Atmospheric River Analysis and Forecast System (AR-AFS): High-Resolution Experiments for Improving AR Precipitation Forecasts

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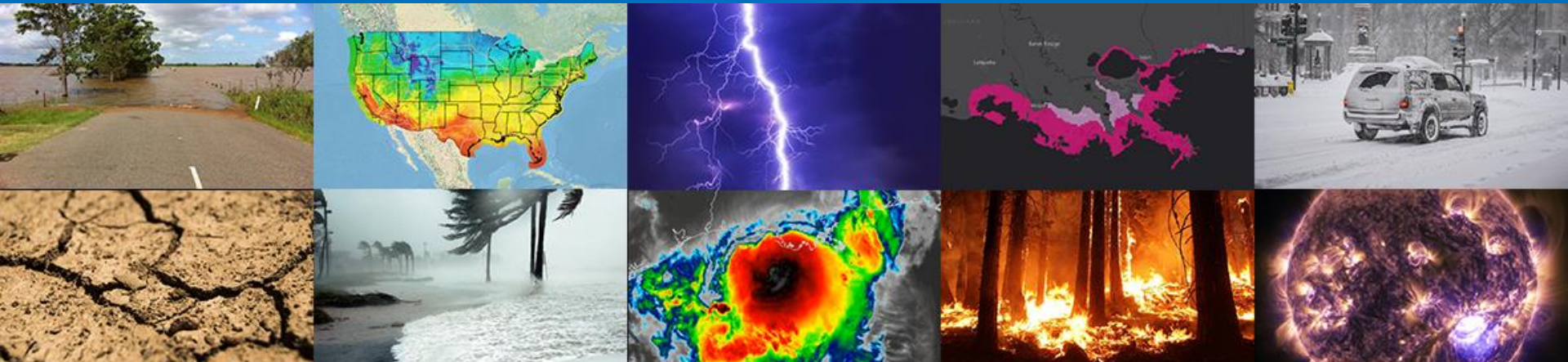
1 EMC/NCEP/NWS/NOAA, 2 NGI, 3 Axiom, 4 CW3E

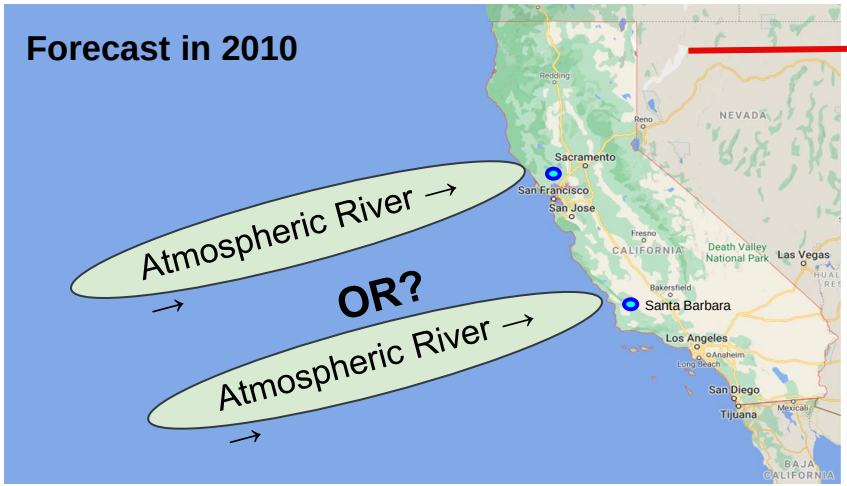


Outlines

- AR-AFS Introduction
- AR-AFS for 2022-2023 AR Recon
  - Summary
  - Case Studies
- AR-AFS Physics Experiments
- Conclusion & Future Work

Motivation

Example: A 5-day Forecast in the year 2030



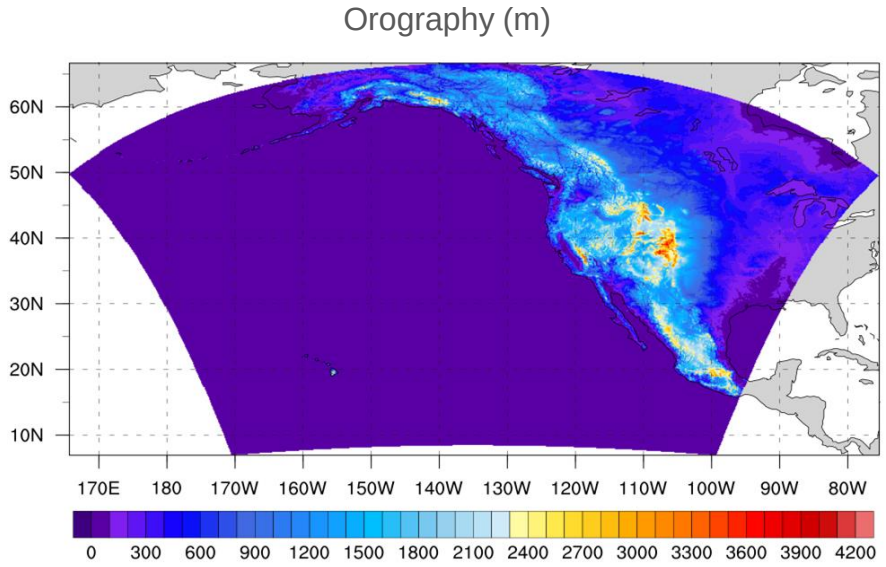
Not much different from today

- Not really sure if State should move resources to San Francisco or Santa Barbara
- Decision makers simply WAIT to act

