SnowView: A Satellite Data and Model Driven Decision Support Tool for monitoring snowpack, precipitation, and streamflow

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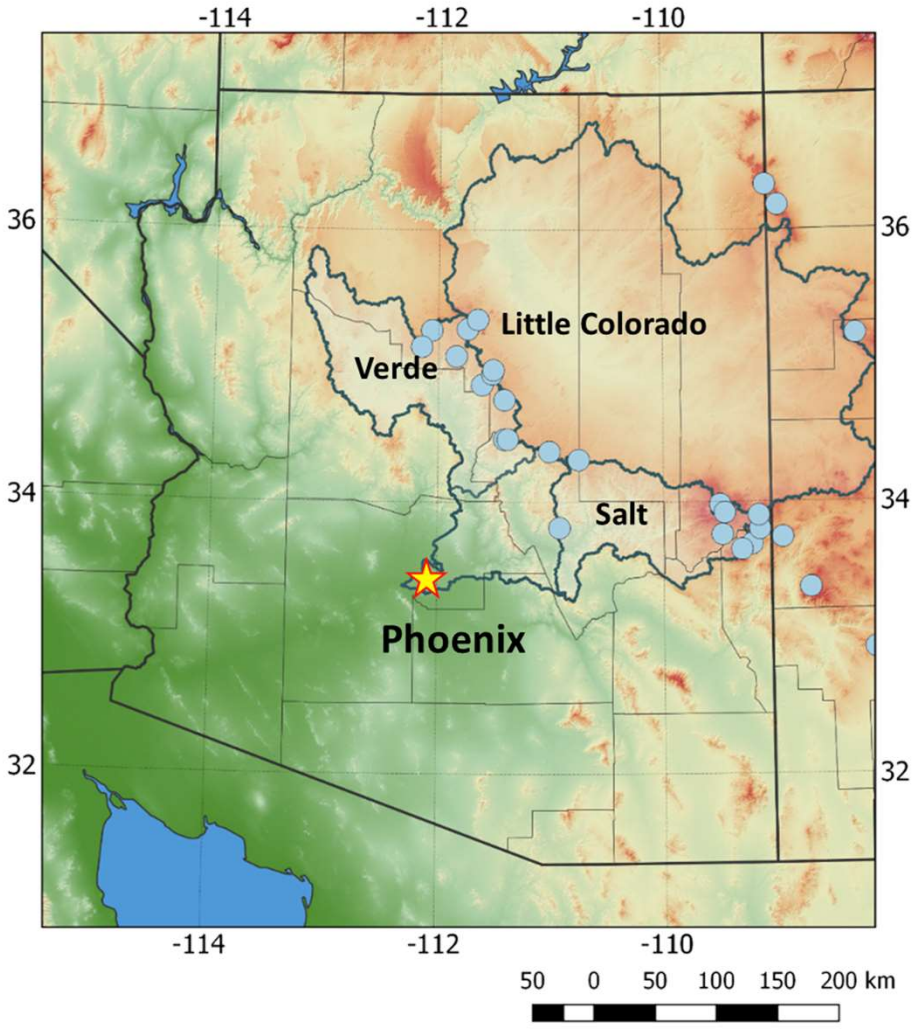
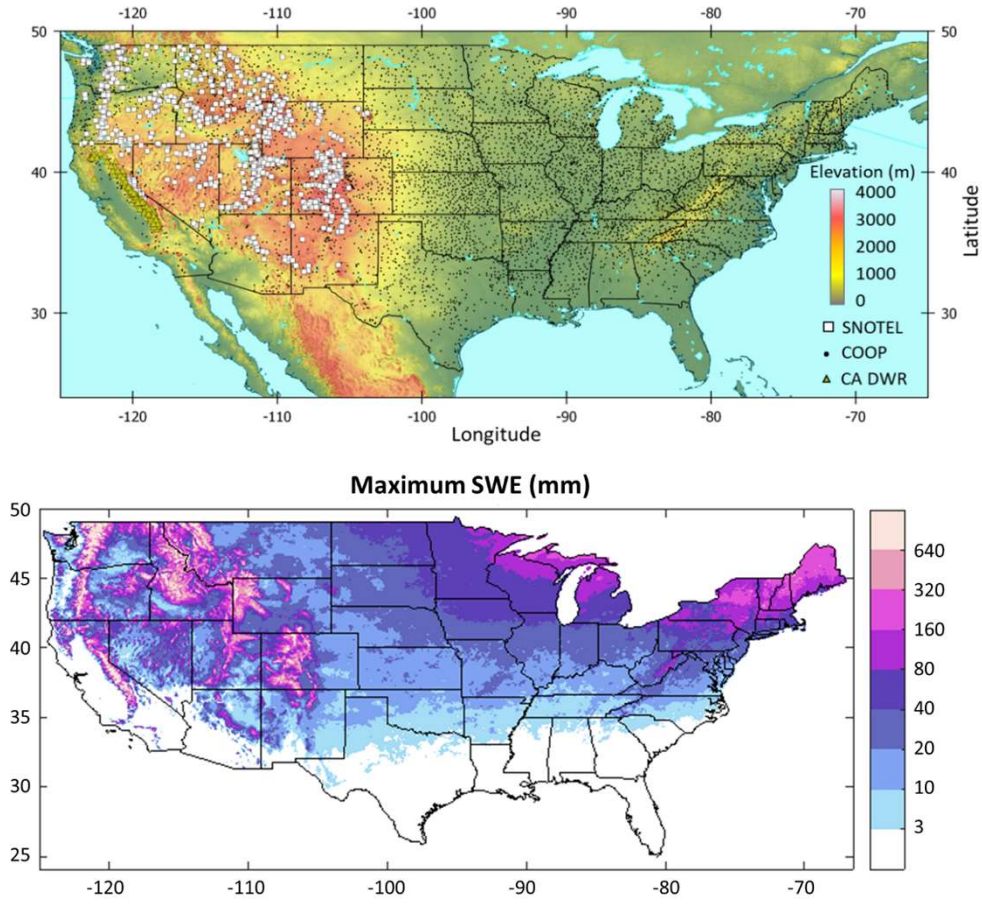
Introduction

