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# Improving Satellite Mountain Snowfall Magnitudes with SWE- Reanalysis and GPROF-NN

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A satellite view of Earth showing the Arctic region and surrounding landmasses. The Arctic is covered in a thick layer of white snow and ice. Dark blue lines represent rivers and streams flowing from the snowmelt into the surrounding oceans. The landmasses are shown in various shades of green, brown, and tan, indicating different vegetation and terrain types. The curvature of the Earth is visible at the top and bottom edges.

# 1.3 billion

About 1/6th of the world's population depends on snowmelt for their freshwater needs

A topographic map of the Western United States, showing mountain ranges, valleys, and the Pacific coastline. A large white box is overlaid on the map, containing the text '70%'. Below this box, another white box contains the text 'of runoff arrives as snow in the Western U.S.'. The map uses color to represent elevation, with browns and tans for lower elevations and greys and whites for higher elevations. The Pacific Ocean is shown in blue on the left side.

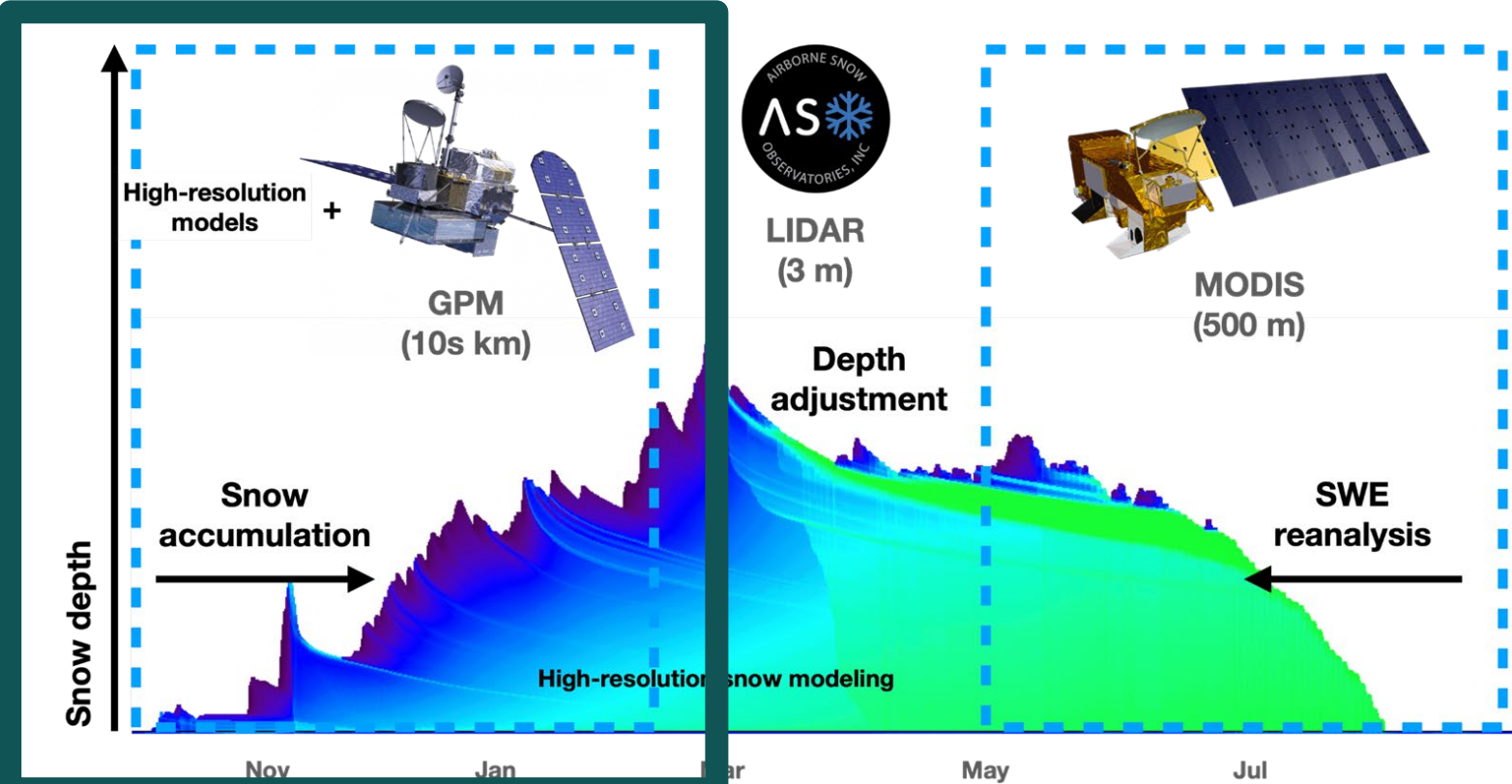
# 70%

of runoff arrives as snow in the Western U.S.