Actionable information

- The State pre-deploys assets to San Francisco
- Emergency Operations Center activates
- The Lake Medocino Reservoir *releases* water to avoid catastrophic flood
- The Twitchell Reservoir *saves* water - enough to serve water to 10,000 households / yr

AR-AFS: HighRes Regional Model within the UFS



- Designed from a combination of **UFS High-Res RRFS and HAFS** configurations
- Initialized with operational GFS IC/BC
- No DA capability yet

Model Configuration

- FV3 Dynamical core
- Horizontal Resolution: 3 km ESG, 3200X2300
- 120 hour forecast at 3 hour interval
- Domain: Eastern Pacific and CONUS
- Vertical Resolution: 64 levels, 1000-0.2 mb

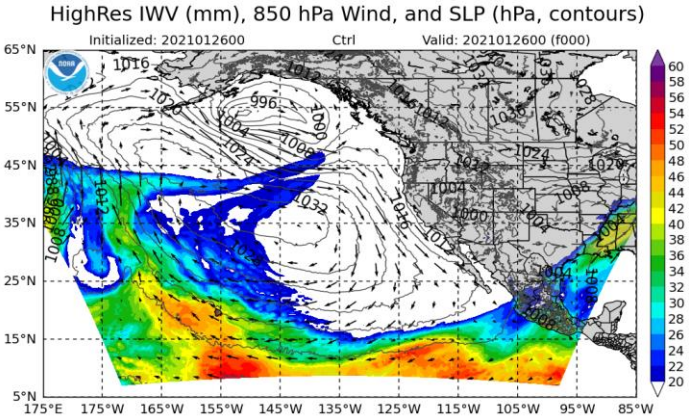
Physics

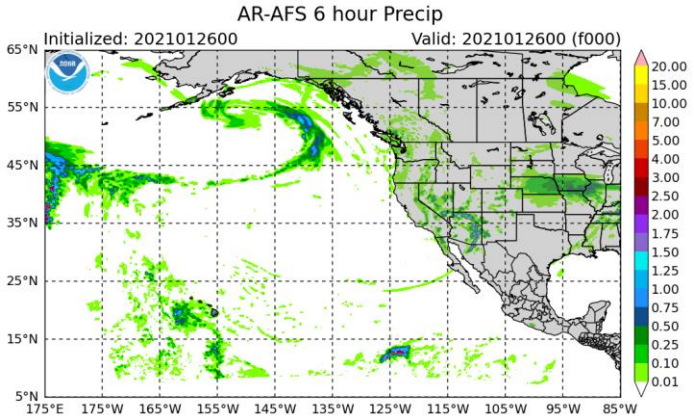
- GFS EDMF PBL
- GFS surface layer
- Thompson Microphysics
- Noah LSM
- RRTMG radiation
- SAMF convection scheme

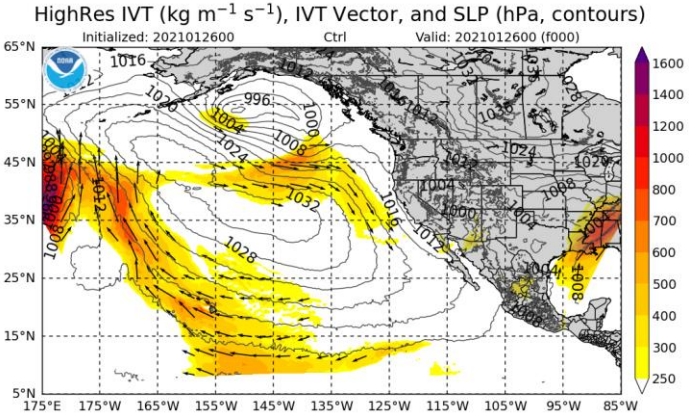
Resource

- CW3E's Comet: 124 compute nodes, 12 hours per cycle
- NOAA's Orion: 110 compute nodes, 4 hours per cycle

AR-AFS: HighRes Regional Model within the UFS







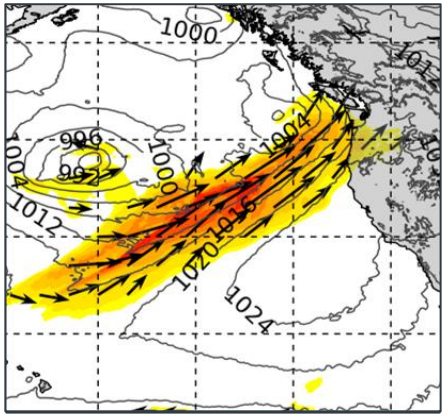
Started testing near real-time experiment during 2022 AR recon on CW3E Comet

Run near real-time experiment during 2023 AR recon on CW3E Comet

AR-AFS: HighRes Regional Model within the UFS

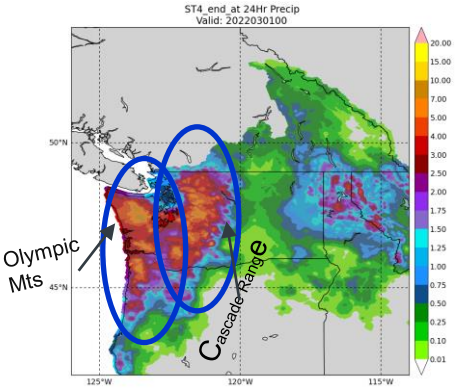
Init 2022022800 (IOP-15) valid 2022030100

