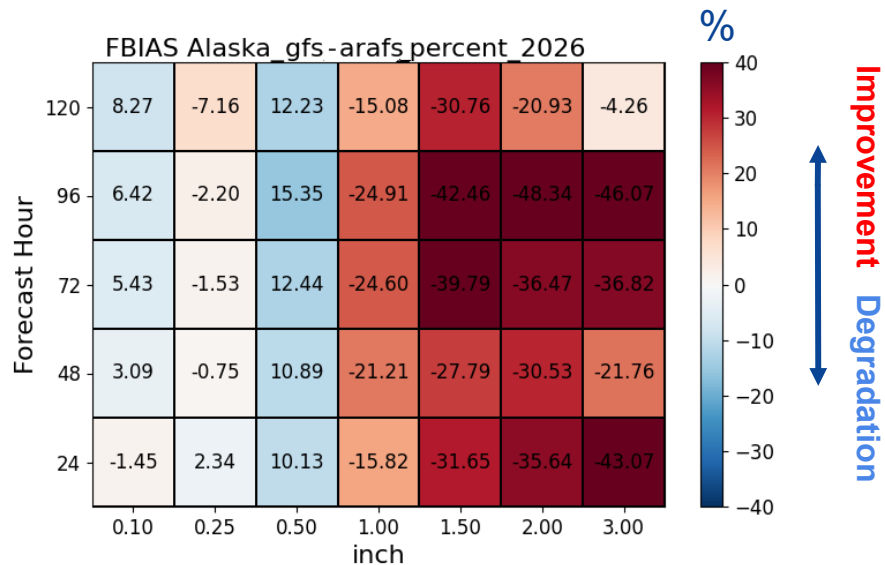


2025 Nov 01 - 2026 Mar 31 (Alaska)

Equitable Threat Score: Difference of ETS



Frequency Bias: Difference of |FBIAS-1|

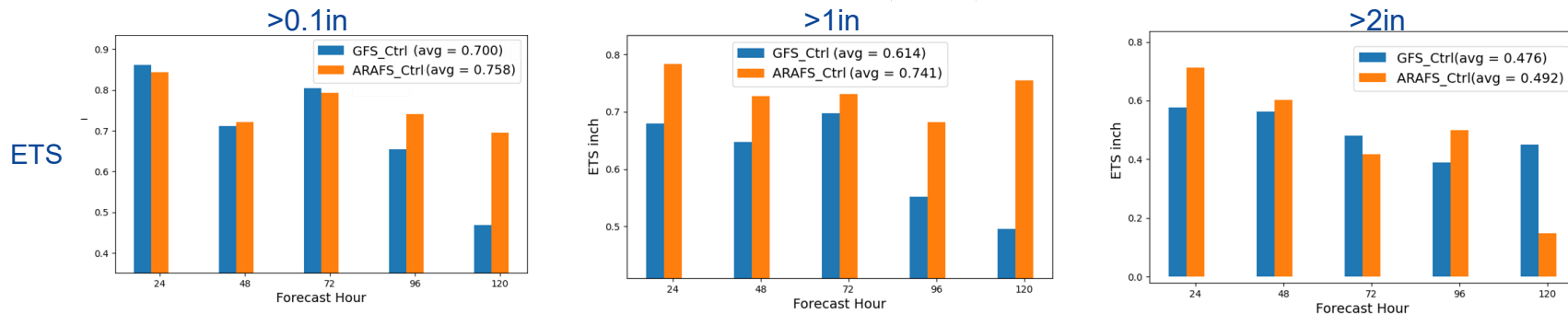
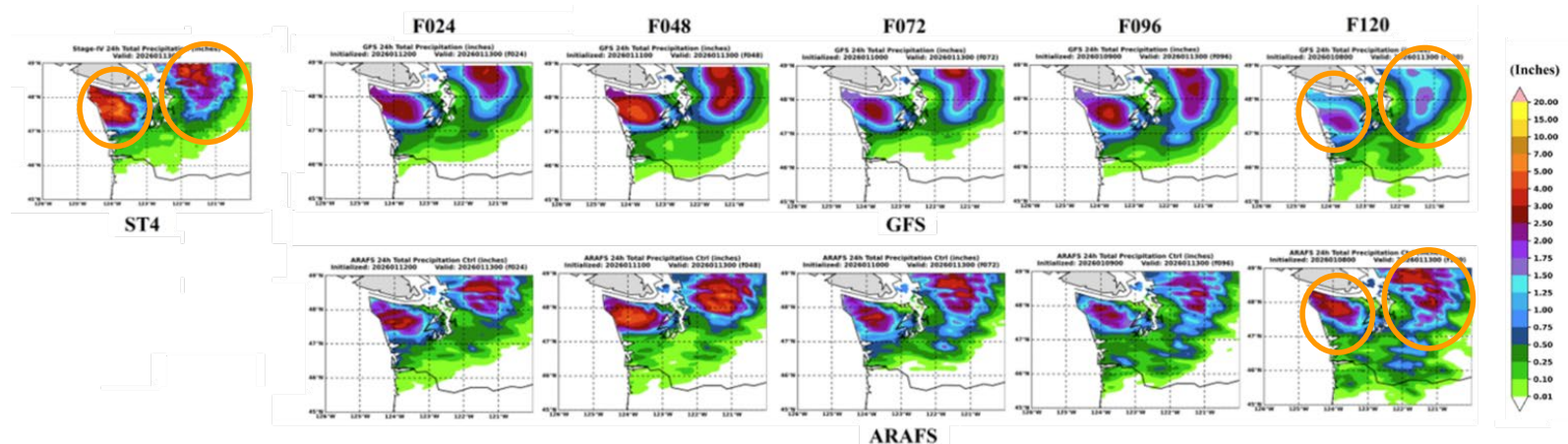