# There are clear, negative trends in snow resources

- Global extent of snow-covered area on land has been declining (*Brown, 2000; Mudryk et al. 2017*)
- The mass of snow (SWE) is also declining (*Brown, 2000; Kunkel et al., 2016*)
- Snow is melting sooner (*Liston and Hiemstra 2011*)
- Winter precipitation is arriving increasingly as rain
- The number and intensity of winter snowfall events appears to be declining (*Lute et al., 2015*)
- There is a worldwide reduction in glacier mass balance (*Gardner et al. 2013*)

# Most critical first step is improving seasonal snowfall accumulations



1.



2.



3.

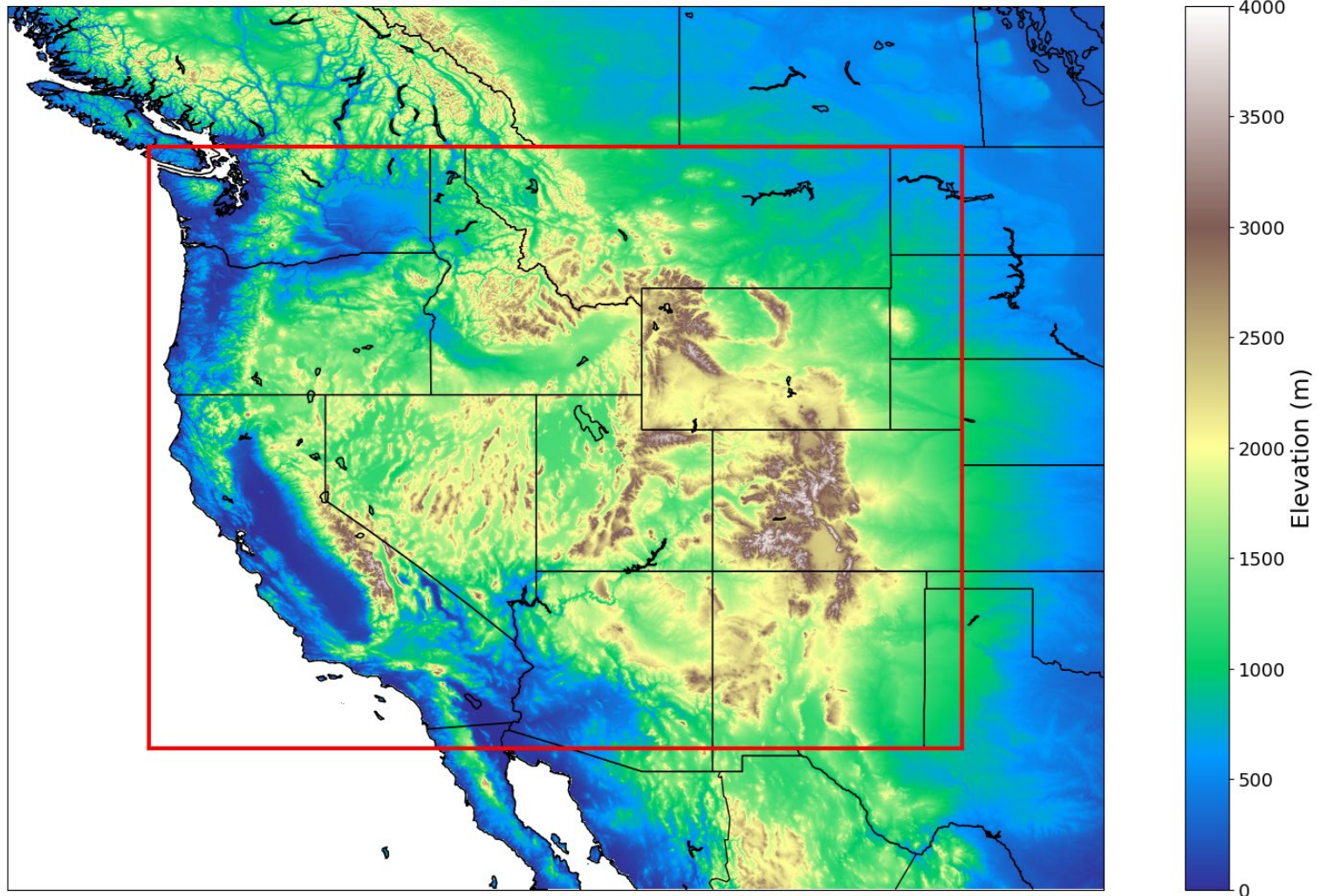