2022022800

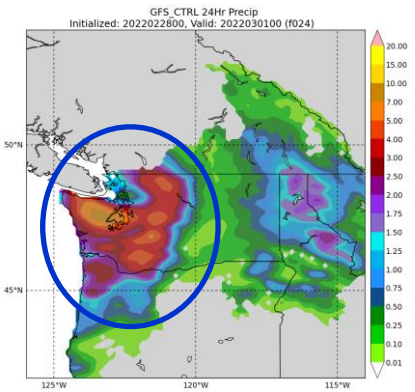


2022030100

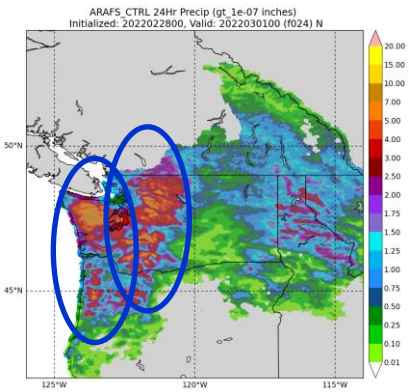
Stage 4



GFSv16



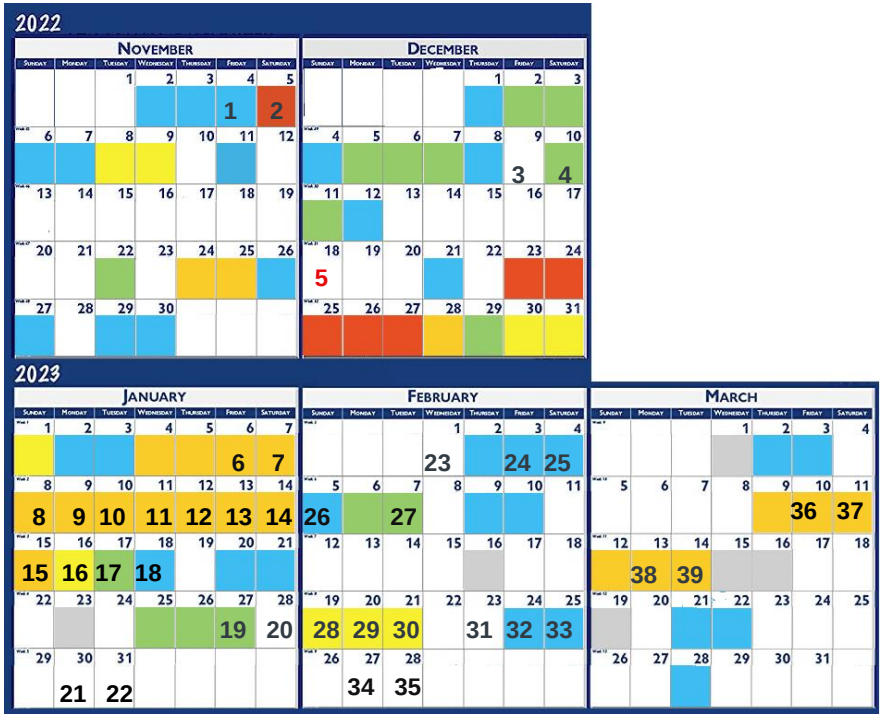
AR-AFS



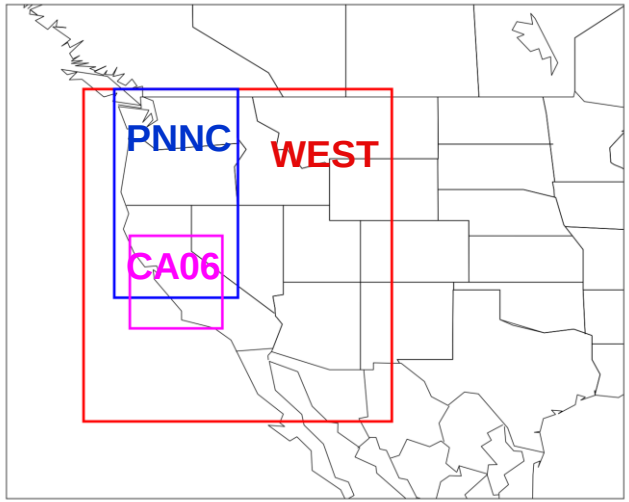
Potentially helps us to better capture structures and small high precipitation regions

AR Recon 2022-2023

2022-2023 Intensive Observation Period (IOPs)



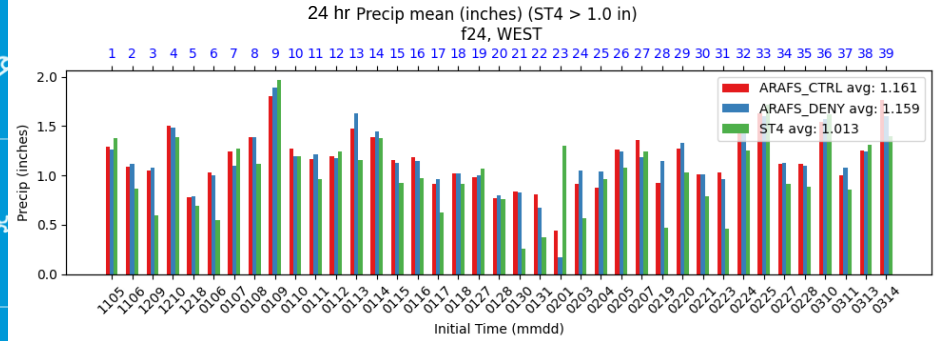
Spatial domains for precipitation verification