- Snowmelt from mountain forests is critical for water supply in Arizona and across the western US
- Seasonal streamflow predictions often use observations that are not representative of surrounding areas
- Long-term gridded snow data needed to infer snow condition across landscape to improve seasonal streamflow predictions



UA/SWANN Data

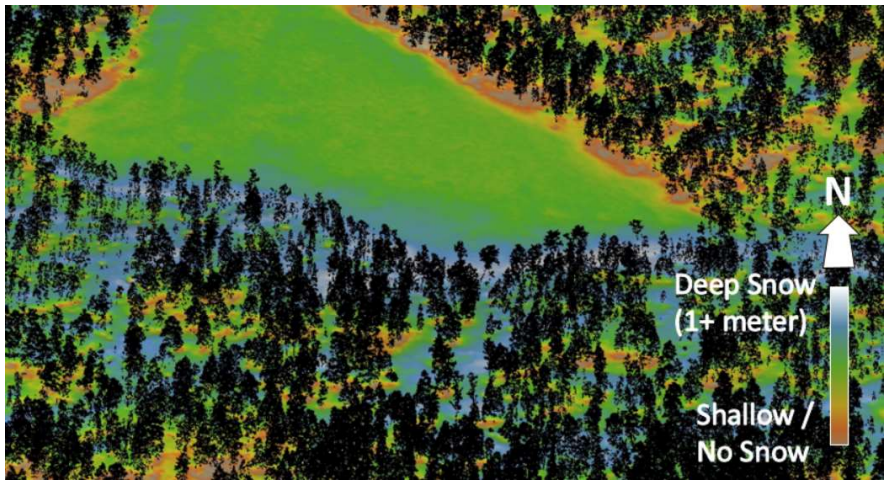
- Based on the University of Arizona (UA) daily 4 km Snow Water Equivalent (SWE) and snow depth dataset
- Daily data starting in 1981
- Includes interpolated SWE estimates from ground stations (Broxton et al., 2016); physically based snow density model (Dawson et al., 2017)
- Data available from NSIDC: https://doi.org/10.5067/0GGPB220EX6A



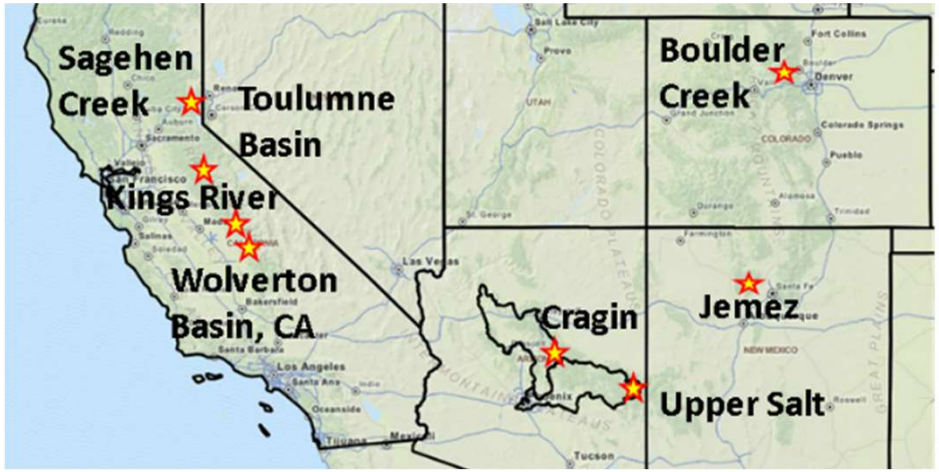
Top: SNOTEL and COOP Stations where snow data is used in the creation of the UA SWE dataset; **Bottom:** average maximum SWE based on this data

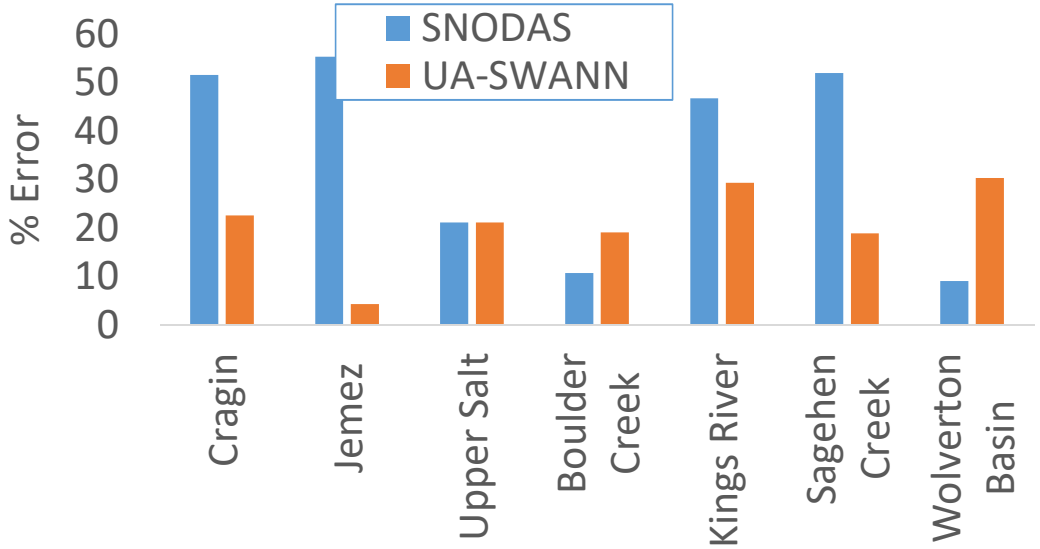
UA/SWANN Data

- **UA/SWANN model: used to provide snow monitoring for SRP**
  - UA data downscaled to < 1 km using machine learning of SWE response to various physiographic indicators
  - Trained and evaluated with snow survey data from Arizona (Broxton et al., 2019) and elsewhere in the western US (Harpold et al., 2014)
  - Generated in near-real time