**Western U.S. Snow  
Reanalysis**

**GPROF Models**

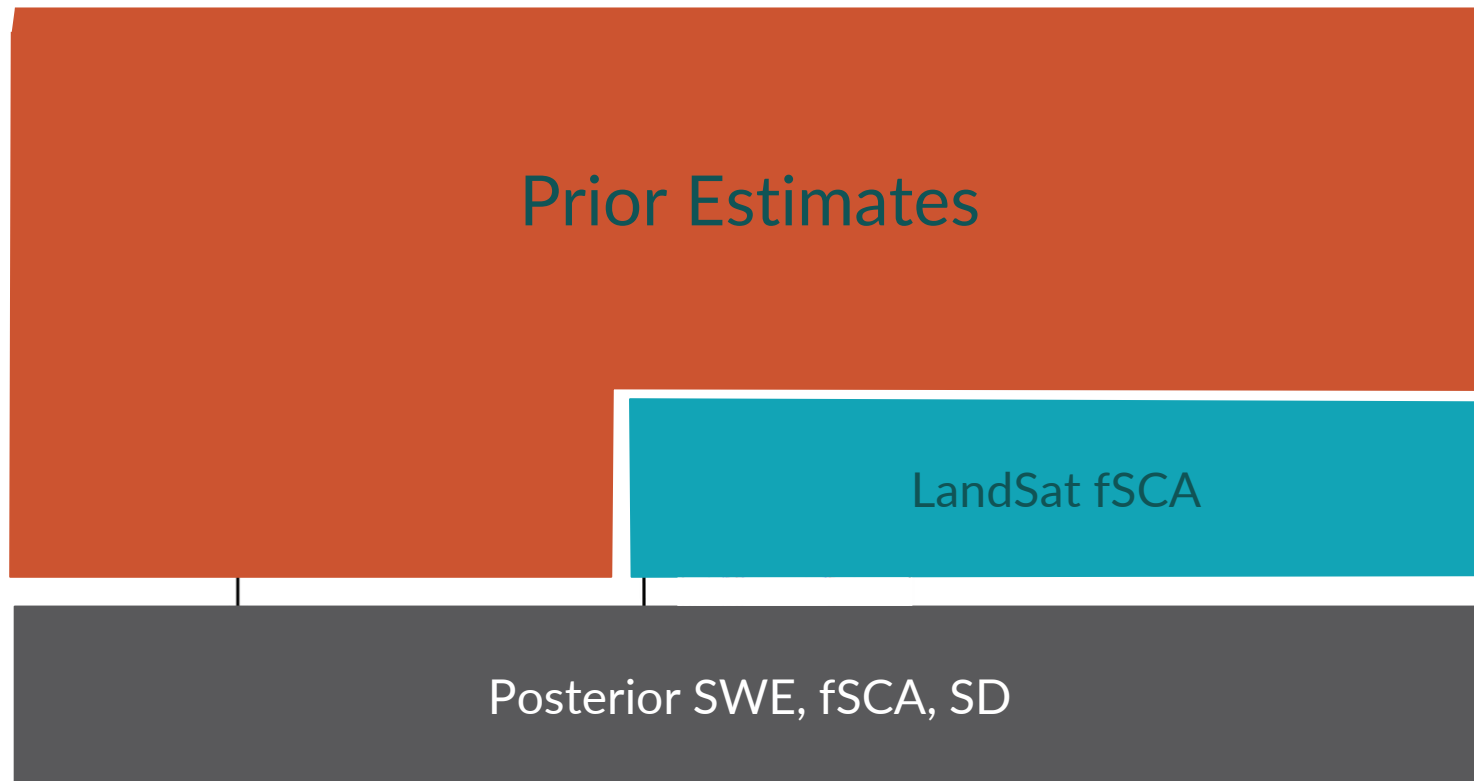
GPROF V7, GPROF-NN 1D, GPROF-  
NN 3D

**Methods and Results**

# Western US Domain

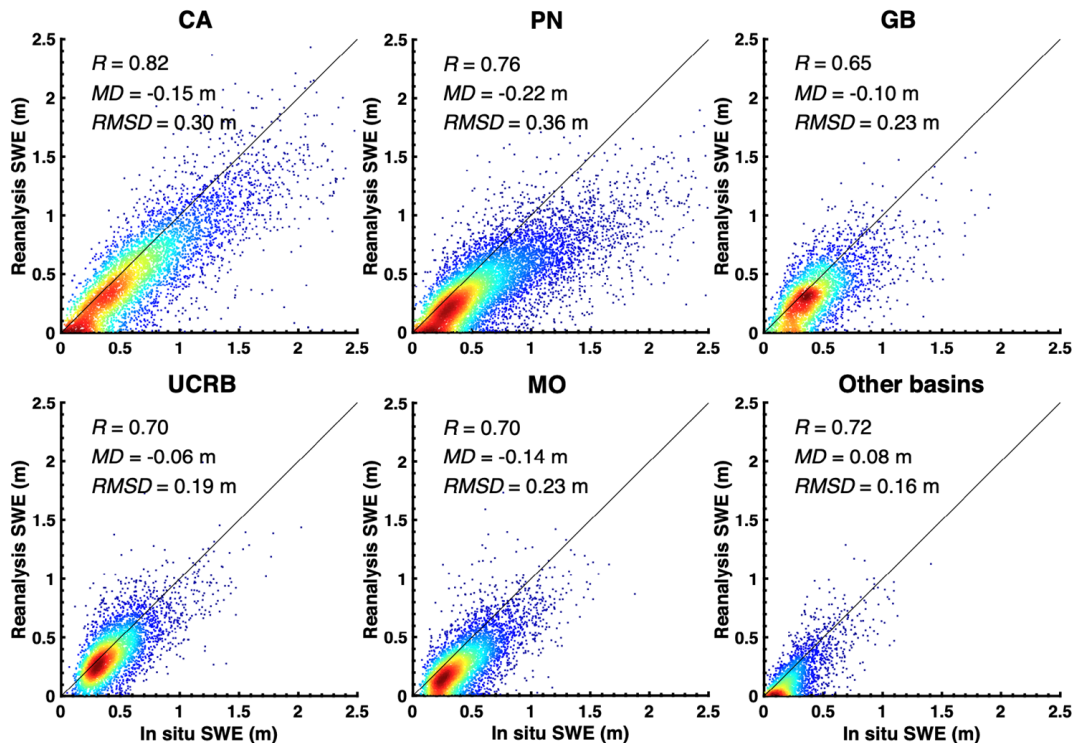


# The WUS-SR product weights priori SWE time series with LandSat fSCA measurements





# WUS-SR correlates well with independent SNOTEL SWE for peak WY SWE across large watersheds.



1.



2.



3.

**Western U.S. Snow  
Reanalysis**

**GPROF Models**

GPROF V7, GPROF-NN 1D, GPROF-  
NN 3D

**Methods and Results**



## GPROF v7

Bayesian inversion technique that weights a priori database entries that are radiometrically consistent with observed TBs