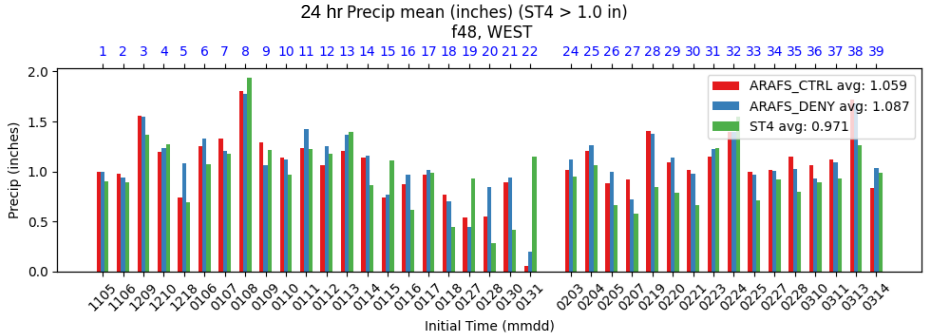


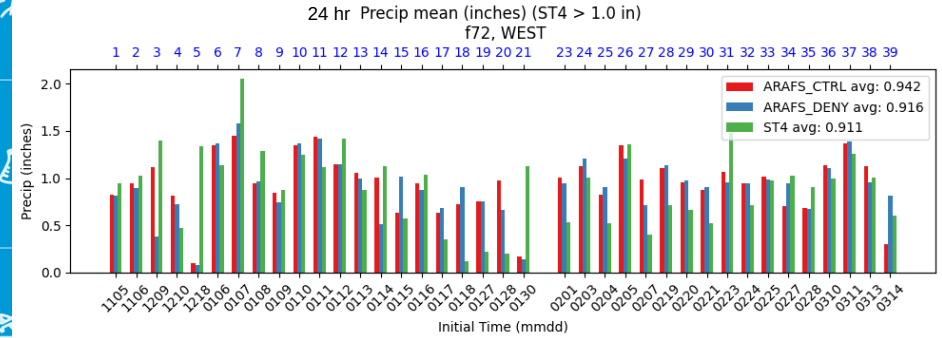
WEST: West Coast
PNNC: Pacific Northwest and Northern California
CA06: Central California

Data Impact Experiment with AR-AFS

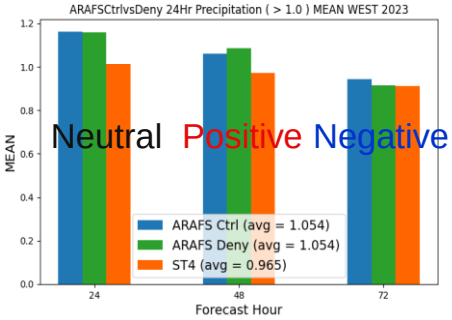
Precipitation Verification in WEST (1.0 in cutoff)







