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Using Satellite Data to Improve the Estimation of Snow-dominated Runoff Available for Hydropower Generation

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CALIFORNIA ENERGY COMMISSION

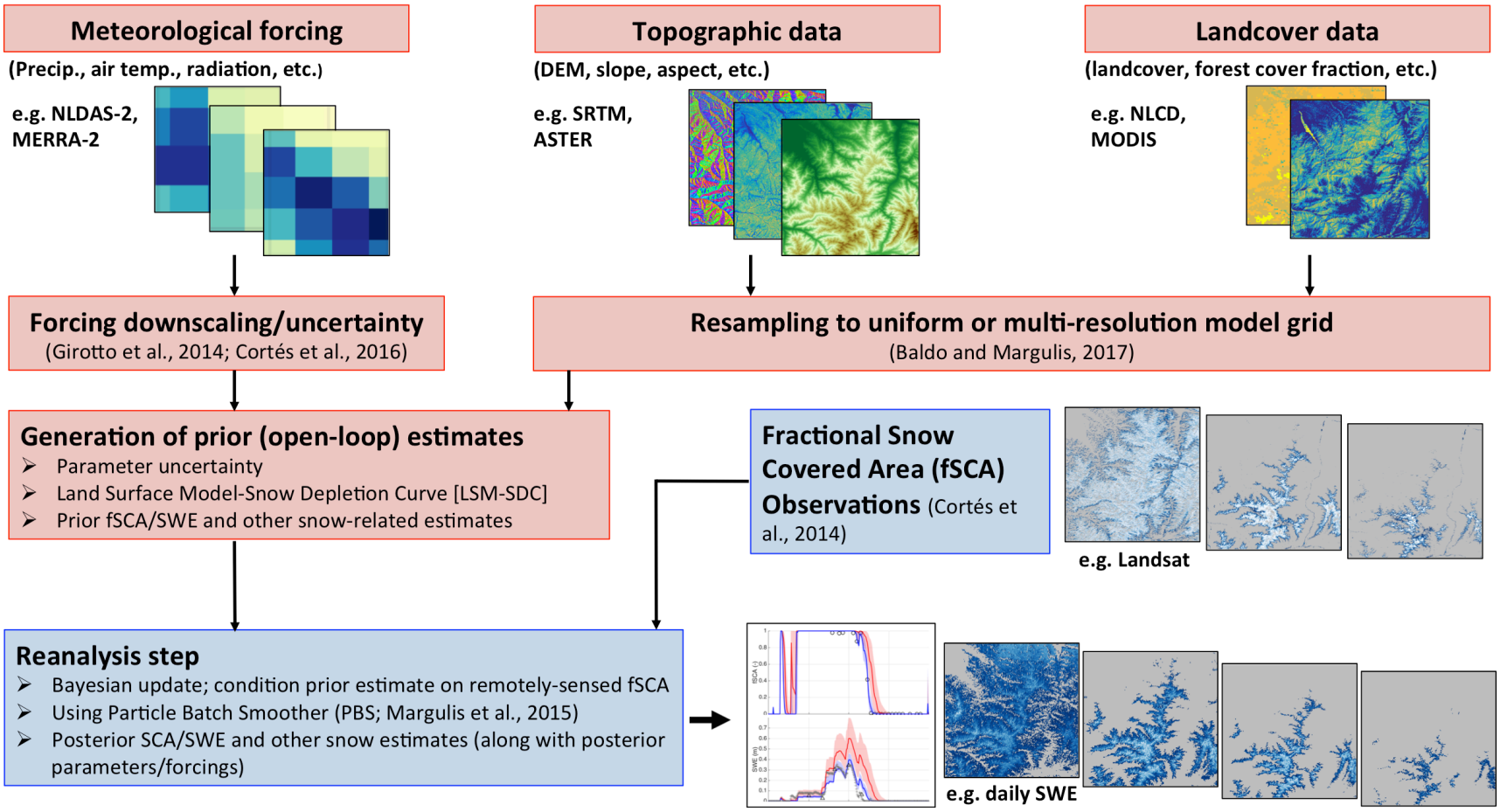
UCLA Civil and Environmental Engineering