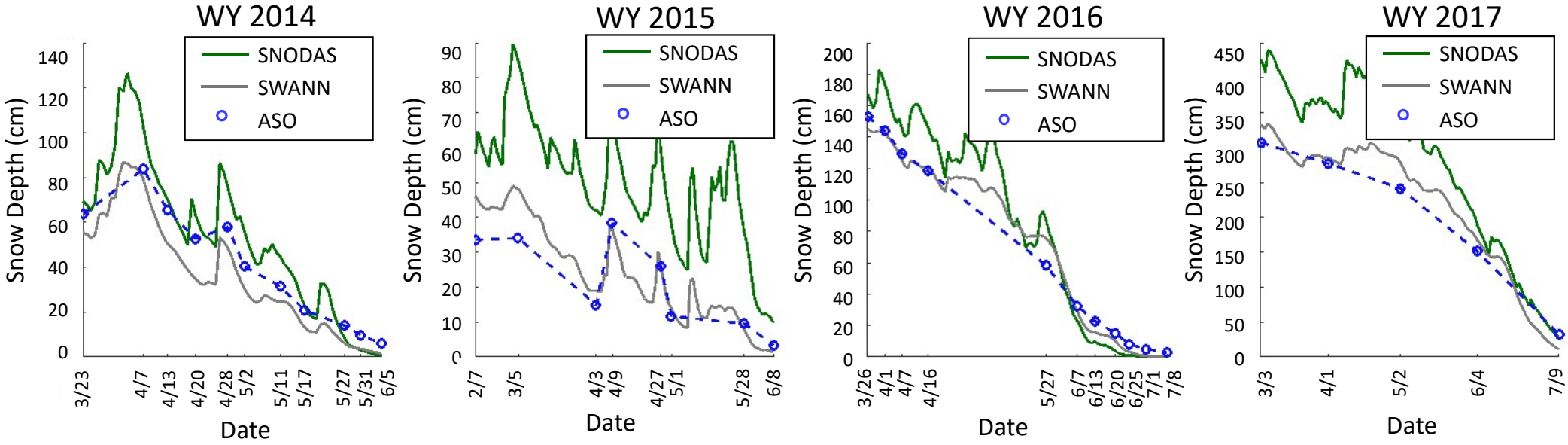
Dataset Evaluation

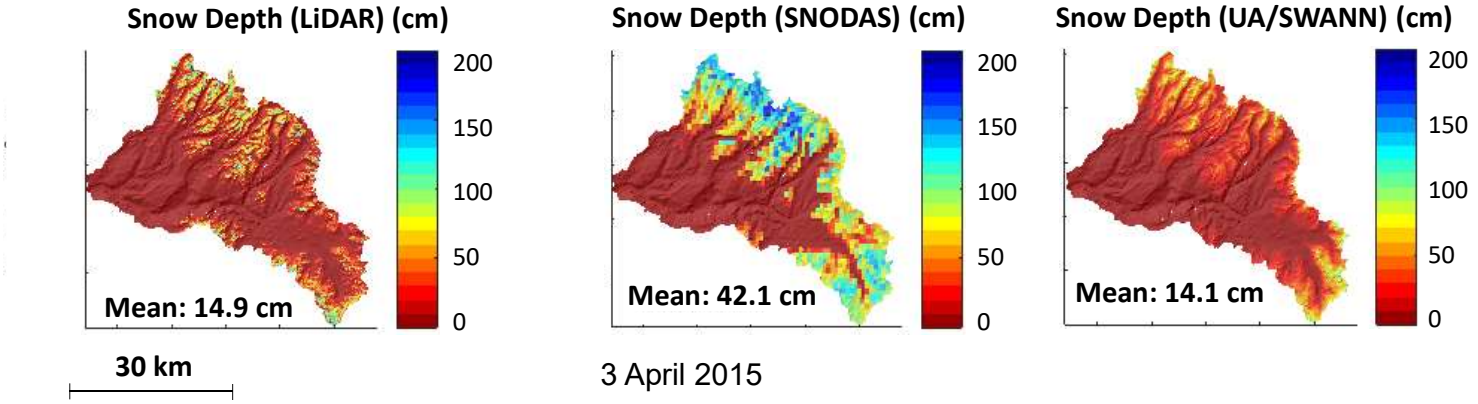




- UA/SWANN data are compared to lidar coverages from the western US
- At most sites, captures the spatial pattern of snow depth at most sites
- Better simulation of snow depth than SNODAS at some sites; goes back much further in time