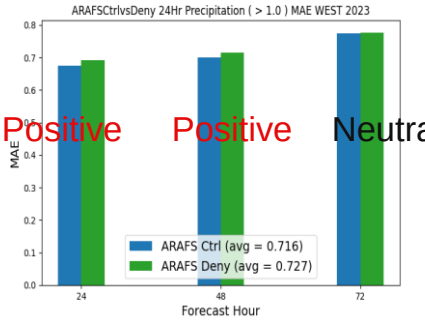
Mean



Neutral Positive Negative

Overall neutral

MAE



Positive Positive Neutra

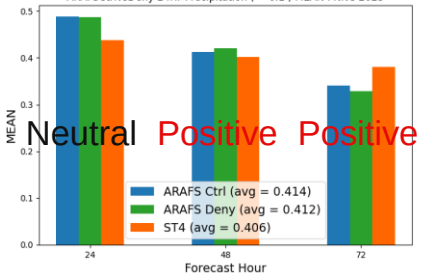
Overall positive

Data Impact Experiment with AR-AFS

Precipitation Verification in PNNC and CA06

PNNC | **Mean** | CA06

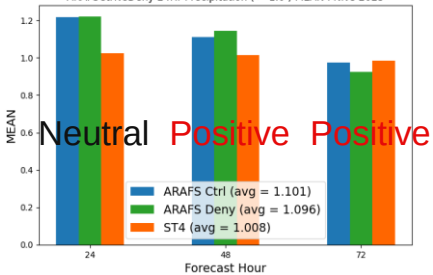
>=0.1 inch



Neutral Positive Positive

Overall positive

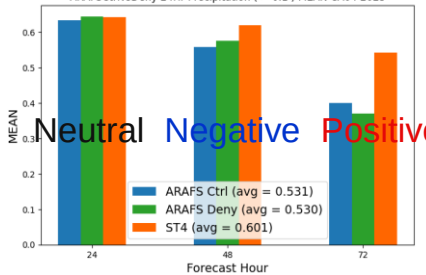
>=1.0 inch



Neutral Positive Positive

Overall positive

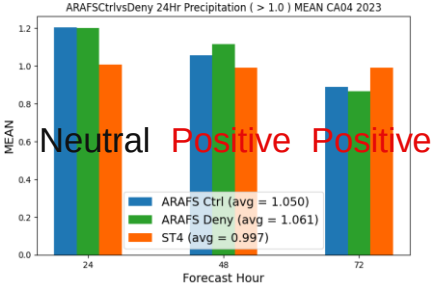
>=0.1 inch



Neutral Negative Positive

Overall neutral

>=1.0 inch

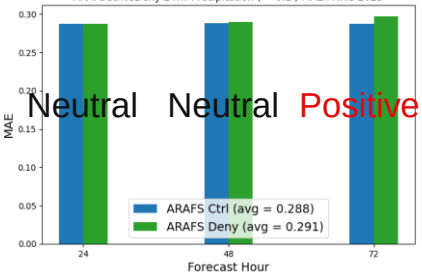


Neutral Positive Positive

Overall positive

MAE

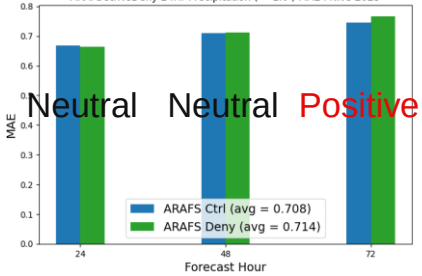
>=0.1 inch



Neutral Neutral Positive

Slightly positive

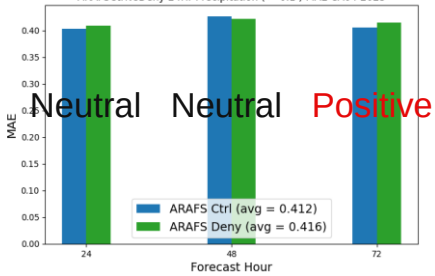
>=1.0 inch



Neutral Neutral Positive

Slightly positive

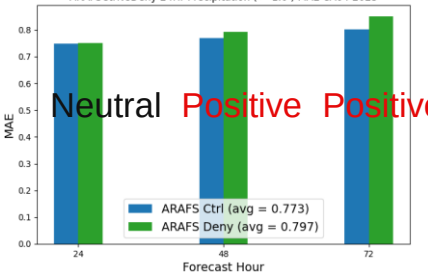
