DOCKETED

Docket Number:	17-IEPR-09
Project Title:	Climate Adaptation and Resiliency
TN #:	220881-10
Document Title:	Using Satellite Data to Improve the Es5ma5on of Snow-dominated Runoff Available for Hydropower Generation
Description:	8.29.2017: Presentation by Steve Margulis of UCLA
Filer:	Raquel Kravitz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	8/25/2017 10:23:20 AM
Docketed Date:	8/25/2017

DOCKETED

Docket Number:	17-IEPR-09
Project Title:	Climate Adaptation and Resiliency
TN #:	220882
Document Title:	Using Satellite Data to Improve the Es5ma5on of Snow-dominated Runoff Available for Hydropower Generation
Description:	8.29.2017: Presentation by Steve Margulis of UCLA
Filer:	Raquel Kravitz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	8/25/2017 10:23:20 AM
Docketed Date:	8/25/2017

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

Steve Margulis, UCLA

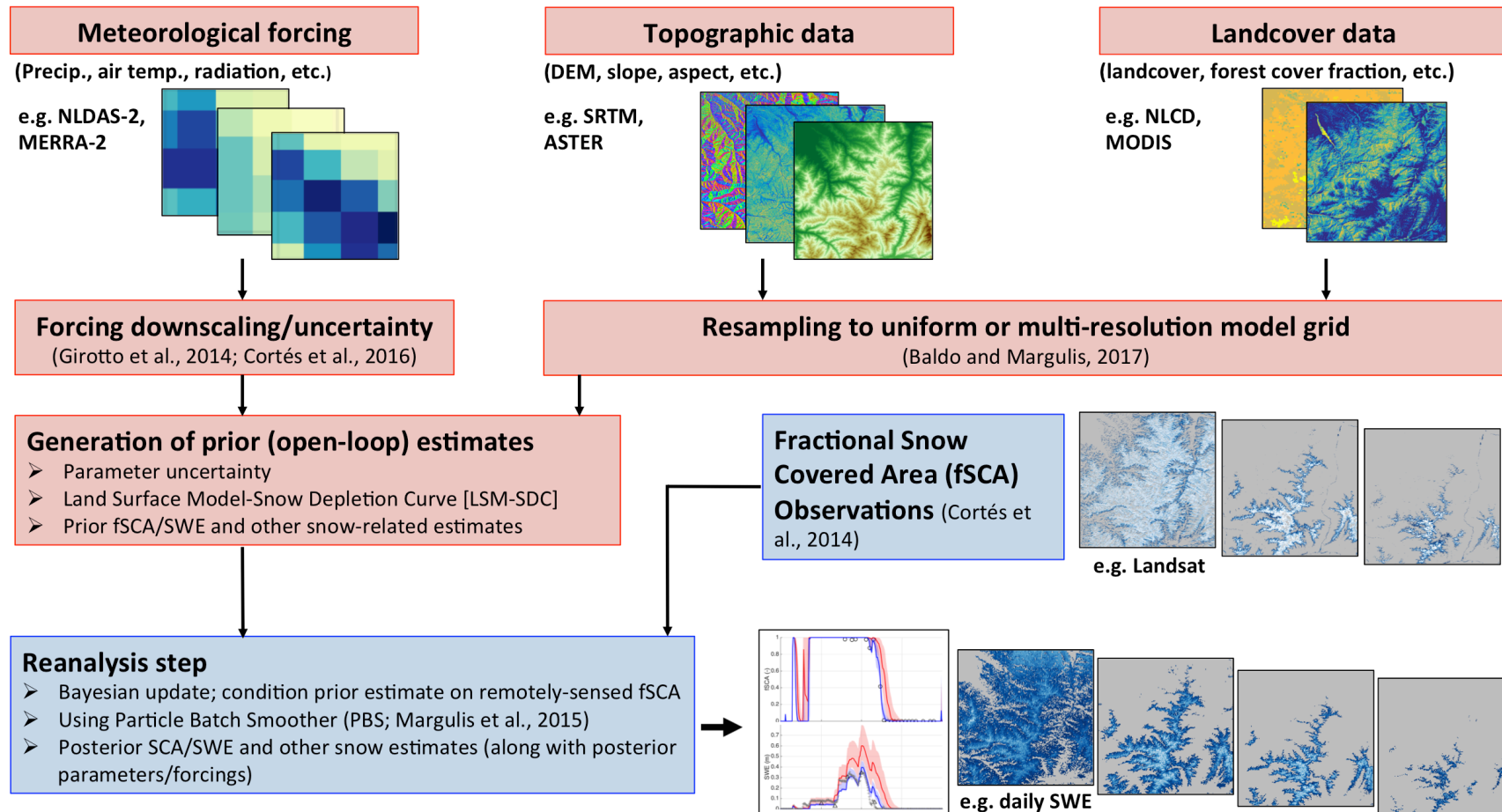2017 IEPR Joint Agency Workshop on Climate Adaptation and Resilience for the Energy System