AR-AFSv2 (NRT) improves significantly (with a higher ETS) at higher threshold (>1 in) and shorter lead hours

AR-AFSv2 (NRT) improves significantly (with a FBIAS closer to 1) at higher thresholds (>1 in)

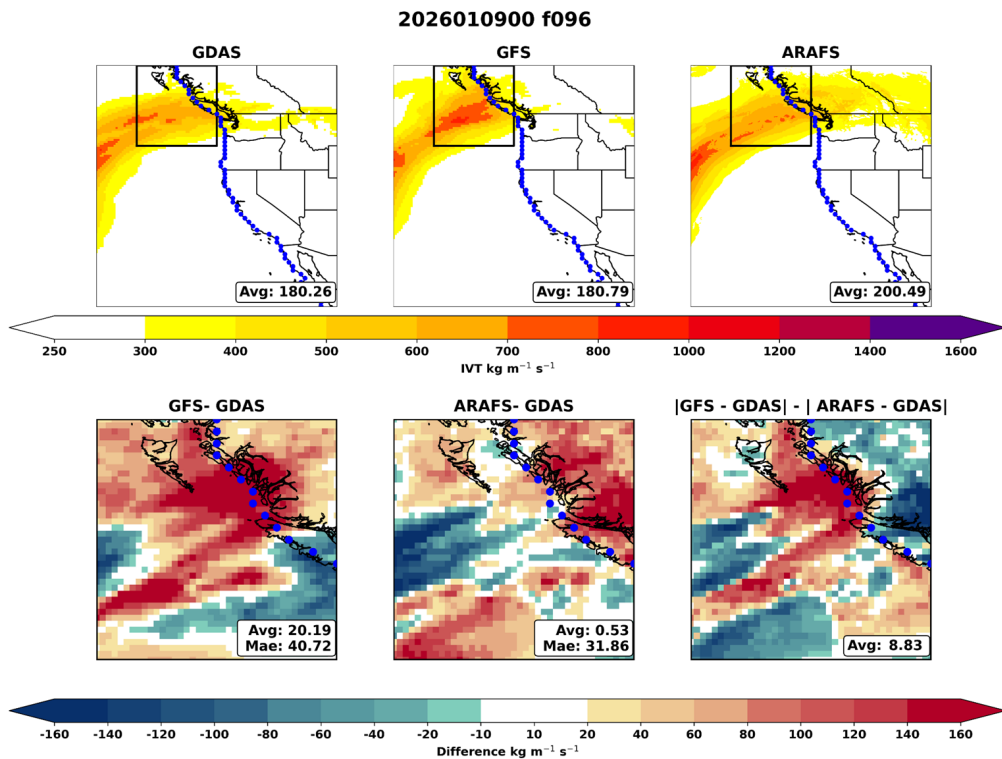


# A Case Study (valid at 2026011300)

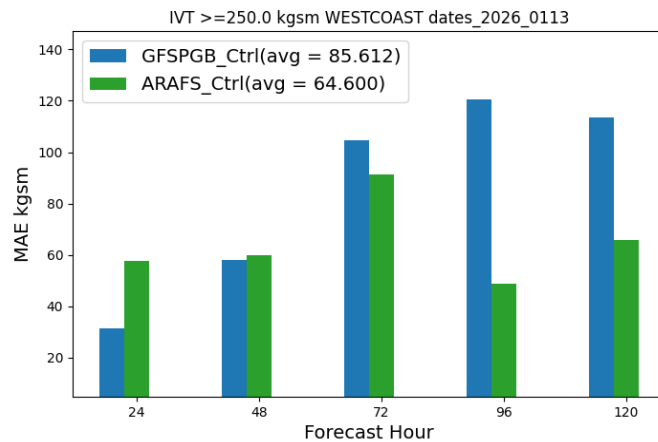


- AR-AFS shows better spatial agreement with ST4 precipitation than GFS across all lead times