Dataset Evaluation





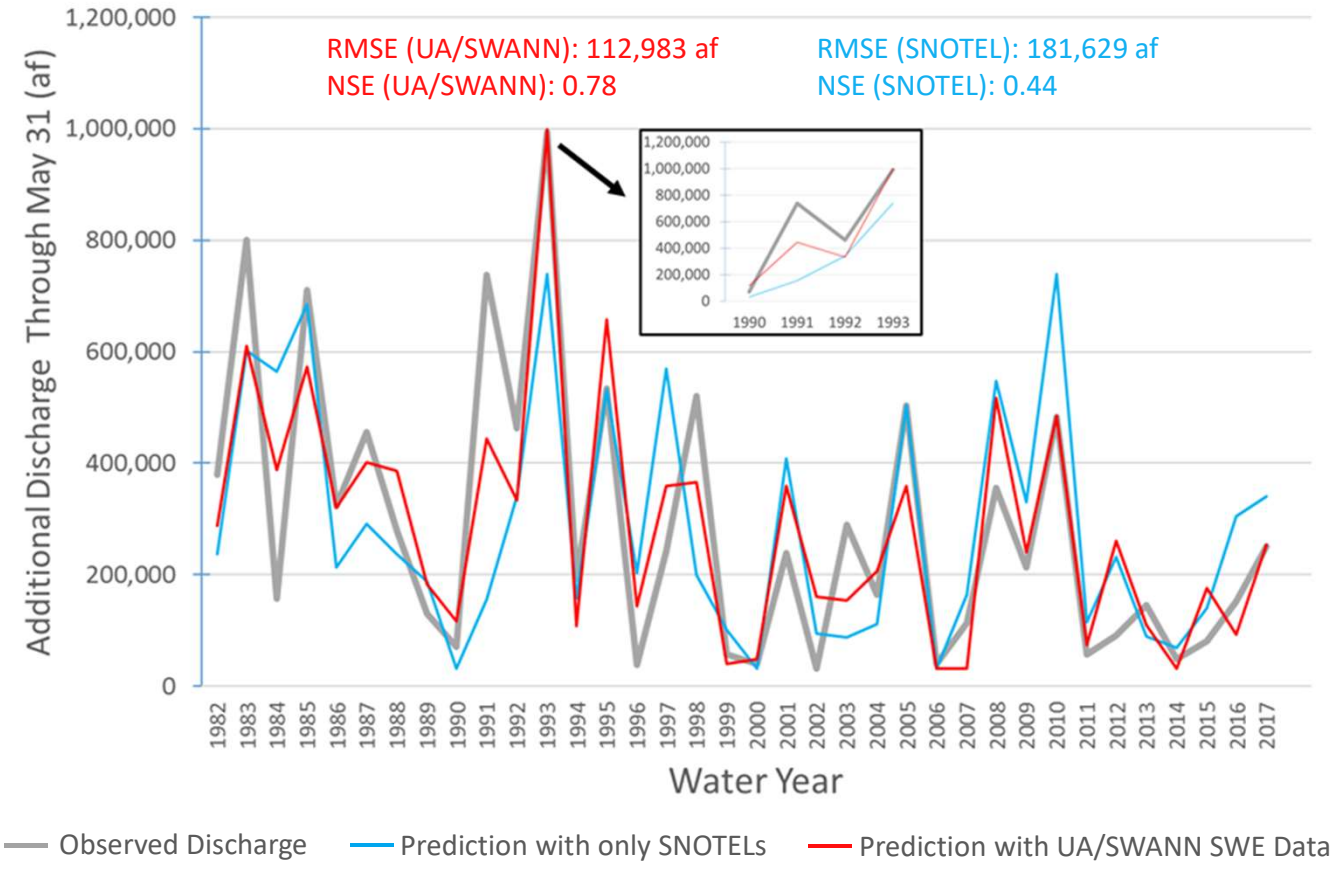
3 April 2015

ASO - NASA Airborne Snow Observatory (Painter et al., 2016)

Streamflow Forecasting

- SnowView datasets improve seasonal streamflow forecasts (e.g. to help SRP plan reservoir operations)

- When based on these gridded snow data (red line), they are better than the current state of the art of using station snow data (blue line)