August 29, 2017

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

Meteorological forcing
(Precip., air temp., radiation, etc.)

e.g. NLDAS-2, MERRA-2

Topographic data
(DEM, slope, aspect, etc.)

e.g. SRTM, ASTER

Landcover data
(landcover, forest cover fraction, etc.)

e.g. NLCD, MODIS

Forcing downscaling/uncertainty
(Girotto et al., 2014; Cortés et al., 2016)

Resampling to uniform or multi-resolution model grid
(Baldo and Margulis, 2017)

Generation of prior (open-loop) estimates
➤ Parameter uncertainty
➤ Land Surface Model-Snow Depletion Curve [LSM-SDC]
➤ Prior fSCA/SWE and other snow-related estimates

Fractional Snow Covered Area (fSCA) Observations (Cortés et al., 2014)

e.g. Landsat

Reanalysis step
➤ Bayesian update; condition prior estimate on remotely-sensed fSCA
➤ Using Particle Batch Smoother (PBS; Margulis et al., 2015)
➤ Posterior SCA/SWE and other snow estimates (along with posterior parameters/forcings)

e.g. daily SWE

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
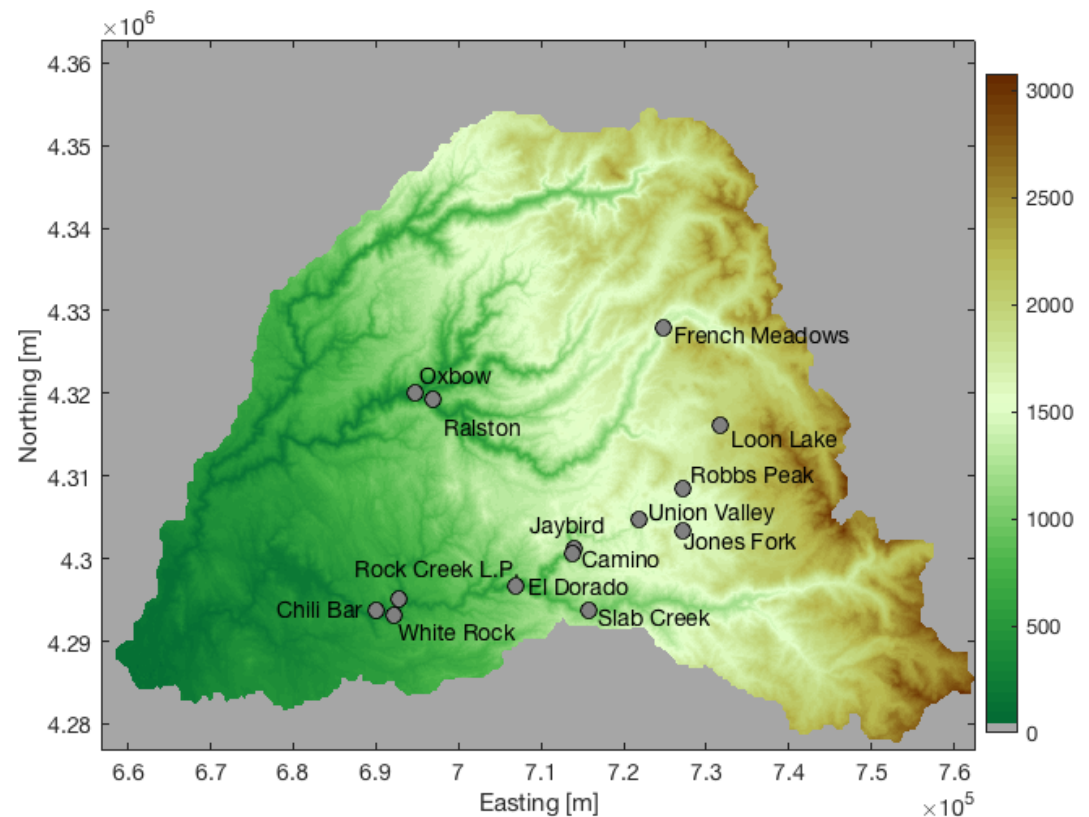
Margulis et al., JHM, 2016

