CALIFORNIA DEPARTMENT OF WATER RESOURCES

Evaluation of Feasibility of BCM Model to Simulate CALSIM3 Rim Inflows

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BCM Model for California

- Basin Characterization Model
  - regional water-balance model
  - Lorraine E. Flint, Alan L. Flint, and Michelle A. Stern
- Snow Accumulation and Ablation Model – SNOW-17
  - Eric Anderson
  - Also employed in SAC-SMA and SWAT
- A bedrock Layer is added
- Horizonal resolution: 270 m
- Temporary resolution: monthly (or daily)
- Input hydrometeorological data: p, Tmax, Tmin, and PET

Schematic of BCM Model Physics

- Runoff/Recharge Process: Amount of water exceeding field capacity that enters bedrock, at a rate of Ks; excess water (rejected recharge) is added to runoff.
- Actual evapotranspiration Process: soil moisture, LAI, Kc, and PET
- Vegetation processes: LAI can change with monthly precipitation and vegetation type
- Sublimation Process: linearly related to PET

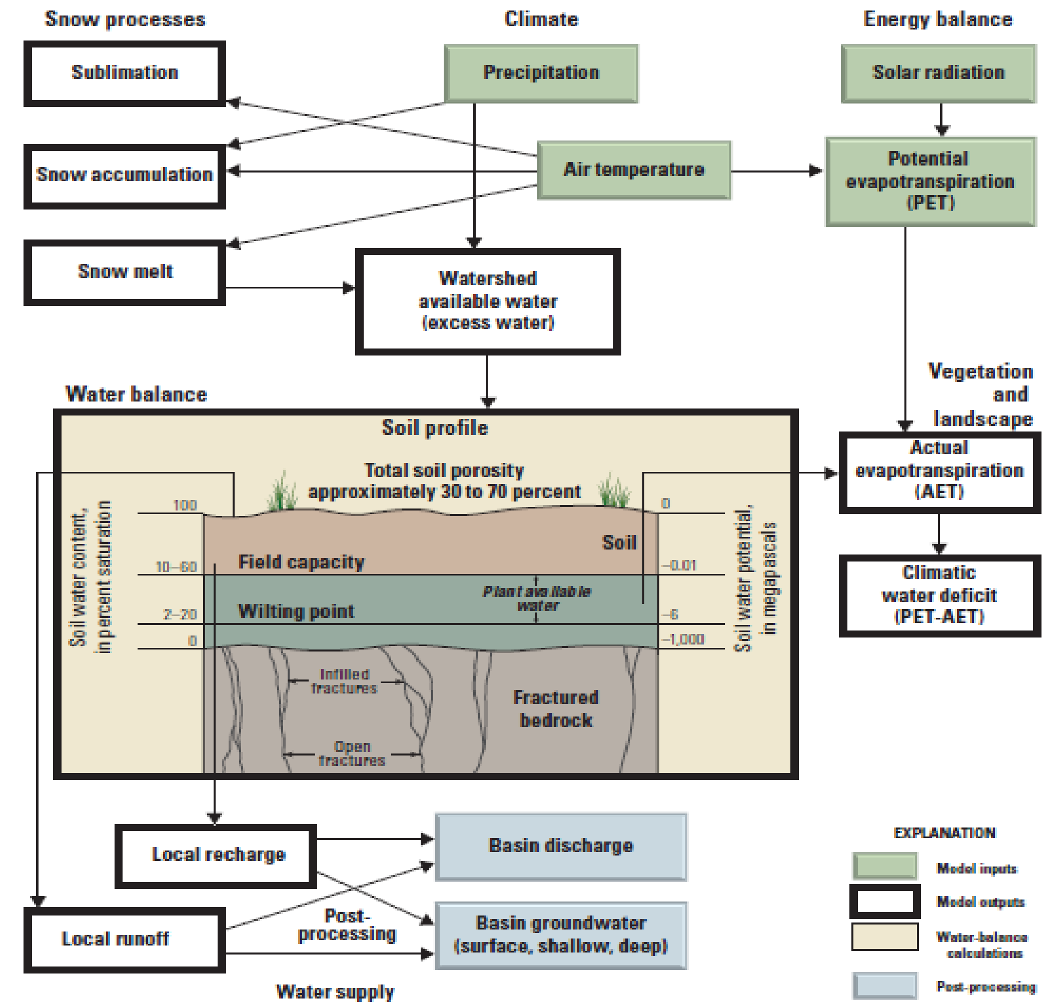
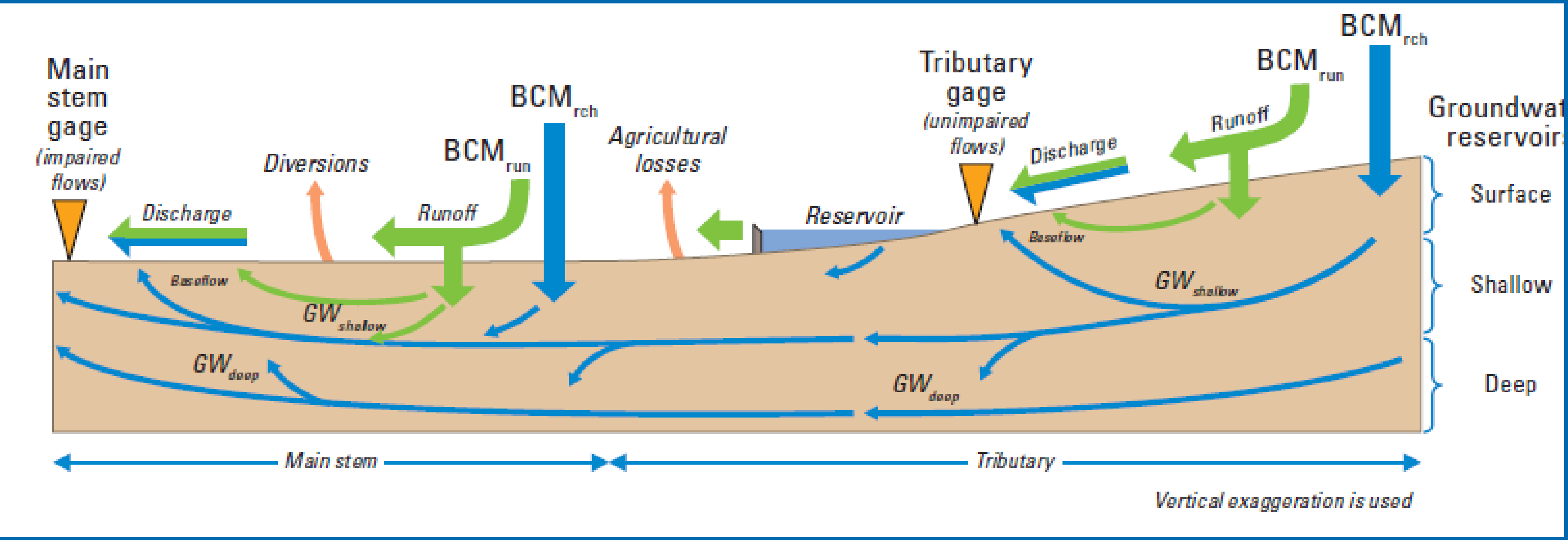


Figure 2. Inputs, outputs, and water-balance components of the Basin Characterization Model (BCM), version 8 (BCMv8).

BCM Flow Routing and Calibration

- Model Output: Runoff, Recharge, ……
- Routing based on a postprocess excel sheet
  - runoff can flow over the surface or move to the shallow zone
  - some recharge may return to the surface as base flow, and some recharge may be lost to the deep unsaturated zone