Hydrology and Water Resources Group

Objectives

- Develop new historical (reanalysis) database of snow over the Sierra Nevada from the remote sensing record
  - to characterize degree to which existing hydropower plants involve snow-dominated flows
  - to build better models for current forecasting
  - to understand how water/energy resources may change in future
- Demonstrate potential for improved streamflow from improved snow characterization
- Demonstrate potential for improved real-time snow characterization
- Build near-real-time/seasonal forecasting system

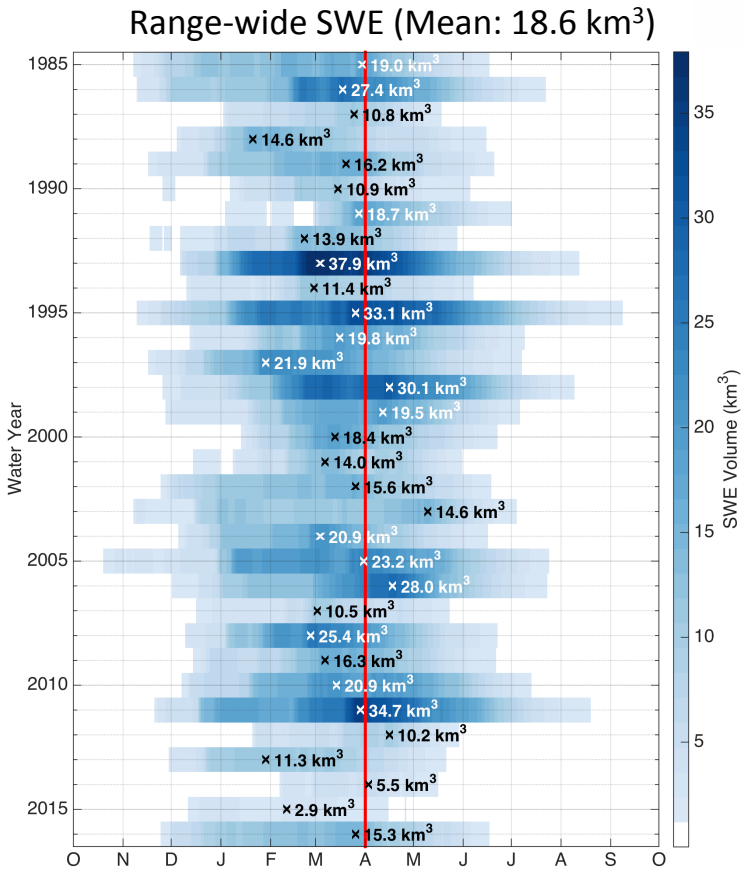
Historical Snow Reanalysis Framework



Sierra Nevada Snow Reanalysis

- Coverage: 20 snow-dominated basins (~49,000 km^2)
- Resolution: daily at 90 meter
- Temporal extent: **Landsat 5-8 Record**: 1985-2016 Water Years (WYs)
- Verification against over 9000 station-years of in situ (snow course/ pillow) data