Range-wide SWE (Mean: 18.6 km^3)
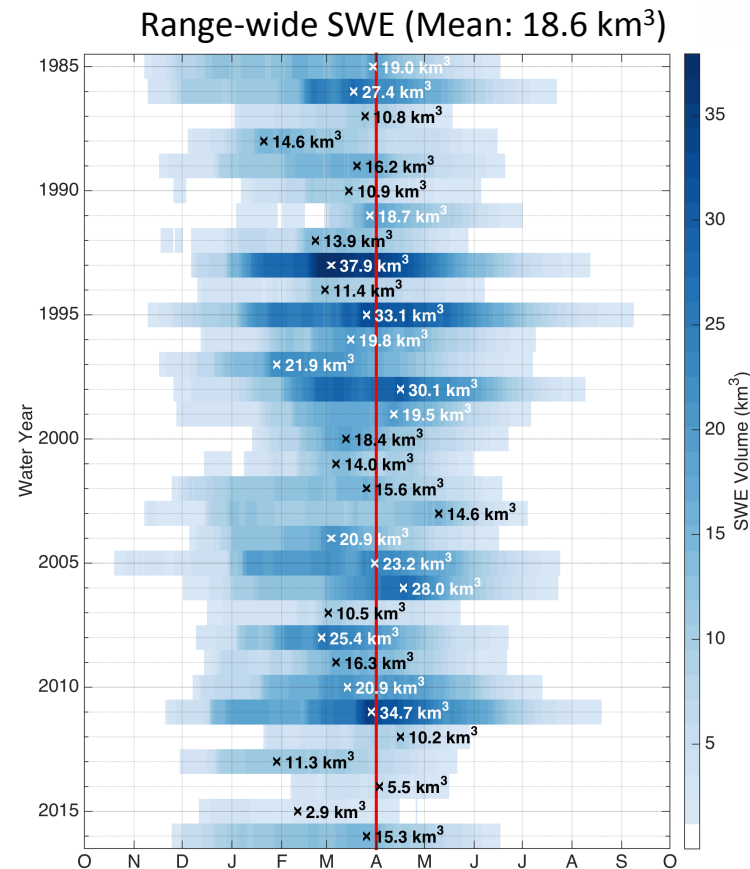
Margulis et al., GRL, 2016

Hydropower plant characterization

e.g. American River Basin:

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

Hydropower plant characterization

Delineated upstream areas
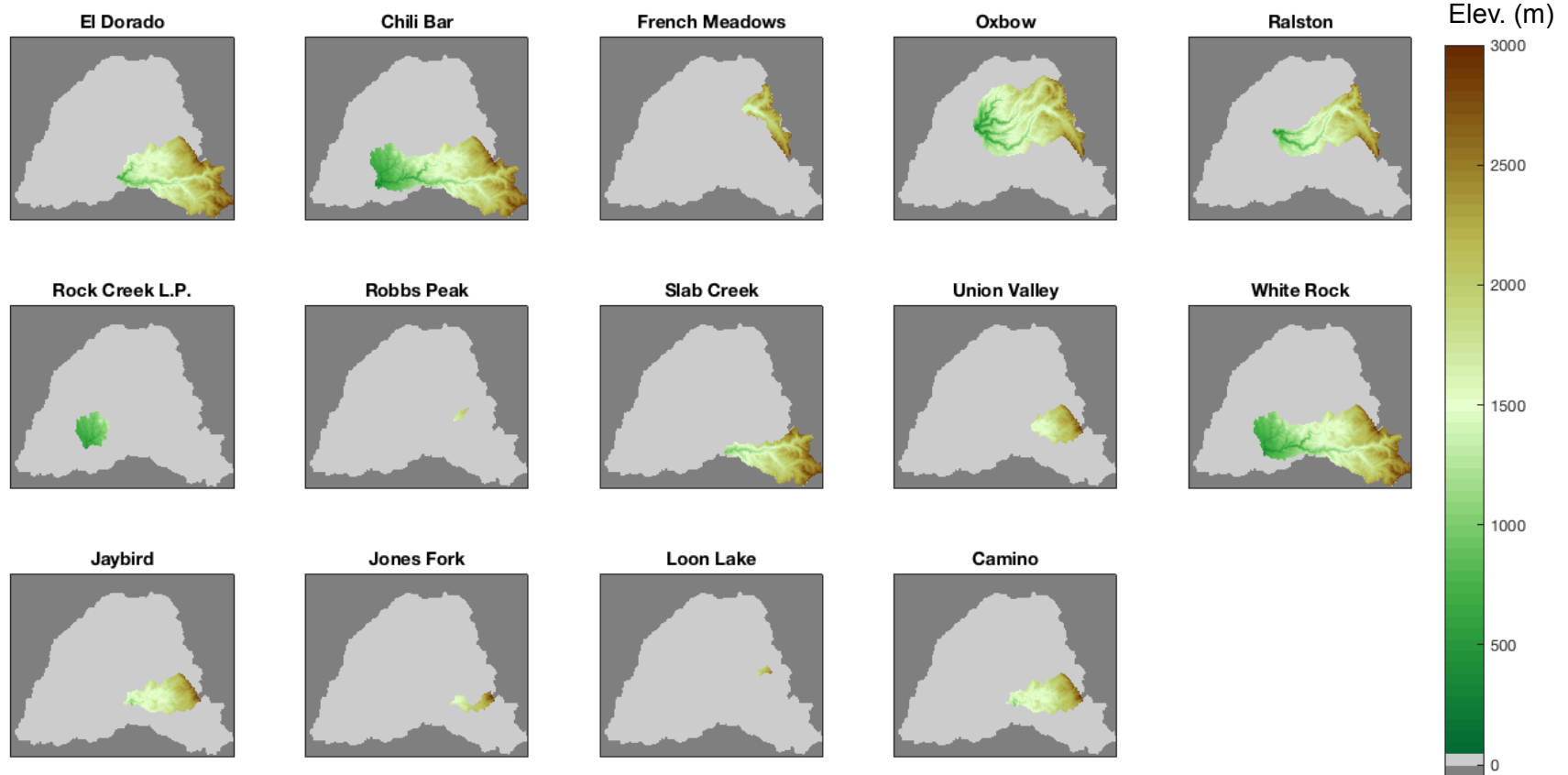
Hydropower plant characterization