Credit: Bo Svoma, SRP

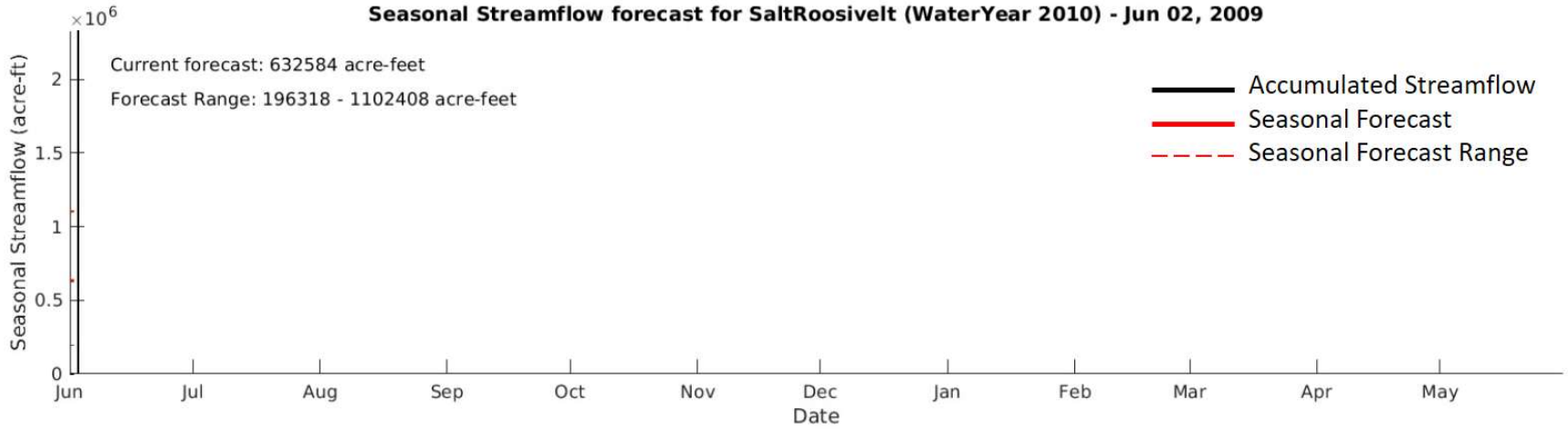
Streamflow Forecasting

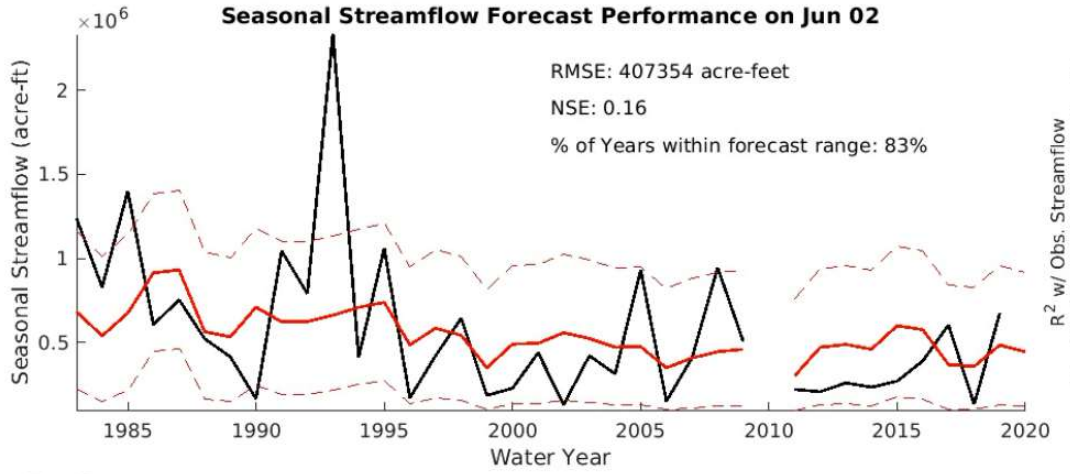
- Forecasts based on UA/SWANN SWE data, climatic indices, long range seasonal forecasts, and other land antecedent conditions

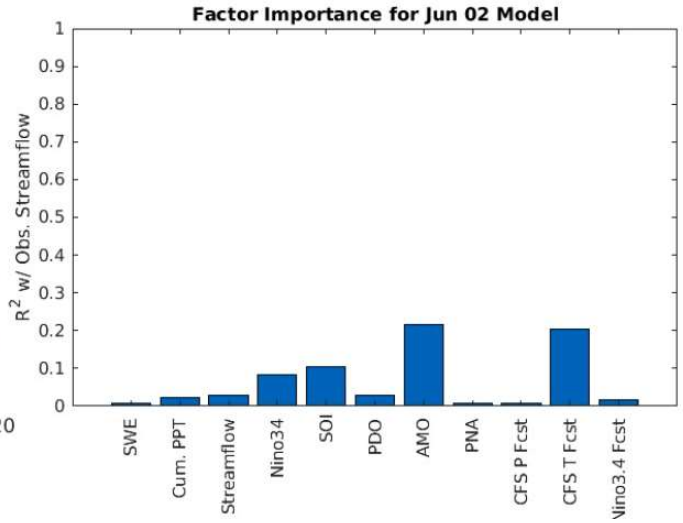
- Machine learning to make predictions of remaining streamflow for every calendar day.