>=0.1 inch



Neutral Neutral Positive

Slightly positive

>=1.0 inch



Neutral Positive Positive

Overall positive

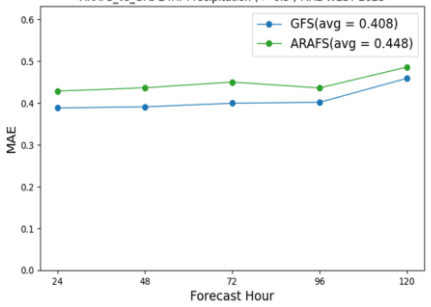
AR-AFS vs GFS

MAE (Mean Absolute Error) 2023

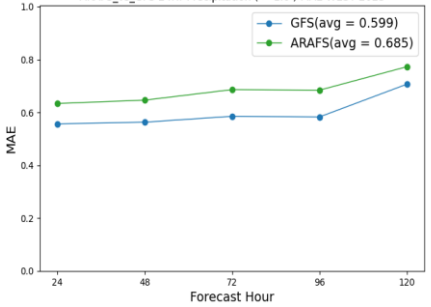
ETS (Equitable Threat Score) 2023

WEST

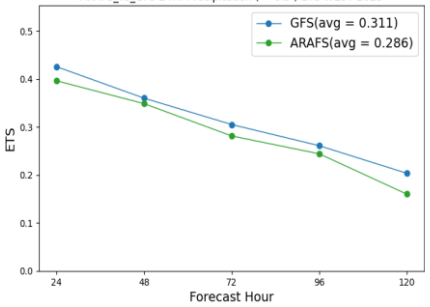
>=0.5 inch



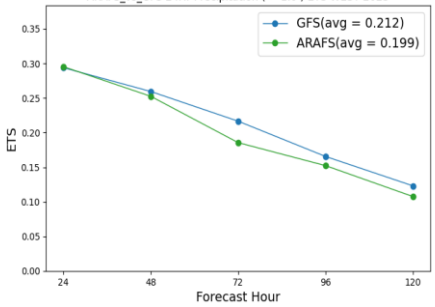
>=1.0 inch



>=0.5 inch

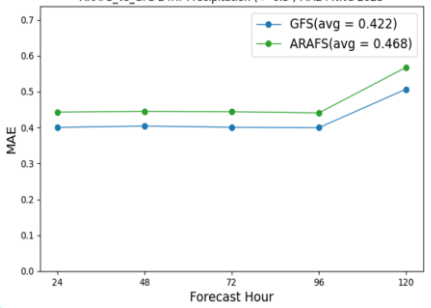


>=1.0 inch

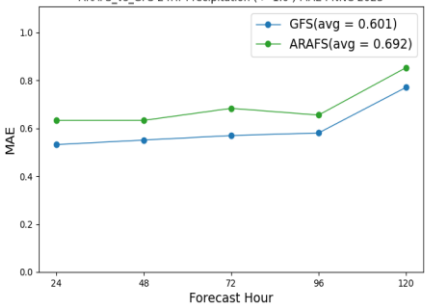


PNNC

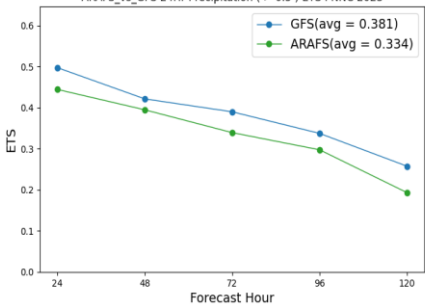
>=0.5 inch



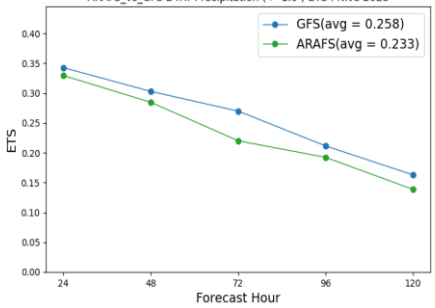
>=1.0 inch



>=0.5 inch



>=1.0 inch



Case Study - IOP 14

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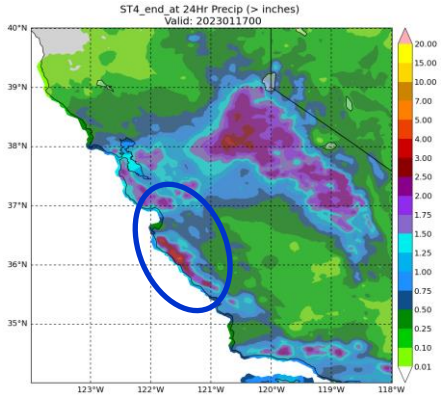
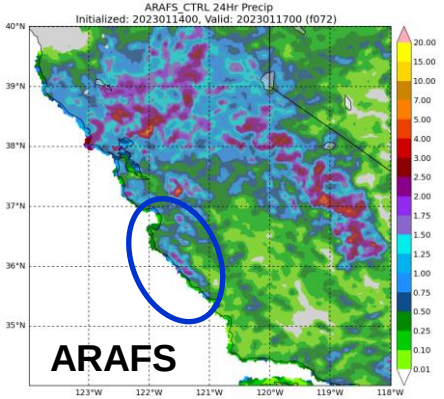
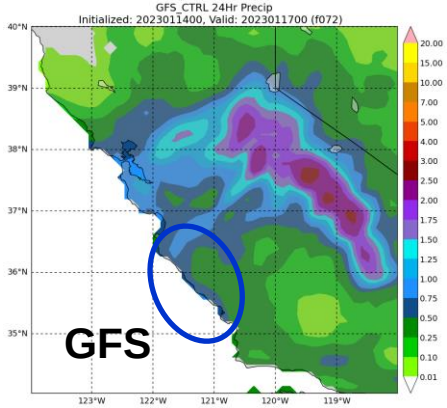
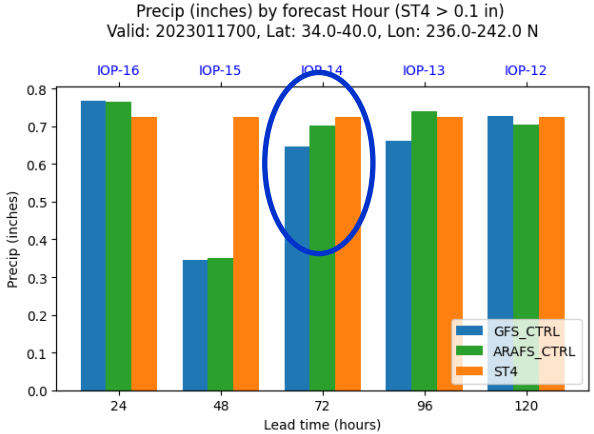
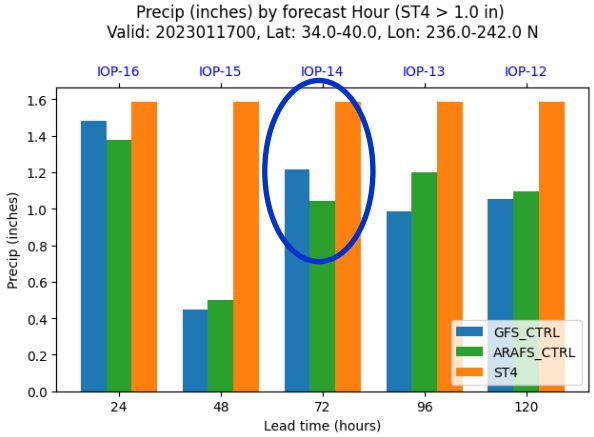