Mean April 01 SWE (in meters) in each basin
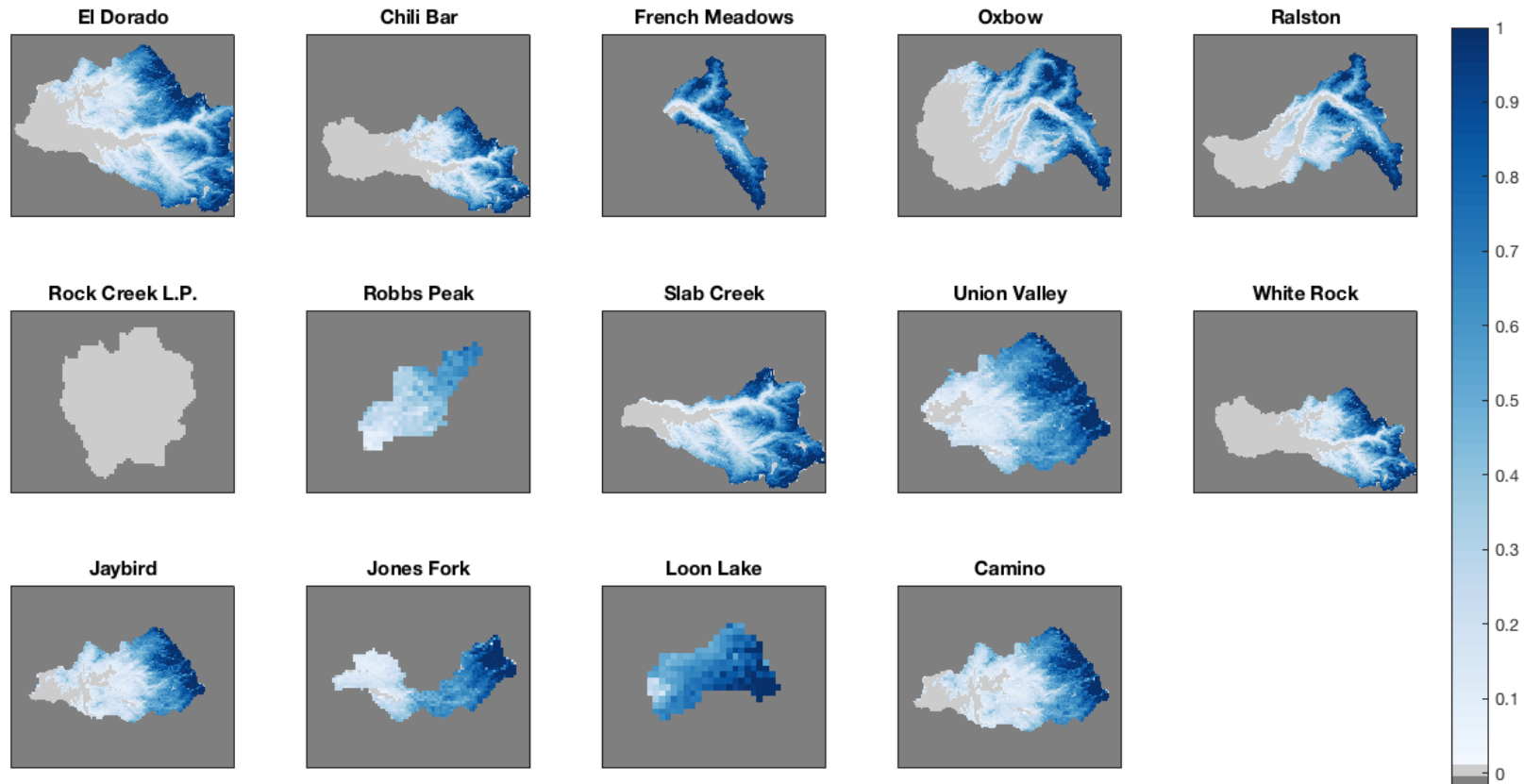
Hydropower plant characterization