## GPROF-NN 1D

Fully connected neural network that retrieves single pixels based on observed TBs

## GPROF-NN 3D

Incorporates spatial information into the retrieval using a CNN

1.



2.



3.

**Western U.S. Snow  
Reanalysis**

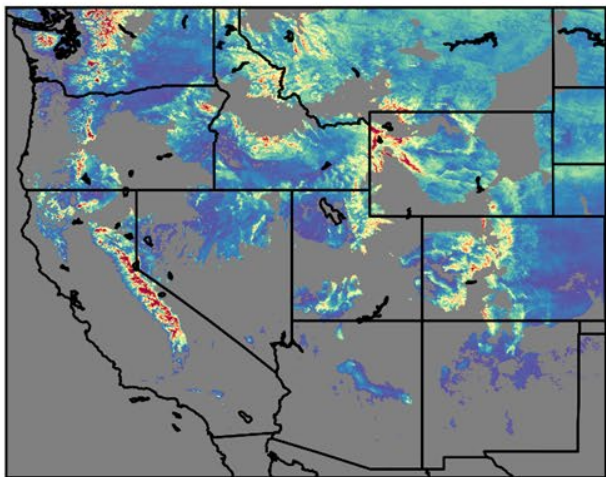
**GPROF Models**

GPROF V7, GPROF-NN 1D, GPROF-  
NN 3D

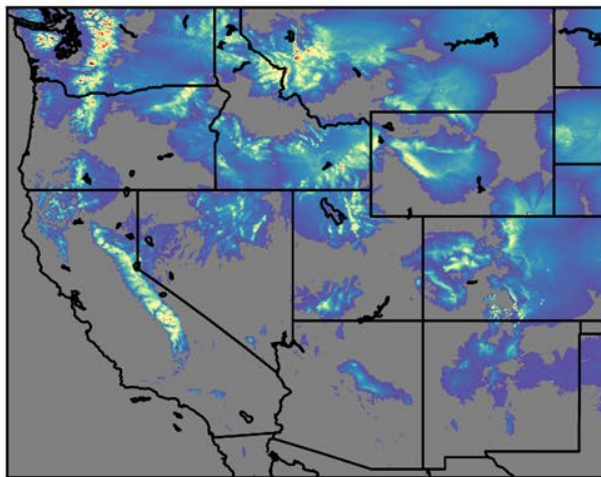
**Methods and Results**

# The ratio between water year snowfall accumulations are used to create scale factors

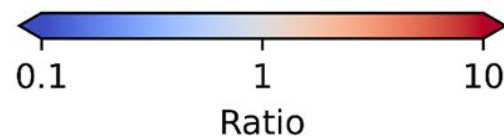
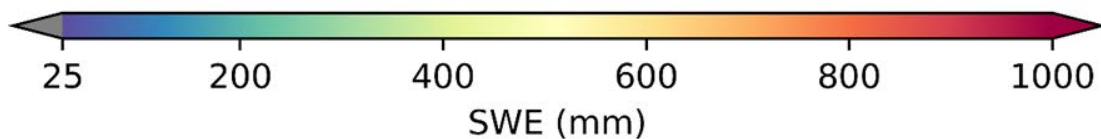
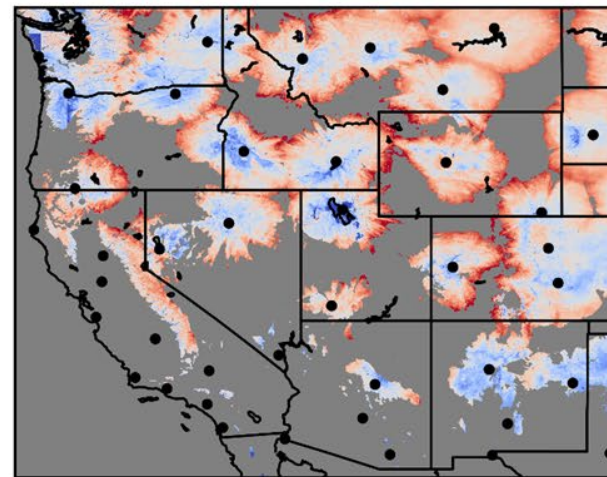
**WUS-SR**