Stage IV Obs









Case Study - IOP 14

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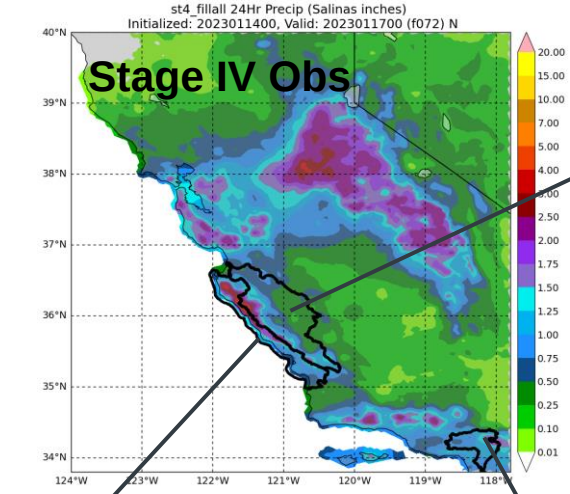
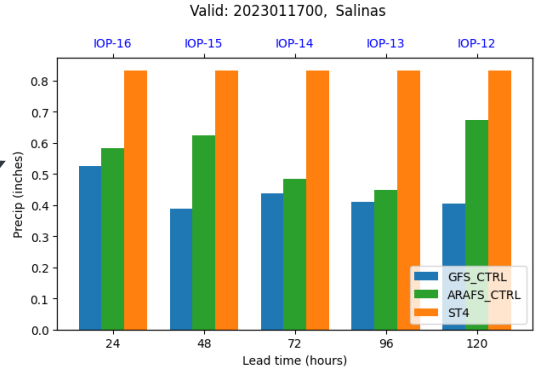
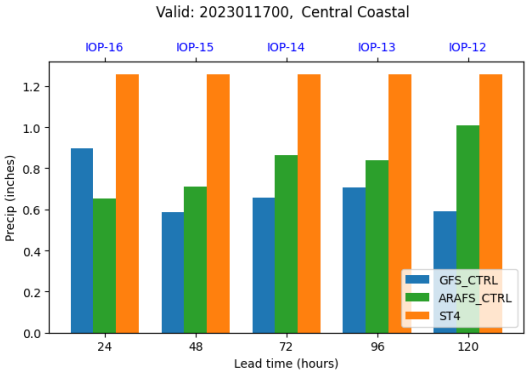
Precipitation Verification on Watersheds



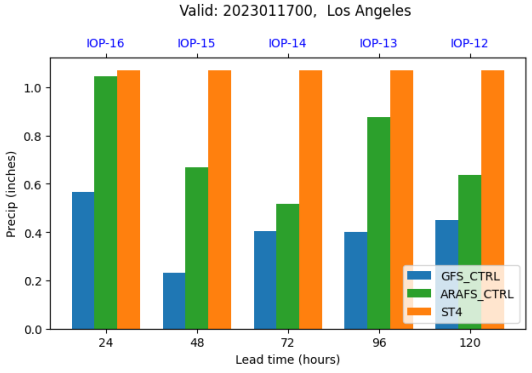
Salinas



Central Coastal

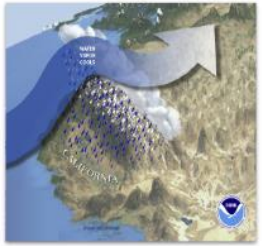


Los Angeles



AR-AFS Physics Experiments

FY23 AR project objectives



- Create a prototype Atmospheric River Forecast System that improves upon current (non-operational) AR models
- Use the FY22–23 winter to test this and other AR models
- Apply social science to assess stakeholder AR forecast experiences

CCPP Suites used in the experiments with AR-AFS

Experiments/Suites	*gfdlmp_tedmf*	*thompson_gfdlsf*	*thompson_gfdlsf_ysu*
Microphysics	GFDL	Thompson	
PBL	EDMF-TKE		YSU
Surface layer	GFDL		
Land surface	GFS-Noah		
Convection	SAMF		
Radiation	GFS-RRTMG		

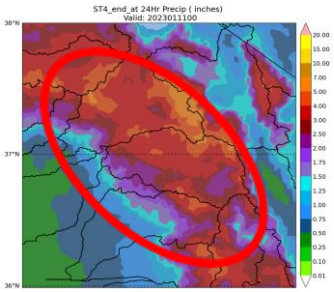
- The comparison is made using 25 AR-AFS forecast cycles from the 2022 AR season and 15 cycles from the 2023 AR season for precipitation forecasts over the U.S. West Coast.
- All forecasts were initialized during the Intensive Observation Periods (IOPs) of active ARs at 00 UTC.
- Hypothesis: Thompson microphysics scheme and YSU PBL scheme are more suitable for simulating AR associated precipitations.

AR-AFS Physics Experiments

IOP-08 (F72) forecast is improved with new physics

Near Real-time ARAFS

ST4



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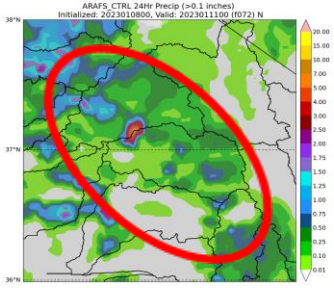