- Forecast skill decreases with lead time, but AR-AFS remains more consistent than GFS, especially beyond 72h
- Both models capture the large-scale AR pattern, with AR-AFS better representing intensity and distribution

# Case Study (Init: Jan. 8-12, 2026 | Valid: Jan. 13, 2026)



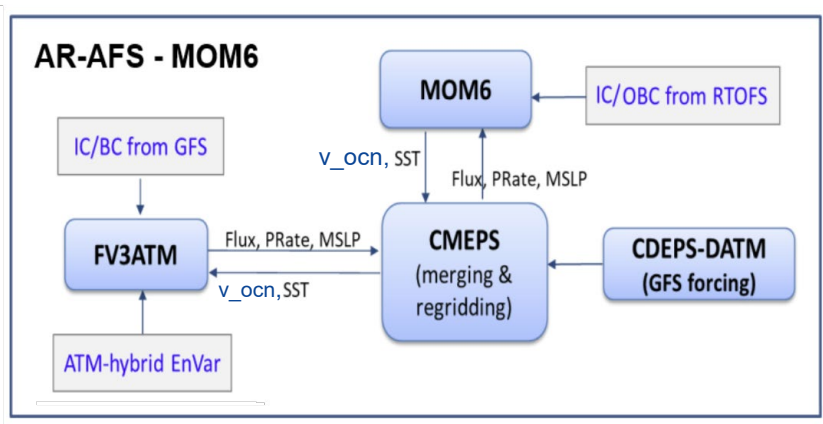
## IVT MAE along the coast line



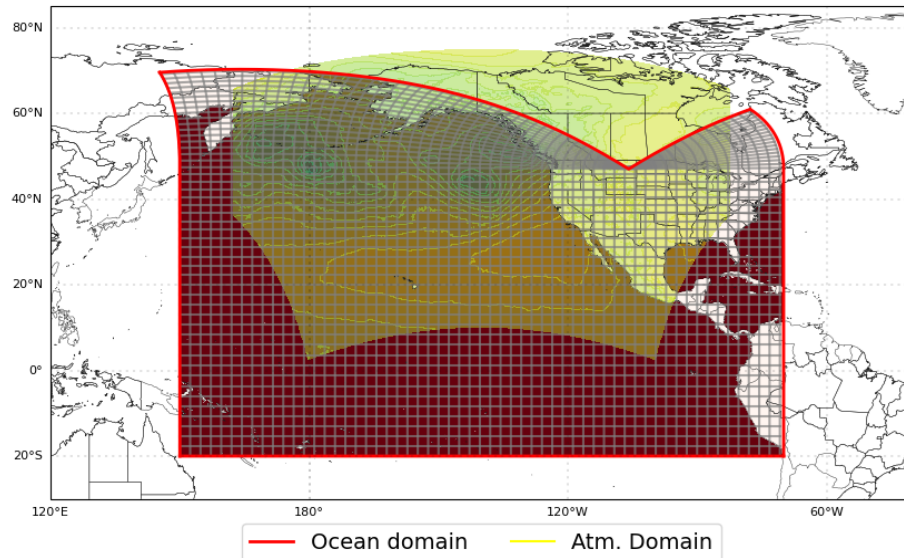
**AR-AFS predicts stronger IVT over land while maintaining lower average MAE along the Coast**