Margulis et al., JHM, 2016

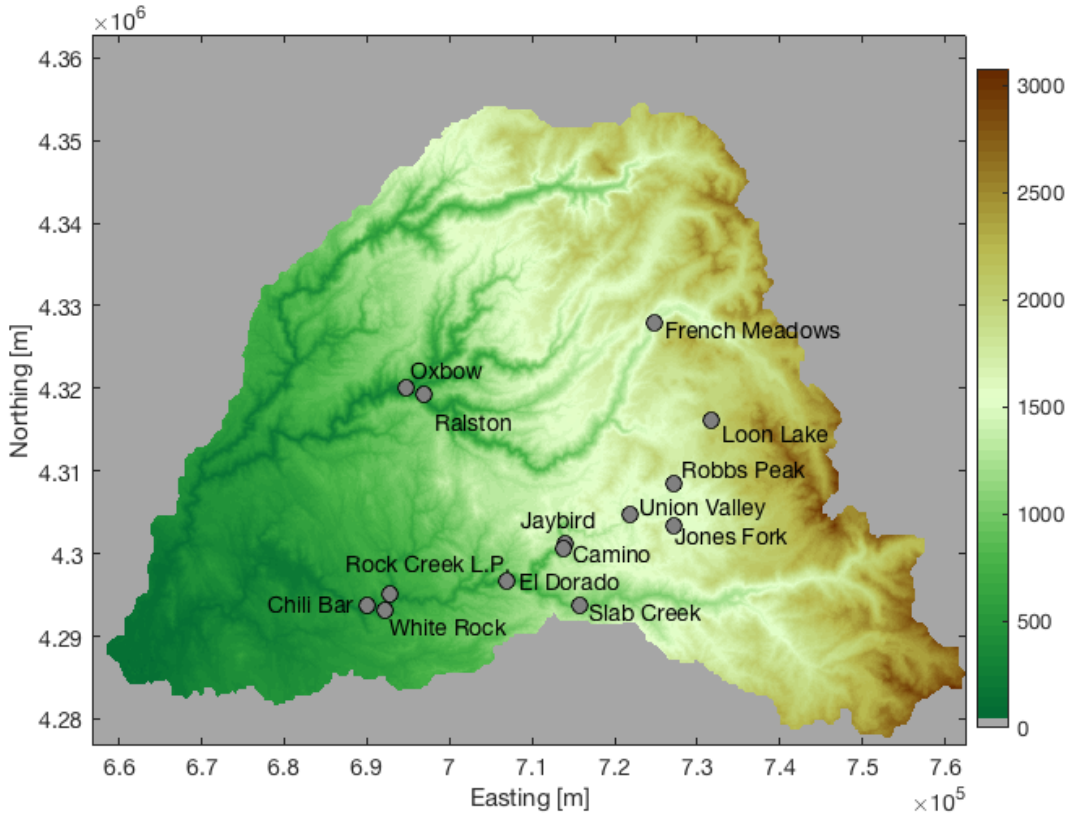


Margulis et al., GRL, 2016