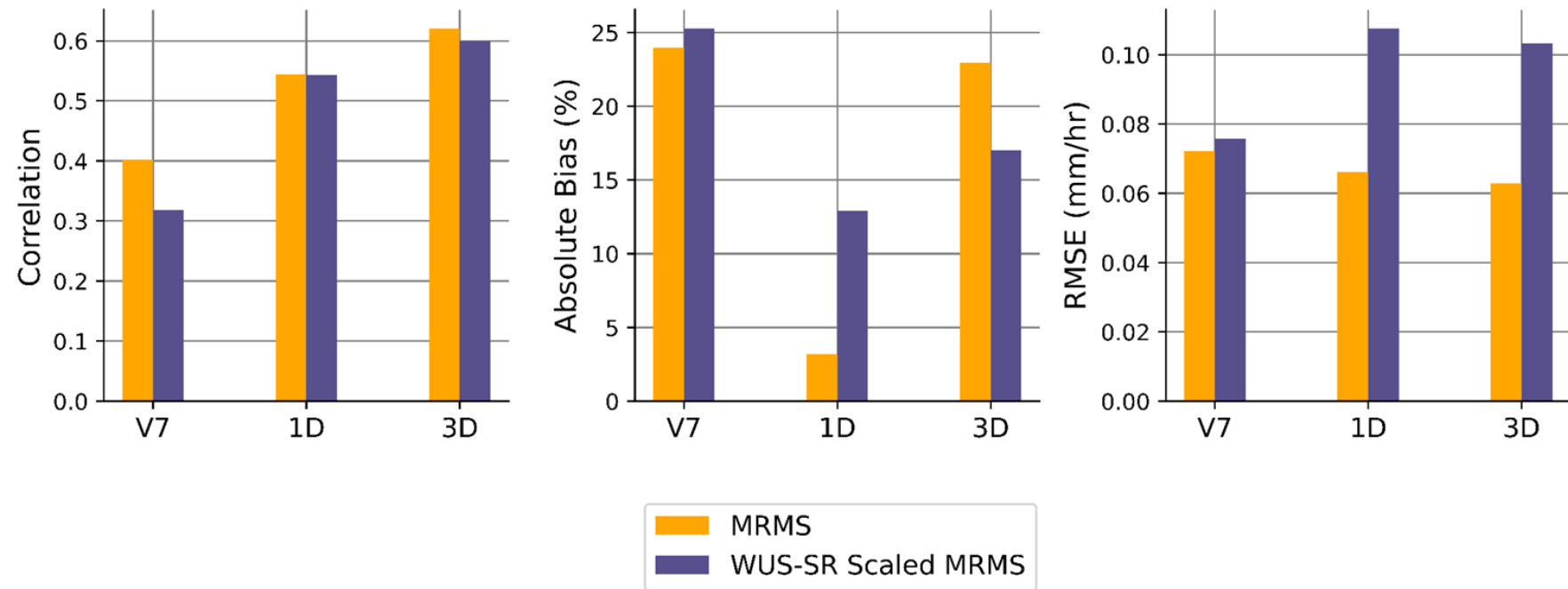
**MRMS**



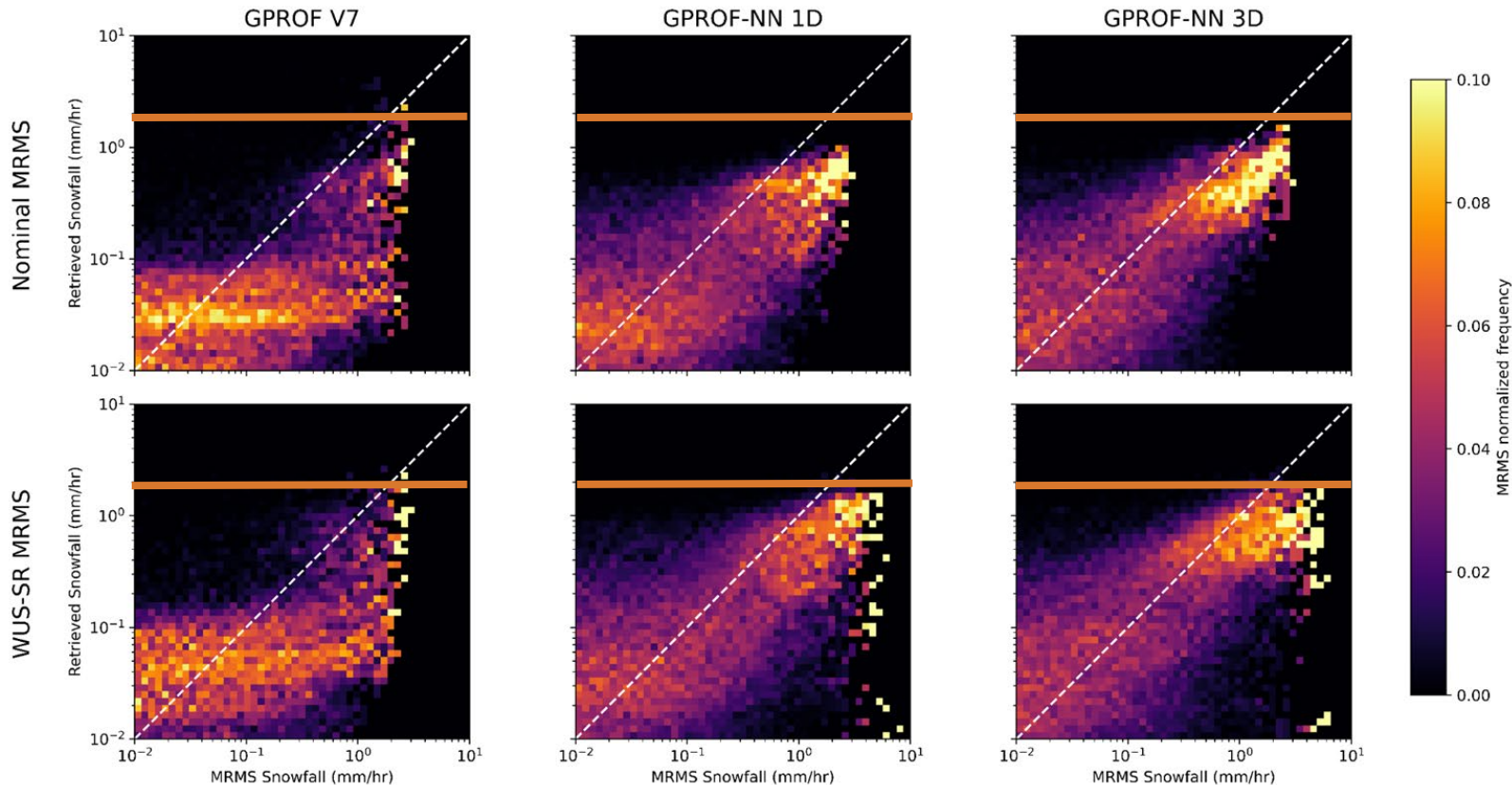
**Ratio (WUS-SR/MRMS)**