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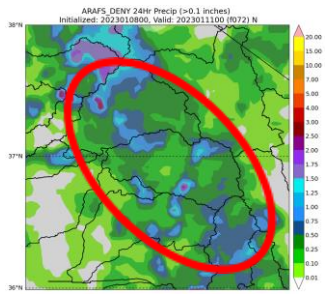
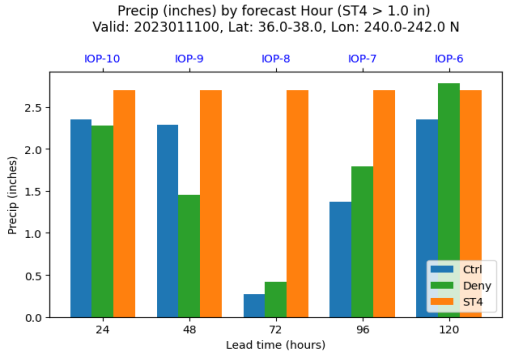
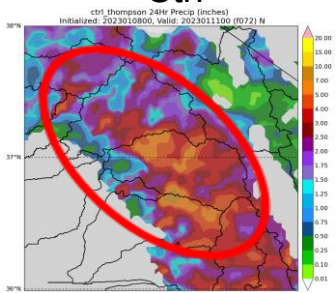




A different Physics Suite

Ctrl



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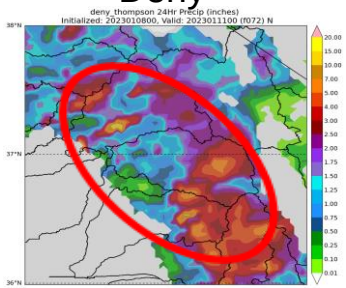
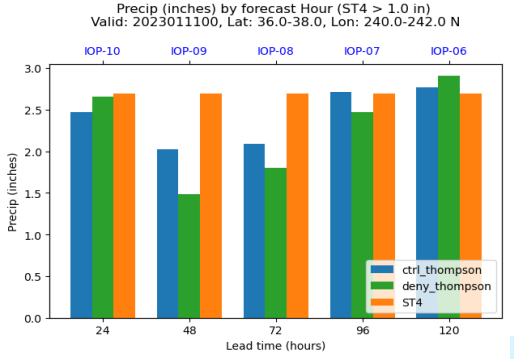
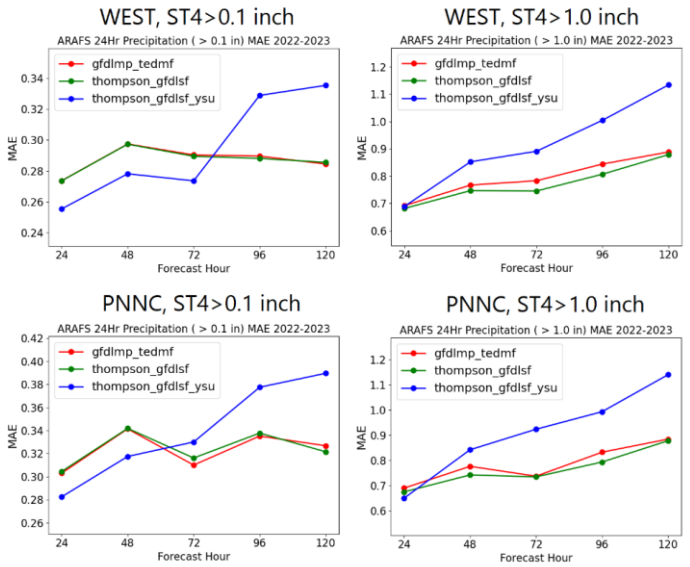


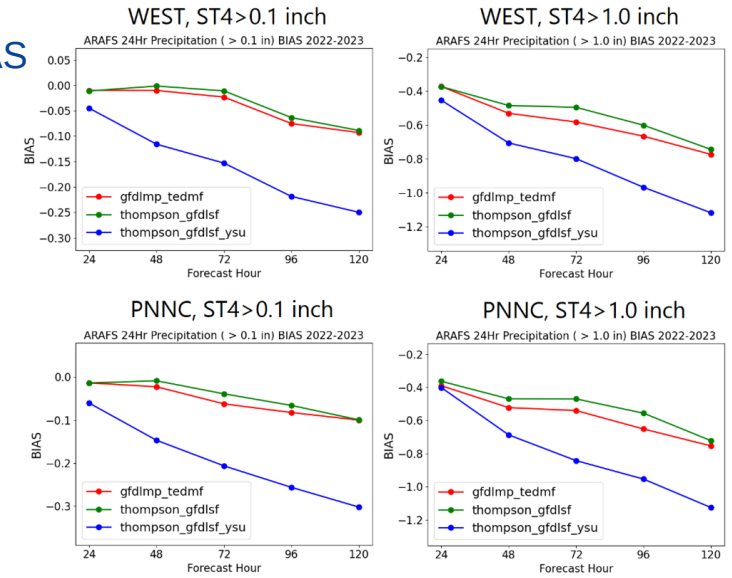


AR-AFS Physics experiments

MAE



BIAS



- Precipitation is sensitive to both microphysics and PBL schemes
- Larger sensitivity occurs in the PBL scheme testing
- Thompson microphysics scheme with GFDL surface scheme showed a potential to improve AR associated precipitation forecasts
- Thompson scheme and YSU scheme showed smaller MAEs at short leads but larger MAEs at long leads (Need further investigation)

Conclusion & Future Work

- AR-AFS capture the structure of precipitation and precipitation on watershed levels better than GFS but has less skills in predicting precipitation in larger domains
- AR-ARS has potential to improve the prediction of AR landfall point and high-resolution precipitation forecast with more suitable model physics and data assimilation
- Data collected from AR Recon could be used to validate model physics
- We will be looking into additional diagnostics