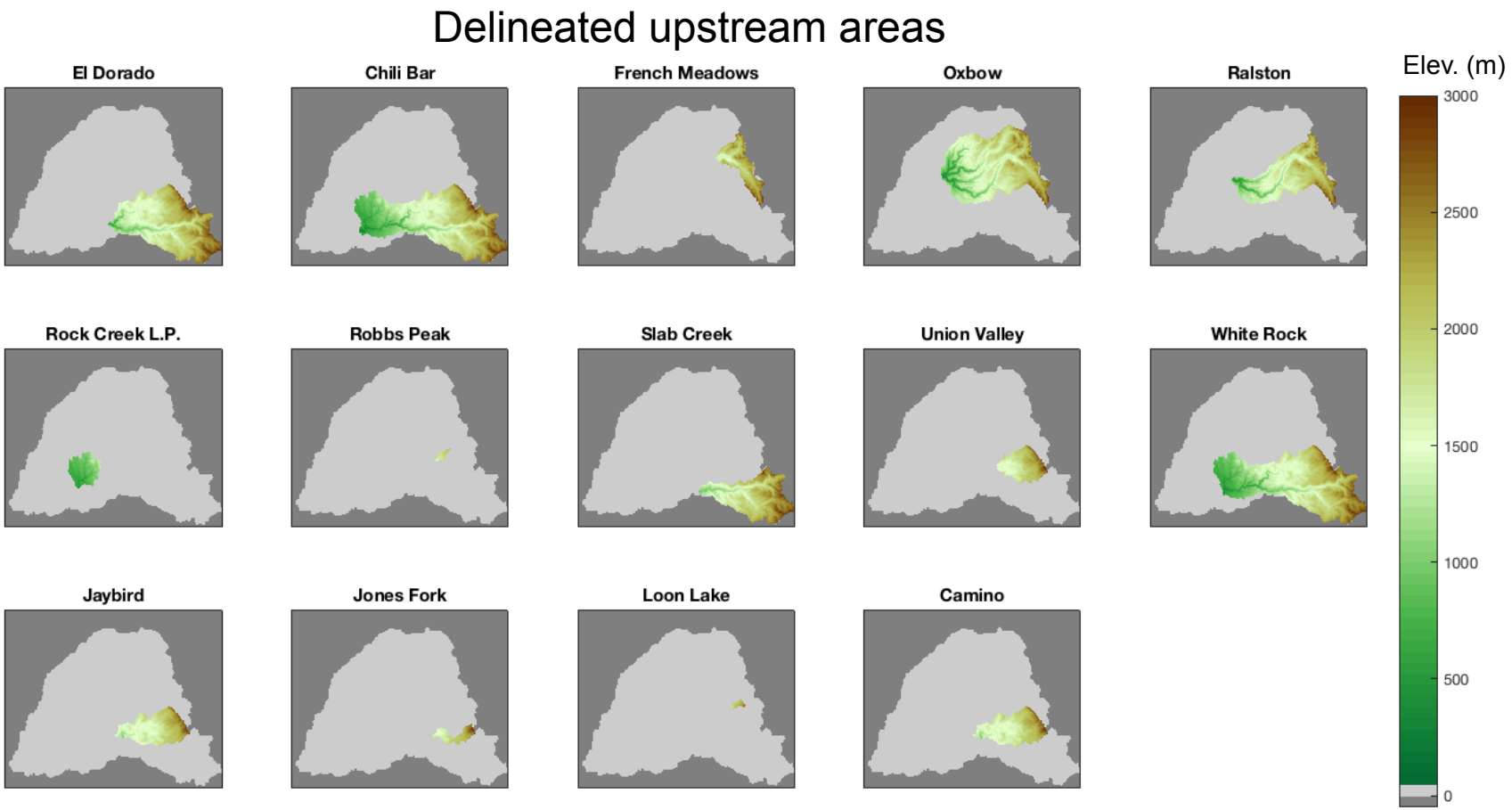
Hydropower plant characterization

e.g. American River Basin:

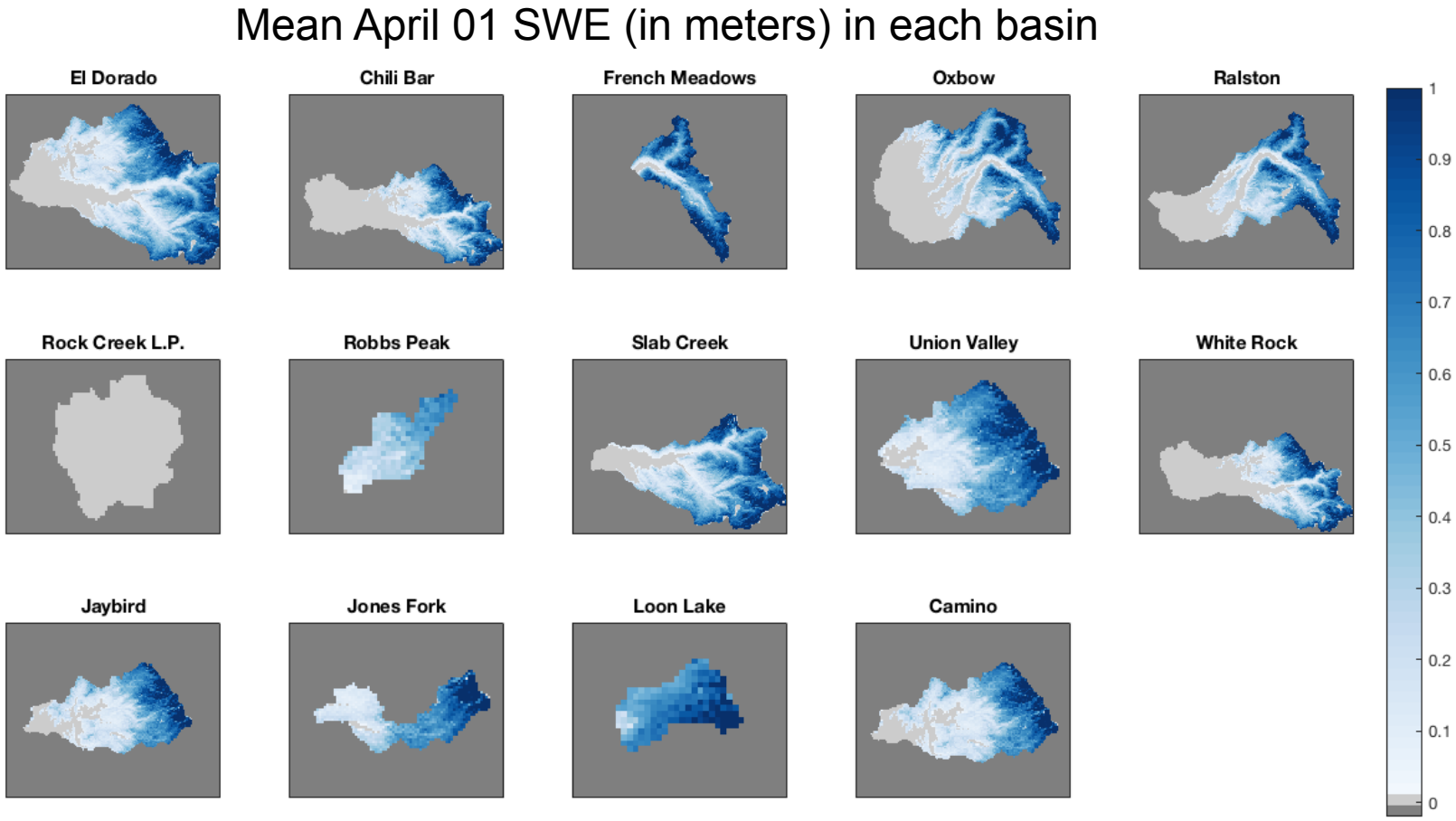
Total of 14 power plants, approximately 1000 MW of installed capacity (source: CEC)