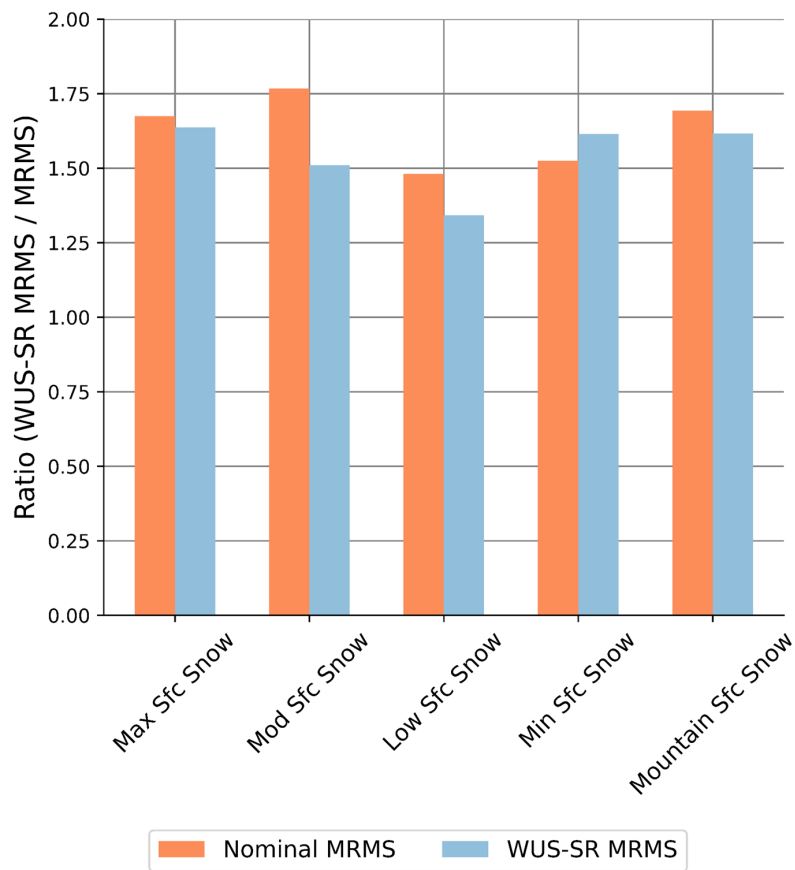
# GPROF-NN models outperform GPROF V7 in terms of quantitative statistics.