- Models trained with data from 1982, run for every year since then

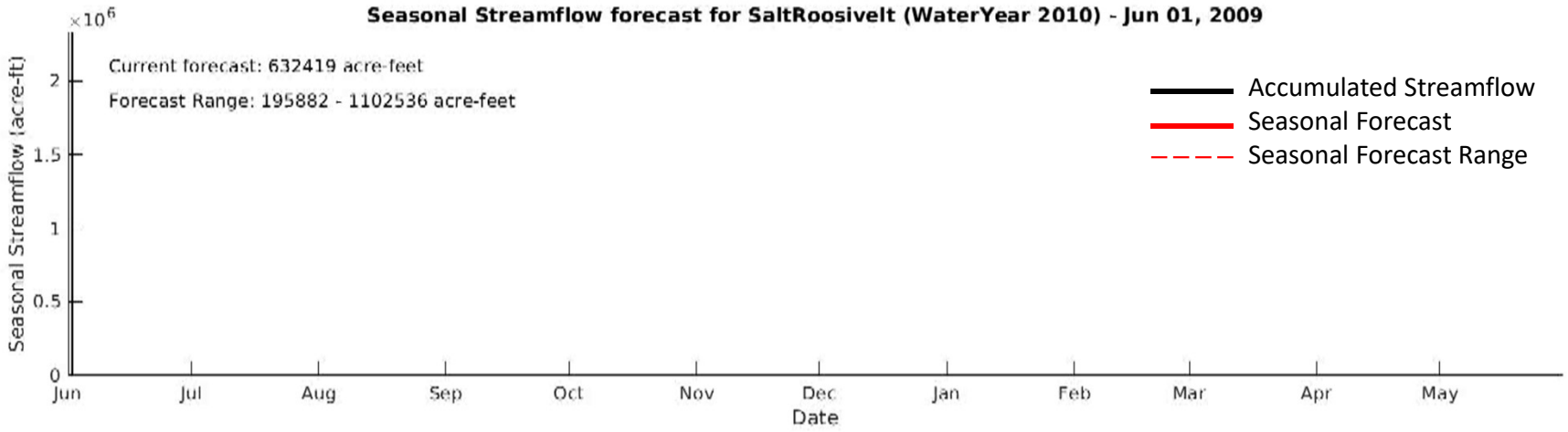
Streamflow Forecasting

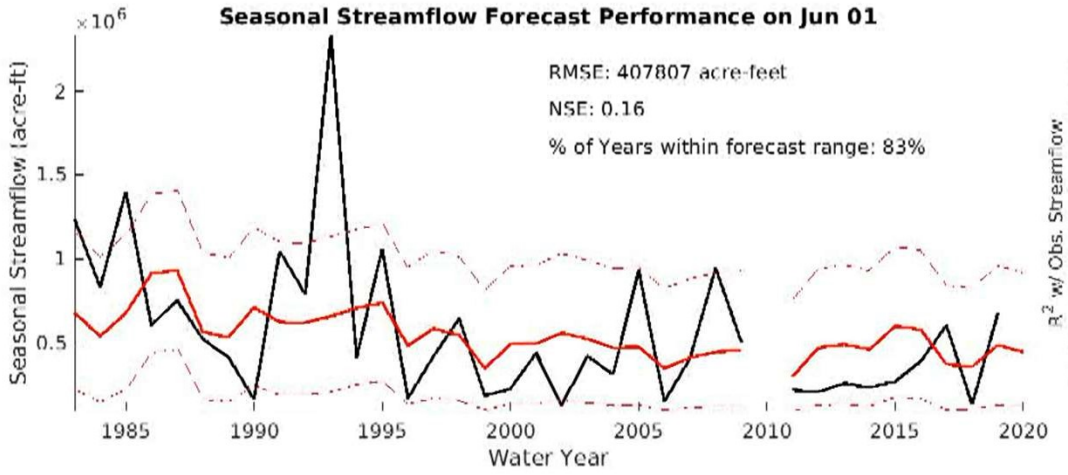


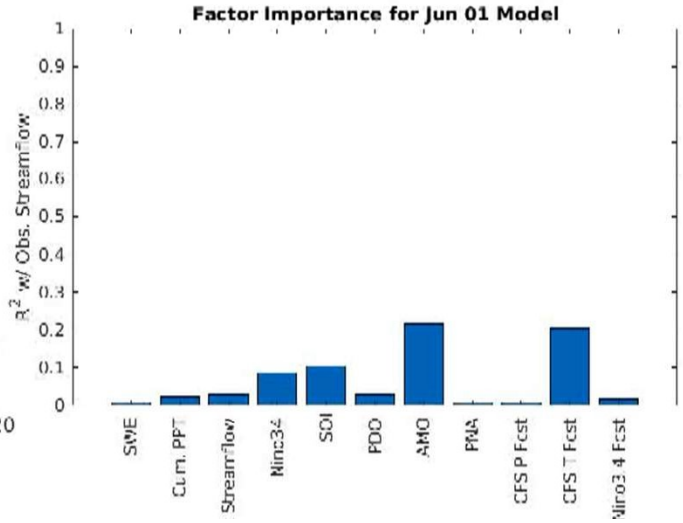




Streamflow Forecasting







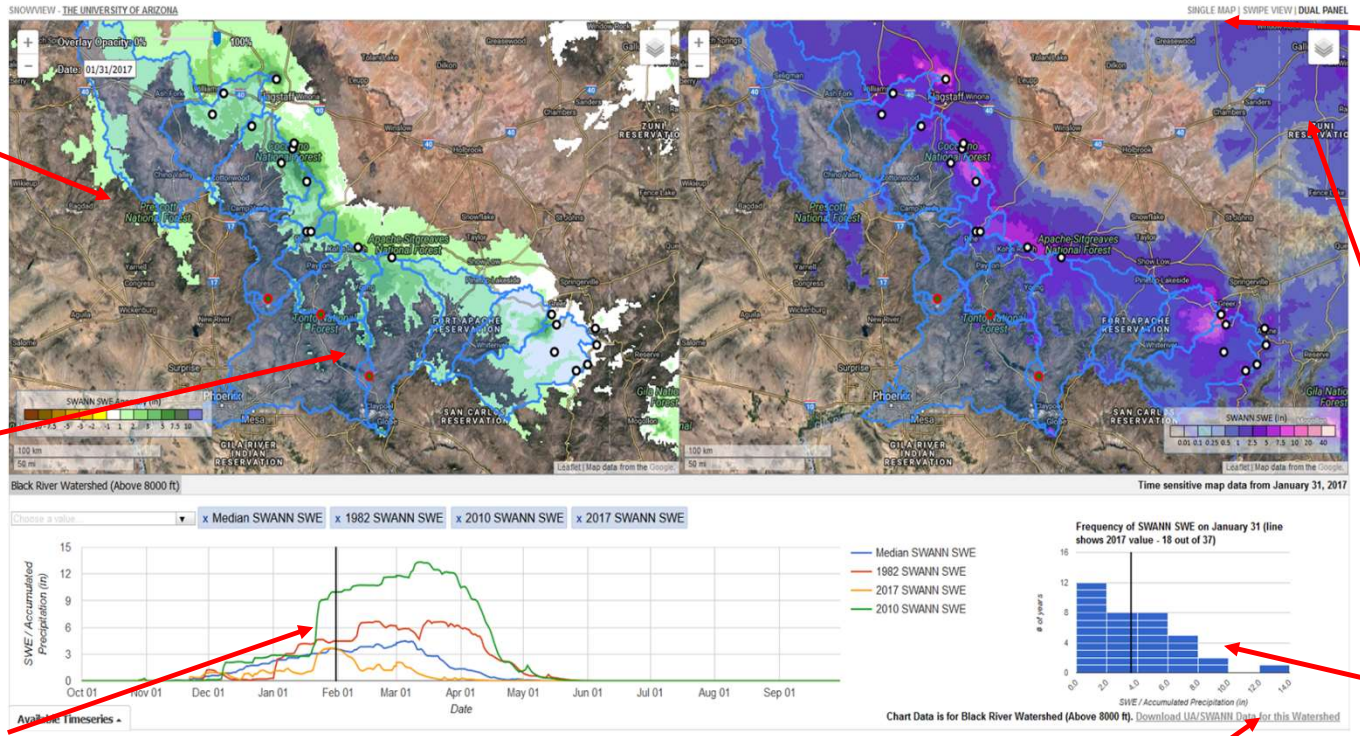
SnowView Decision Support Tool

Zoomable web map

Choose single map or side-by-side maps

Detailed data for SNOTEL, USGS gauges, and river basins

Various snow related data layers



Timeseries for comparing data for different years

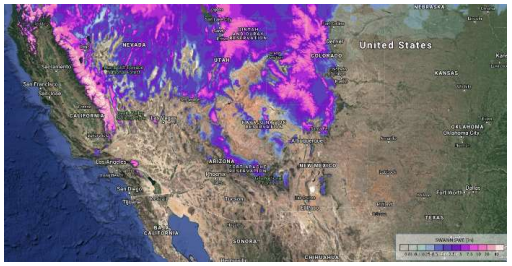
Find comparable snow seasons

Download data

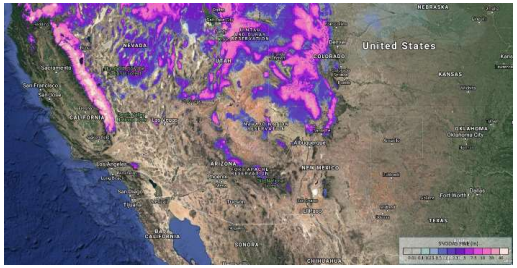
- Helps Salt River Project (SRP) to determine how current year's water supply might compare with previous years