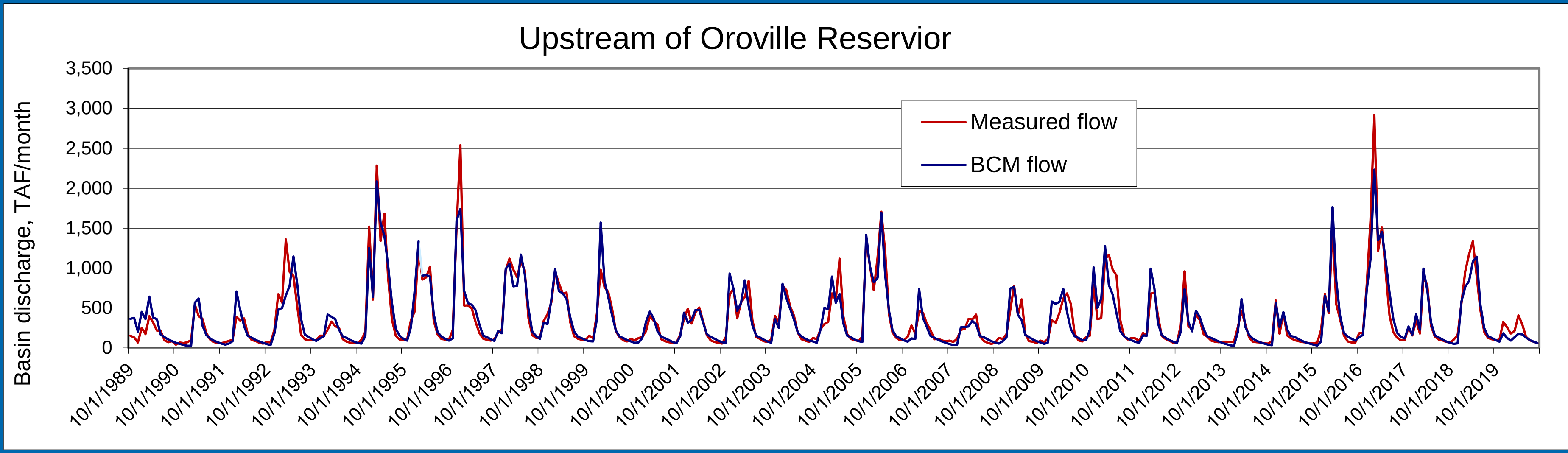


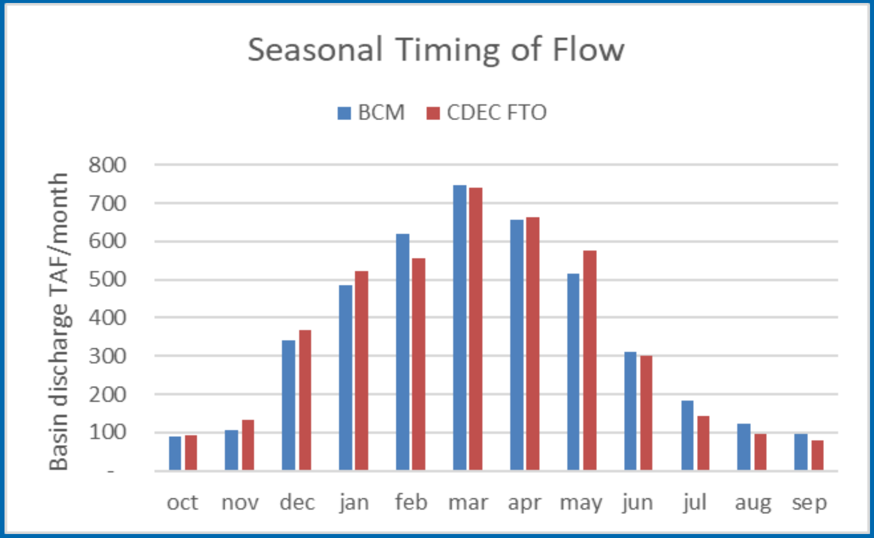
BCM Improvement by MSO

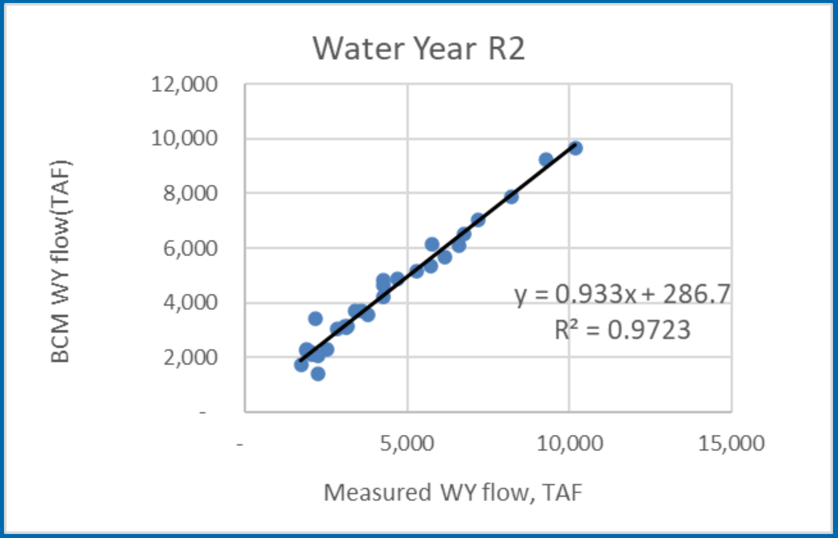
- Monthly time scale, simulation of snow melt is a little tricky
  - Even if monthly averaged temperature equal to zero, snow melting still happens in some days of that month
- Rain-on-snow (ROS) process is not implemented in current BCM
  - Cause simulated monthly flow in some wet months too low
  - The Sierra Nevada, like other maritime mountain ranges worldwide, is prone to ROS