# WUS-SR scaled snowfall show noticeable increases in instantaneous snowfall.

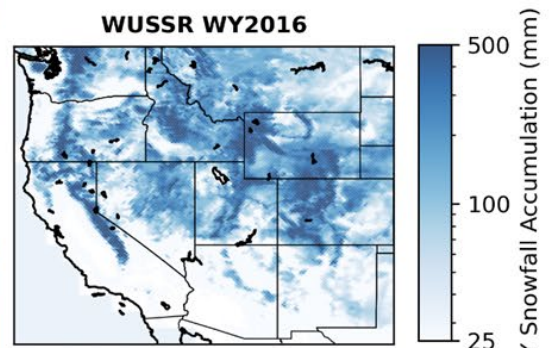
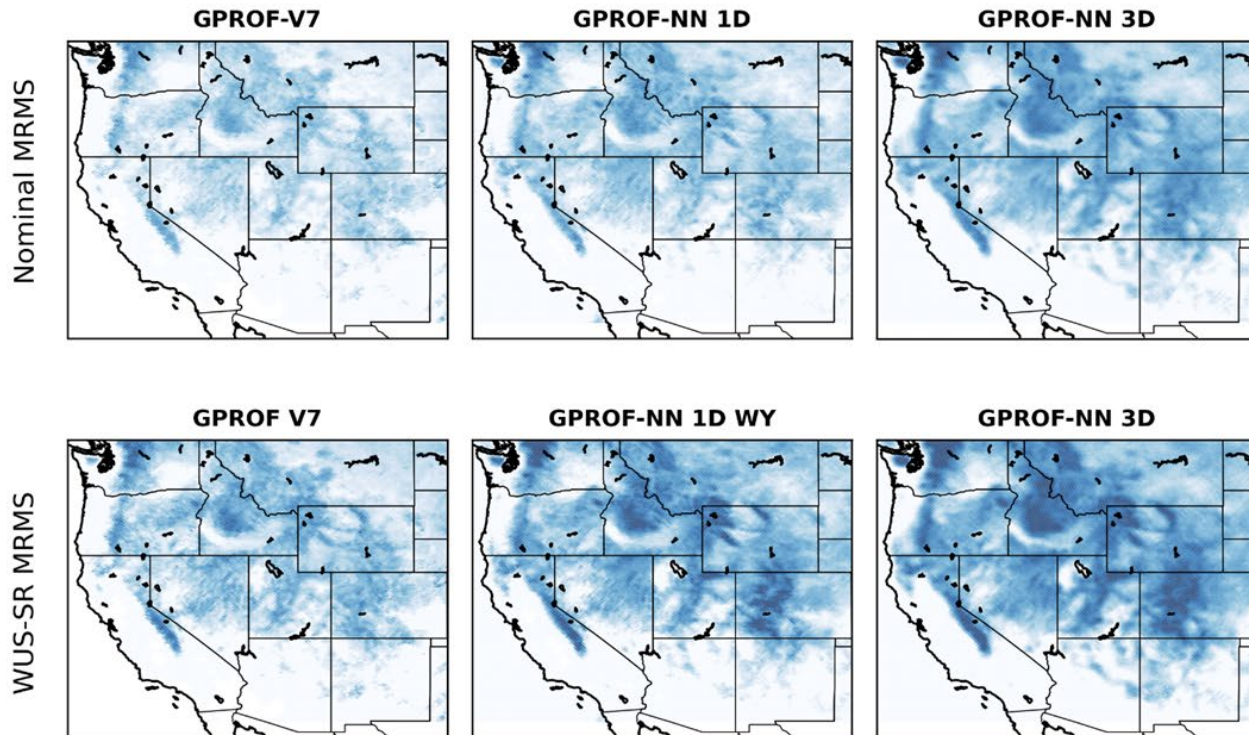