# Coupling of Modular Ocean Model Version 6 with AR-AFSv2

Schematic of the AR-AFS-MOM6 coupled system



MOM6 domain and Atmospheric Domain

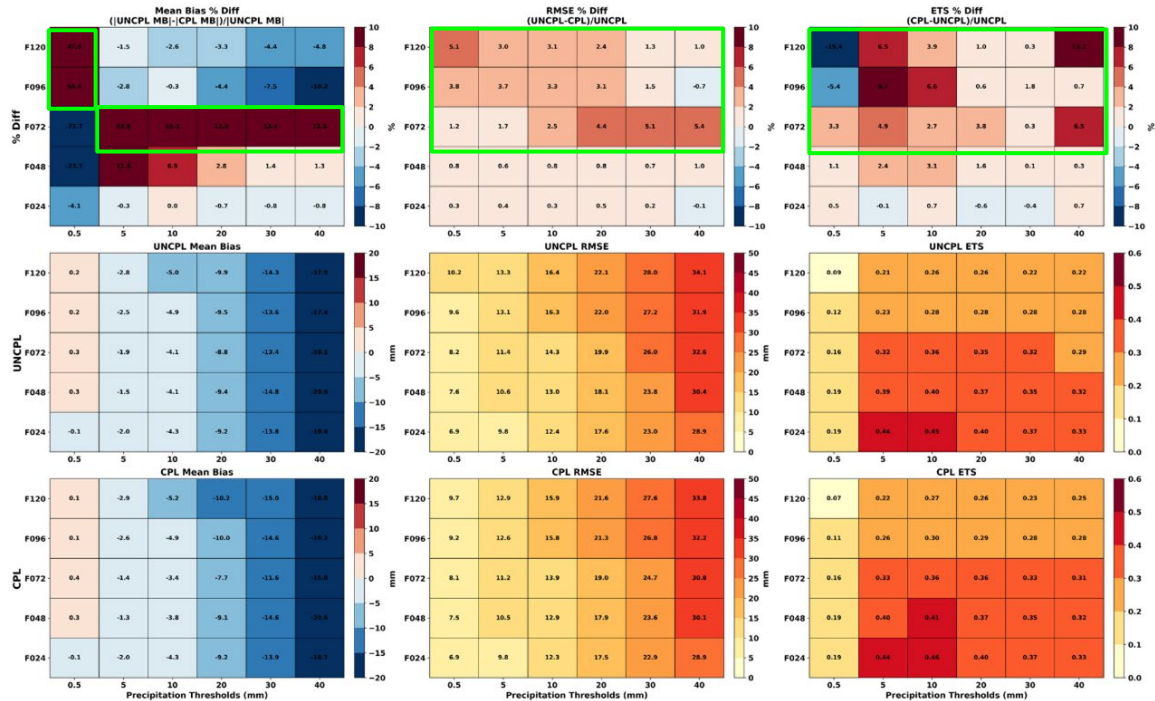
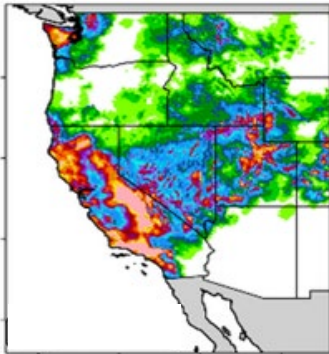


MOM6 grid: ~ 9 - 4 km horizontal resolution.

# Preliminary Results with Ocean Coupled AR-AFSv2 (Exp5)

## 24h. Accumulated precipitation Verification against ST4 (2023-2026)

West-Central domain



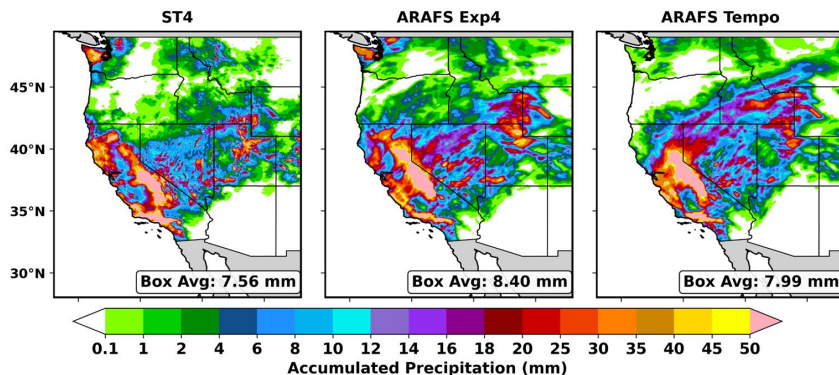
Improvement  
Degradation

Coupling AR-AFS with MOM6 yields additional gains in forecast performance, especially at longer lead times.

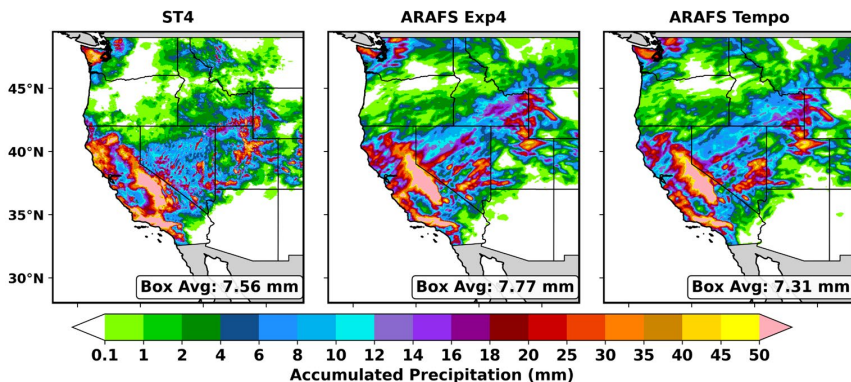
But the large negative bias persists.

