Addressing the largest source of uncertainty in real-time snow modeling: bias correction of HRRR precipitation using in-situ observations

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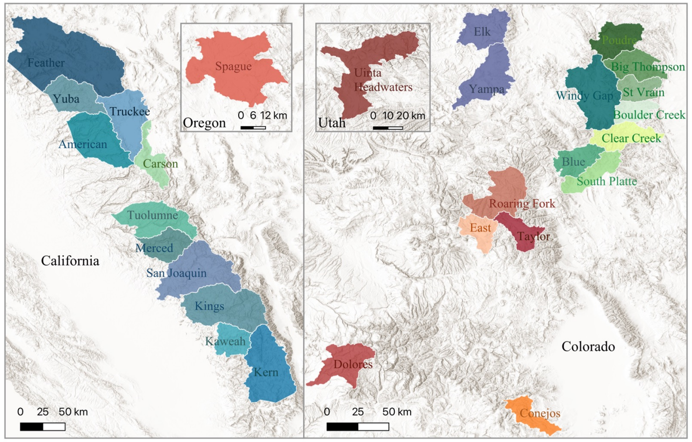
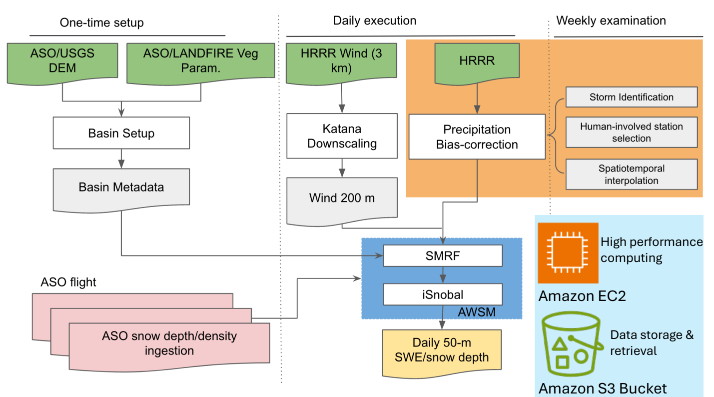
Background

To support operational water resources management, M3 Works has been collaborating with Airborne Snow Observatories, Inc (ASO) since WY 2020. This partnership focuses on providing near real-time estimates of spatially distributed SWE at a 50-meter spatial resolution across multiple basins in the Western U.S.



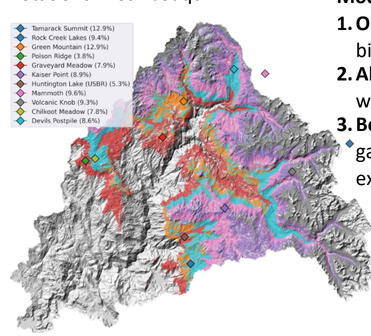
A major challenge in accurately modeling SWE arises from the high uncertainty in precipitation input data. Although precipitation data downscaled from NOAA's HRRR v4 shows good temporal alignment with observations, its magnitude agreement varies significantly across different regions. To address this, we developed a workflow to bias-correct HRRR precipitation model input using in-situ observations.