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.
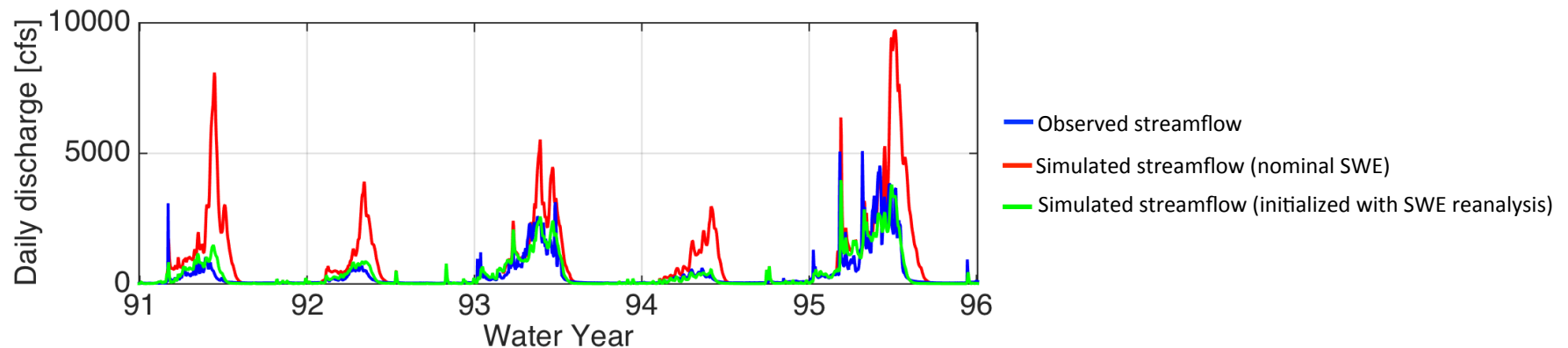
Ability to improve real-time SWE estimates?

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?

Reanalysis Peak SWE (m)   Nominal Precip. Peak SWE (m)   Bias-corrected Precip. Peak SWE (m)
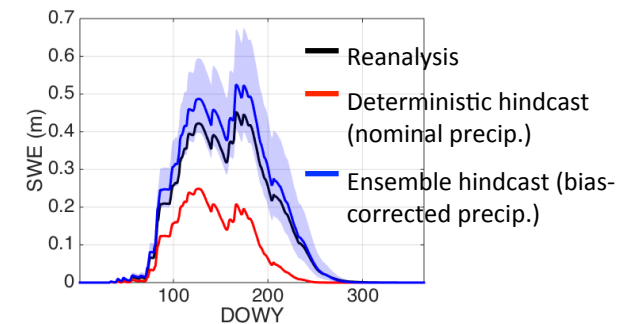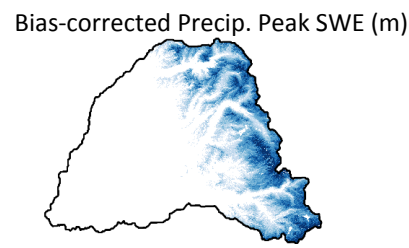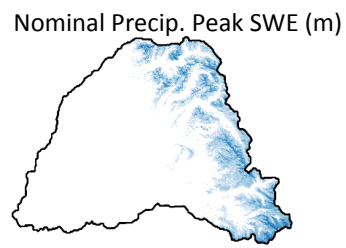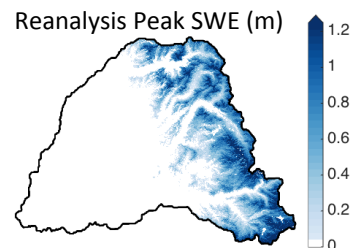
Next steps

- 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