# Preliminary results from new physics (TEMPO)

Init: 2023010600 F120



Init: 2023010800 F72

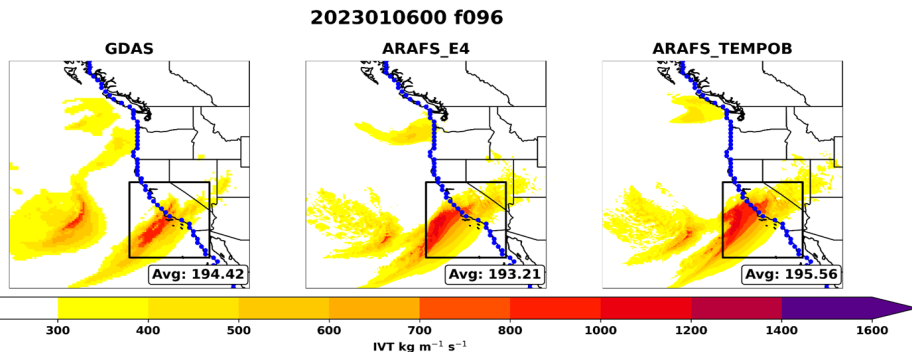


**Case studies:** Forecasts from Jan 6 & 8, 2023; validated Jan 10–11, 2023

- Both Exp4 and TEMPO capture the overall precipitation pattern observed in ST4, e.g., the precipitation maxima over California and Great Basin.
- Their relative performance is mixed. TEMPO is worse than Exp4 for the Jan 06, 2023 run, but better for the Jan 08 run, in term of capturing the structure.
- In this case, TEMPO captures the average precipitation better than Exp4

# Preliminary results from new physics

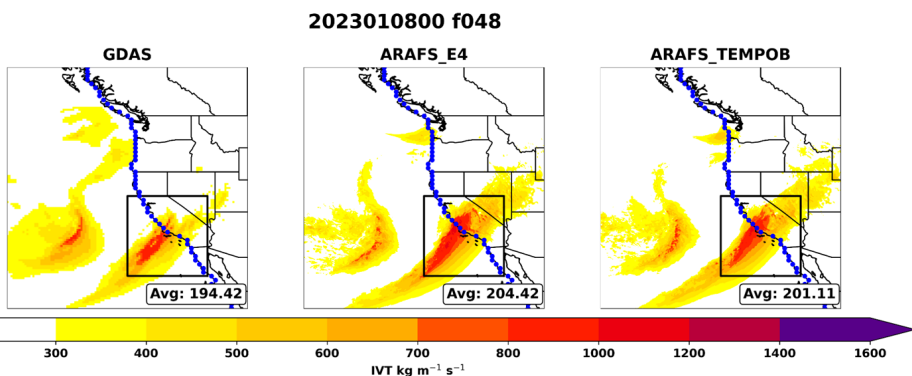
Init: 2023010600 F96



**Case studies:** Forecasts from Jan 6 & 8, 2023; validated Jan 10–11, 2023

- Both ARAFS Exp4 and TEMPO capture the overall IVT pattern observed in GDAS, e.g., the intensity and location of AR landfalls.
- Their relative performance is mixed. TEMPO is worse than Exp4 for the Jan 06, 2023 run, but better from the Jan 08 run, in terms of capturing the intensity along the coast
- Fine tuning is going on, e.g. the combination of TEMPO and C3

Init: 2023010800 F48



# Summary & Future Work

## Summary

- AR-AFSv2 was operated in Near-Real-Time (NRT) from November 1, 2025 to March 31, 2026
- NRT AR-AFS enhances performance in predicting precipitation, specifically for heavy precipitation.
- Ocean coupling may further improve AR prediction and associated precipitation.

## Ongoing and Future work

- Continue evaluating the NRT AR-AFS.
- Advance the integration and testing of the coupled AR-AFS and MOM6 ocean model.
- Refine model physics for AR-AFS/AR-EFS through cross-agency collaboration with PSL, GSL, CW3E, and other partners.
- Expand diagnostic capabilities by incorporating additional variables, performance metrics, and analytical diagrams.