iSnobal Modeling system & HRRR bias correction



Results: a case study in San Joaquin River Basin, California

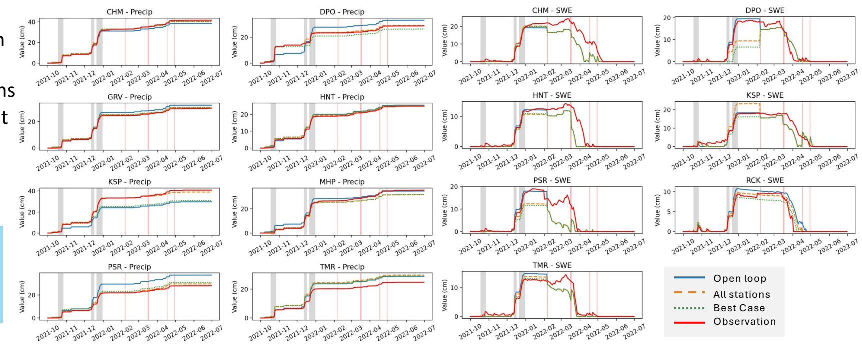
Stations in San Joaquin



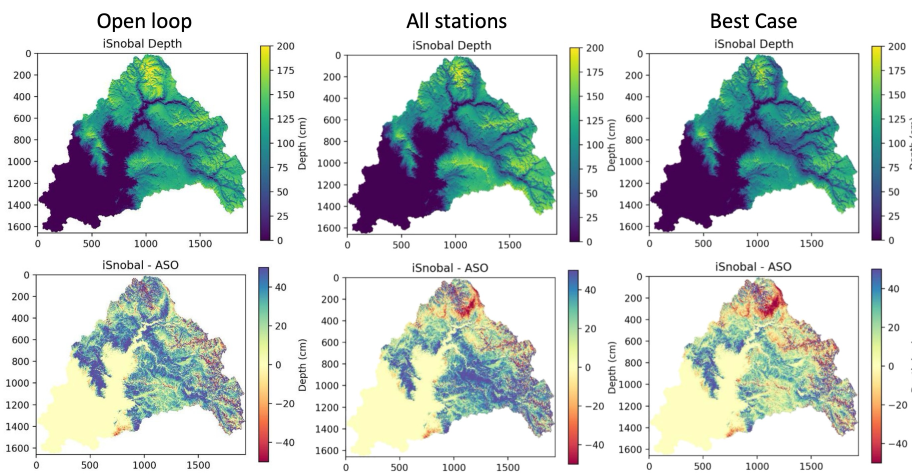
Model runs

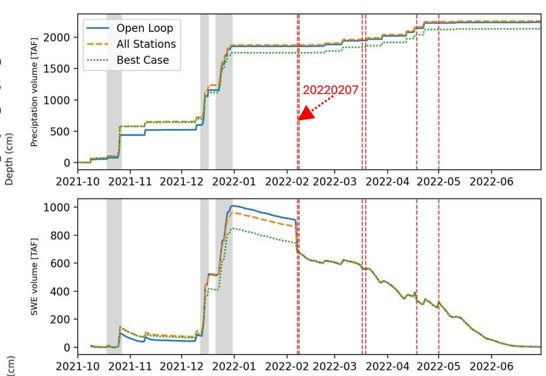
1. **Open Loop**: no precipitation bias-correction
2. **All Stations**: using all stations without human involvement
3. **Best Case**: using selected gauges after human examination

7 snow pillows
8 precipitation gauges
6 collocated sites



Improved snow depth distribution and basin-wide SWE volume





Model Run	SWE error (TAF)	snow depth RMSE (cm)
Open Loop	-232	35.5
All Stations	-184	34.6
Best Case	-71	29.1

Summary

The developed workflow has proven effective in rapidly correcting biases in precipitation data, which has significantly enhanced the accuracy of near real-time snow modeling. This improvement directly contributes to better decision-making in water resource management, ensuring more reliable outcomes.

Future work will be focused on incorporating topographic data and advanced statistical techniques, particularly machine learning algorithms, to further enhance precipitation bias correction. By integrating these cutting-edge methods, we aim to continuously improve the reliability of SWE estimations and, consequently, the effectiveness of water resource management strategies.

Citation

[1] Marks, D., Dozier, J., 1992. Climate and energy exchange at the snow surface in the Alpine Region of the Sierra Nevada: 2. Snow cover energy balance. Water Resources Research, 28, 3043–3054.

[2] Hedrick, A.R., Marks, D., Havens, S., Robertson, M., Johnson, M., Sandusky, M., Marshall, H.-P., Kormos, P.R., Bormann, K.J., Painter, T.H., 2018. Direct Insertion of NASA Airborne Snow Observatory-Derived Snow Depth Time Series Into the iSnobal Energy Balance Snow Model. Water Resources Research 54 (10), 8045–8063.

[3] Meyer, J., Horel, J., Kormos, P., Hedrick, A., Trujillo, E., & Skiles, S. M. (2023). Operational water forecast ability of the HRRR-iSnobal combination: an evaluation to adapt into production environments. *Geoscientific Model Development*, *16*(1), 233-250.