Hydropower plant characterization



Hydropower plant characterization



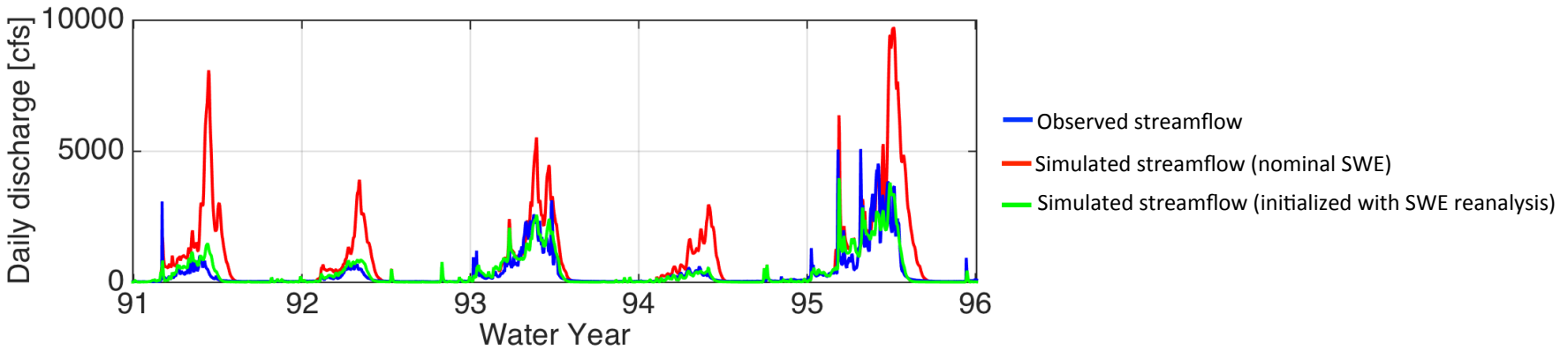
Hydropower plant characterization

Power Plant	Owner	Mean Elev. [m.a.s.l.]	Area [sq.km]	MW	April 1st mean SWE [m]	% Snow covered on April 1st
El Dorado	El Dorado	1883	1617	20	0.38	79%
Chili Bar	PG&E	1645	1541	7	0.29	60%
French Meadows	Placer County Water Agency	2140	286	15	0.69	96%
Oxbow	Placer County Water Agency	1647	1351	6	0.31	63%
Ralston	Placer County Water Agency	1723	818	79	0.35	67%
Rock Creek L.P.	Rock Creek LTD PNSP	879	191	3.6	-	0
Robbs Peak	Sacramento MUD	1833	22	29.5	0.37	99.6%
Slab Creek	Sacramento MUD	1996	664	0.4	0.43	84.6%
Union Valley	Sacramento MUD	1970	286	46.7	0.49	94%
White Rock	Sacramento MUD	1652	1532	230	0.29	60%
Jaybird	Sacramento MUD	1835	421	154	0.38	85%
Jones Fork	Sacramento MUD	2009	96	11.5	0.52	97%
Loon Lake	Sacramento MUD	2127	17	82	0.72	100%
Camino	Sacramento MUD	1834	422	308	0.38	84.6%

Improved streamflow via improved SWE?

Exploration of potential runoff improvement with better SWE characterization:

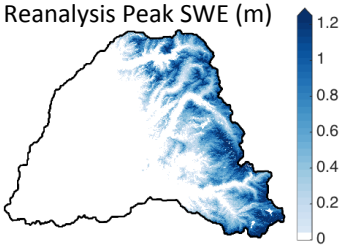
- Will runoff predictions improve given better SWE initial conditions?
- Initialized runoff model (VIC) with reanalysis SWE to assess whether runoff performance improved vs. a free-running nominal simulation.

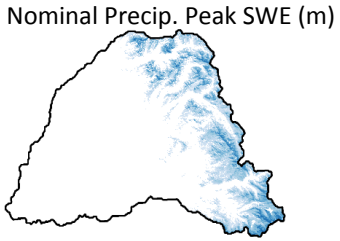


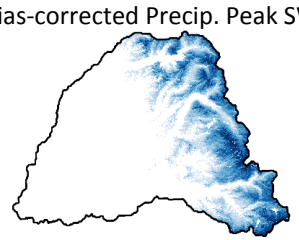
Ability to improve real-time SWE estimates?

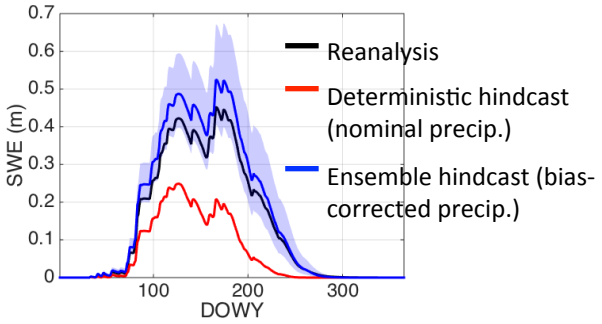
Exploration of potential for real-time SWE improvements based on information derived from historical SWE reanalysis

- Retrospective reanalysis results show significant biases in nominal precipitation
- Can bias-correction be used for real-time SWE prediction?









Next steps

- Sierra Nevada-wide characterization of snow-dominated hydropower plants using historical snow database; identify and target large plants with significant snowmelt contributions to streamflow
- Seek input from hydropower agencies for understanding current state-of-the art forecasting methodologies
- Build real-time/seasonal snow estimation and runoff forecasting system
- Test forecasting system at identified hydropower plants; quantify forecasting potential via hindcasts over historical record
- Characterization of how forecasting system will be impacted by climate change