SnowView Decision Support Tool

UA/SWANN SWE



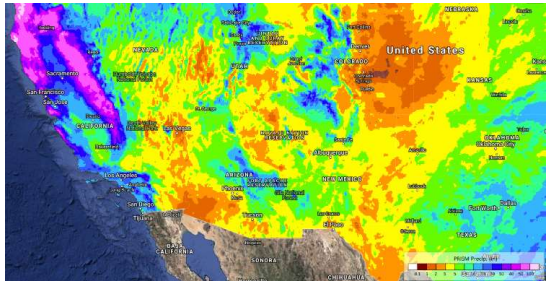
SNODAS SWE



MODIS Imagery

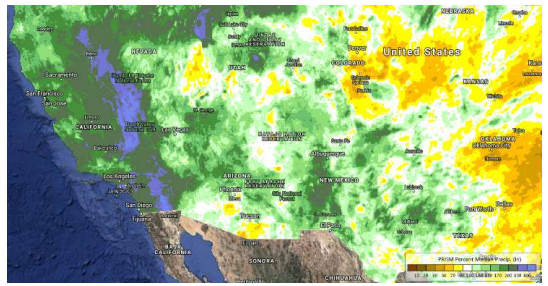
IMS Snowcover

PRISM Precipitation



Percent of Normal SWE

Percent of Normal Precipitation



SWE Data: UA / SWANN, SNODAS data

Snowcover Data: MODIS imagery, IMS data

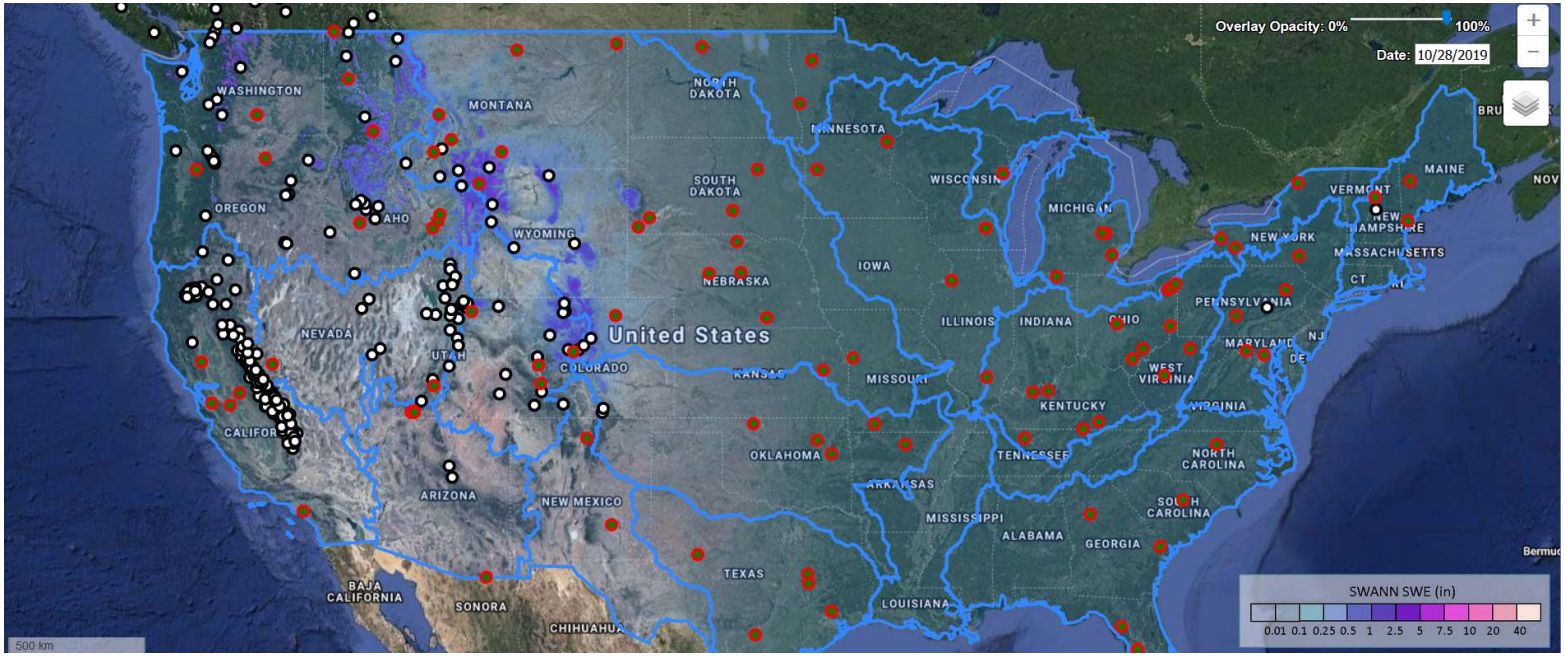
Precipitation Data: PRISM data

Point Data: SNOTEL SWE and Precipitation data, USGS Streamflow data

SnowView Decision Support Tool

SWANN
Snow-Water Artificial Neural Network

- Expanded to include similar information and functionality for additional watersheds across the US

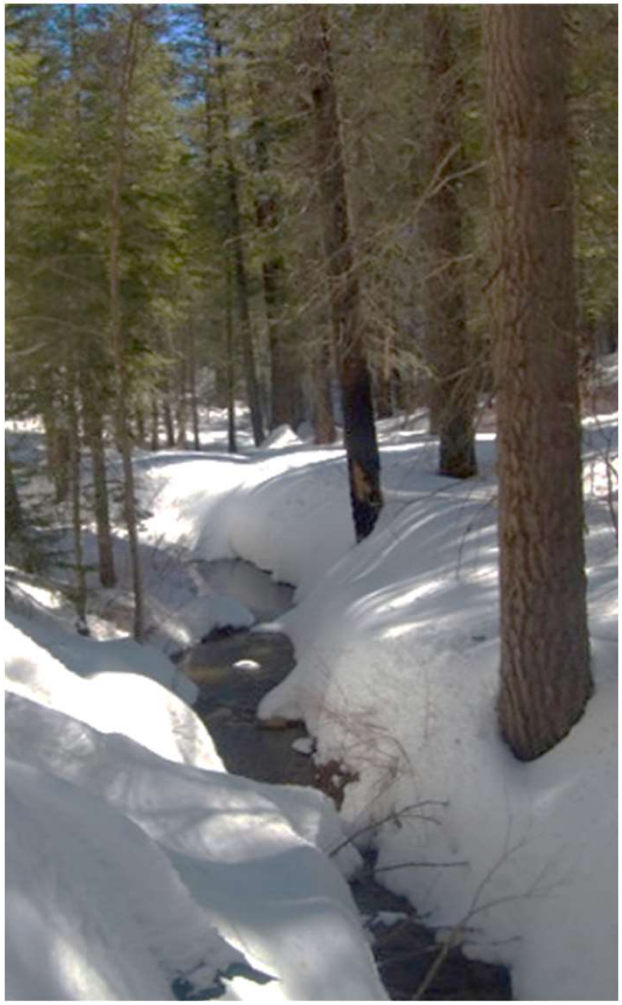


- Map visualization across the US as well as timeseries data for USGS HUC2,4,6,8 watersheds, SNOTEL stations, and USGS stream gauges

https://climate.arizona.edu/snowview/

Summary

- Gridded SWE data offer advantages over point SWE observations for water supply modelling because they can estimate SWE conditions across the landscape
- The UA/SWANN SWE data provide near real-time SWE estimates that can be used for water supply modelling
- They improve SRP seasonal streamflow forecasts over using only SNOTEL data
- Currently, we are using UA/SWANN SWE data to develop daily updating seasonal streamflow forecasts for SRP
- 4 km SWE dataset (1981-2017) can be downloaded from NSIDC: **https://doi.org/10.5067/0GGPB220EX6A**
- Higher Resolution data can be visualized using our SnowView interface: **https://climate.arizona.edu/snowview**



References

- Broxton, P., X. Zeng, and N. Dawson. 2019: Daily 4 km Gridded SWE and Snow Depth from Assimilated In-Situ and Modeled Data over the Conterminous US, Version 1. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi:10.5067/0GGPB220EX6A.
- Broxton, P. D., W. van Leeuwen, J. Biederman, 2019: Improving Snow Water Equivalent Maps with Machine Learning of Snow Survey and Lidar Measurements, *Water Resources Research*, doi:10.1029/2018WR024146.
- Dawson, N., P. D. Broxton, X. Zeng, 2017: A new snow density parameterization for land data initialization. *J. Hydrometeor*., 18, 197-207, doi:10.1175/JHM-D-16-0166.1.
- Broxton, P. D., X. Zeng, N. Dawson, 2016: Why Do Global Reanalyses and Land Data Assimilation Products Underestimate Snow Water Equivalent? *J. Hydrometeor*., 17, 2743–2761, doi:10.1175/JHM-D-16-0056.1.
- Painter, T. H., Berisford, D. F., Boardman, J. W., Bormann, K. J., Deems, J. S., Gehrke, et al., 2016: The Airborne Snow Observatory: Fusion of scanning lidar, imaging spectrometer, and physically-based modeling for mapping snow water equivalent and snow albedo. Remote Sensing of Environment, 184, 139-152.
- Harpold, A. A., Q. Guo, N. Molotch, P. D. Brooks, R. Bales, J. C. Fernandez-Diaz, K. N. Musselman et al., 2014: LiDAR-derived snowpack data sets from mixed conifer forests across the Western United States. *Water Resources Research,* 50(3), 2749-2755.

Thank You!

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