# WUS-SR scaling is properly handled through the GPROF-NN models

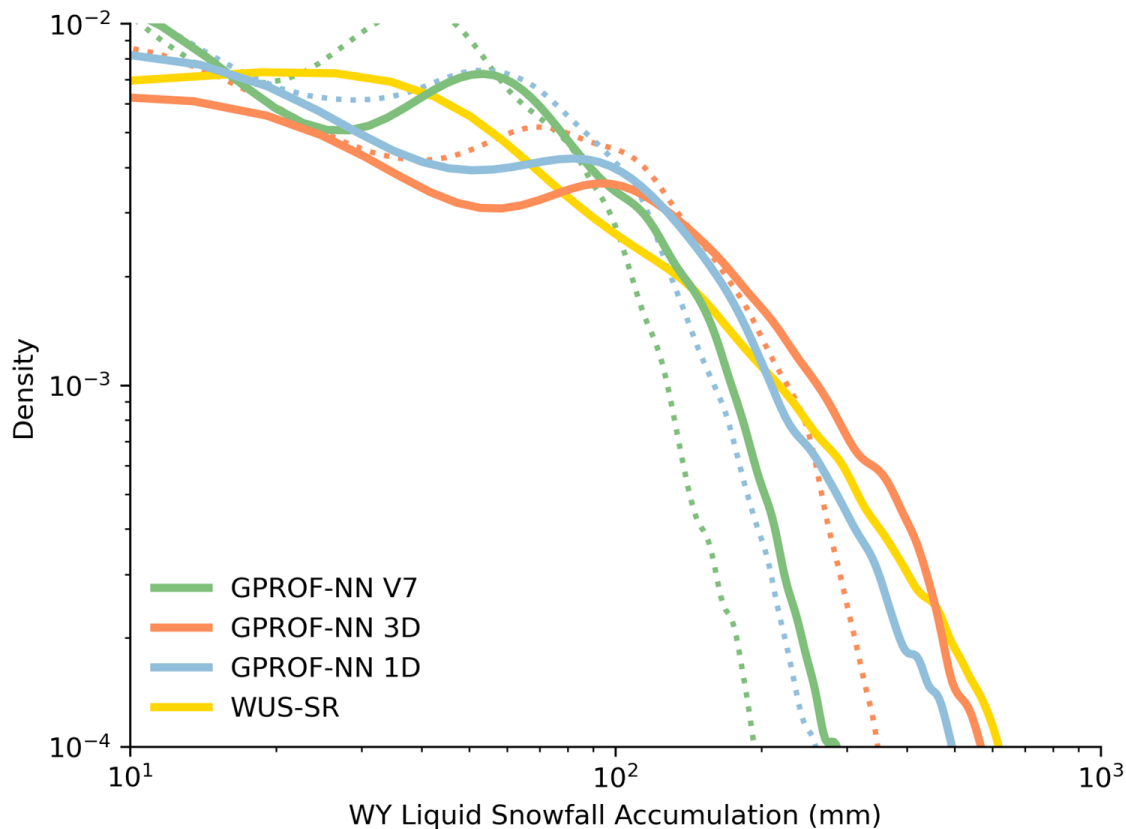




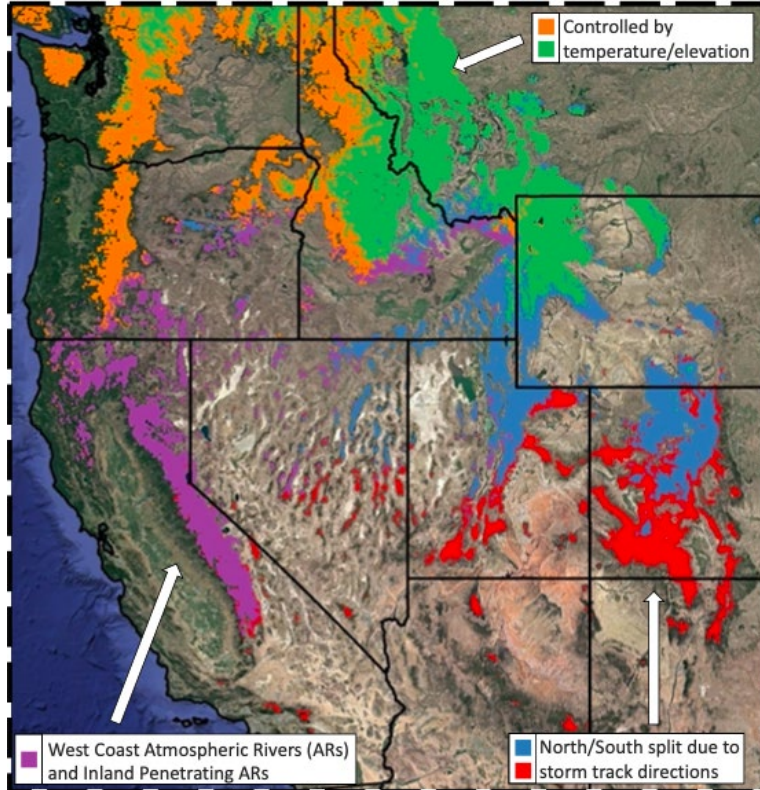
More snow



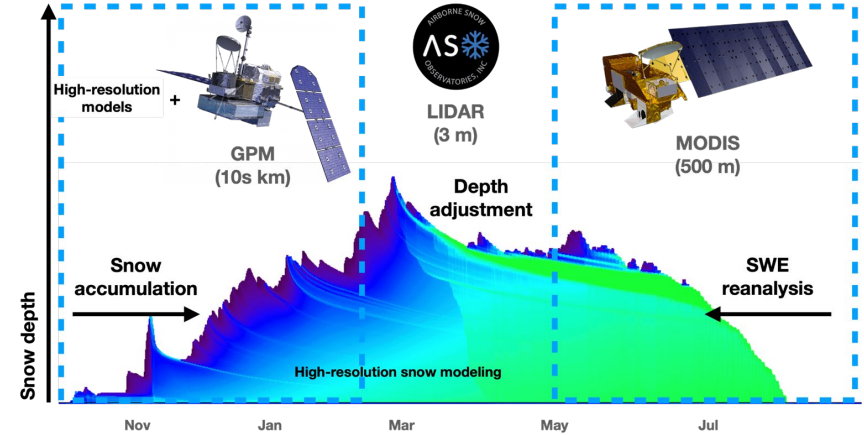
# GPROF-NN models are better able to match WUS-SR water year snowfall accumulations at higher accumulations.



# Clustered correlated interannual SWE variability



# SWE-Reanalysis + ML Retrieval as input to SnowModel



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**Thank You  
Questions?**

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# Extra Slides

# USCRN-MRMS $Z=\alpha S^2$