  - ROS is an efficient generator of runoff that can produce 50%–80% higher peak flows than spring snowmelt
  - After this processed added, simulated monthly flow is much more realistic
- Parameter Adjustment
  - Snow accumulation temperature, snow melt factor,…

Routed Flow to Oroville Reservoir

Monthly r2:	0.89
NSE:	0.89
PBIAS:	-0.01

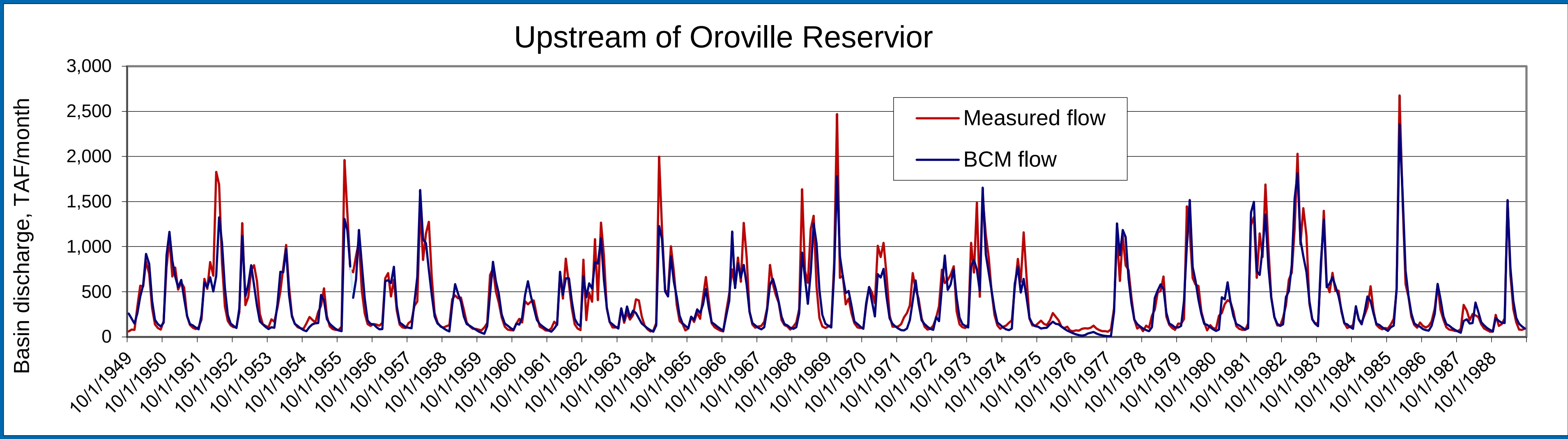






BCM Model Validation

- Monthly Inflow to Oroville Reservoir (1950-1989)



- Performance in the validation and calibration period

Validation:

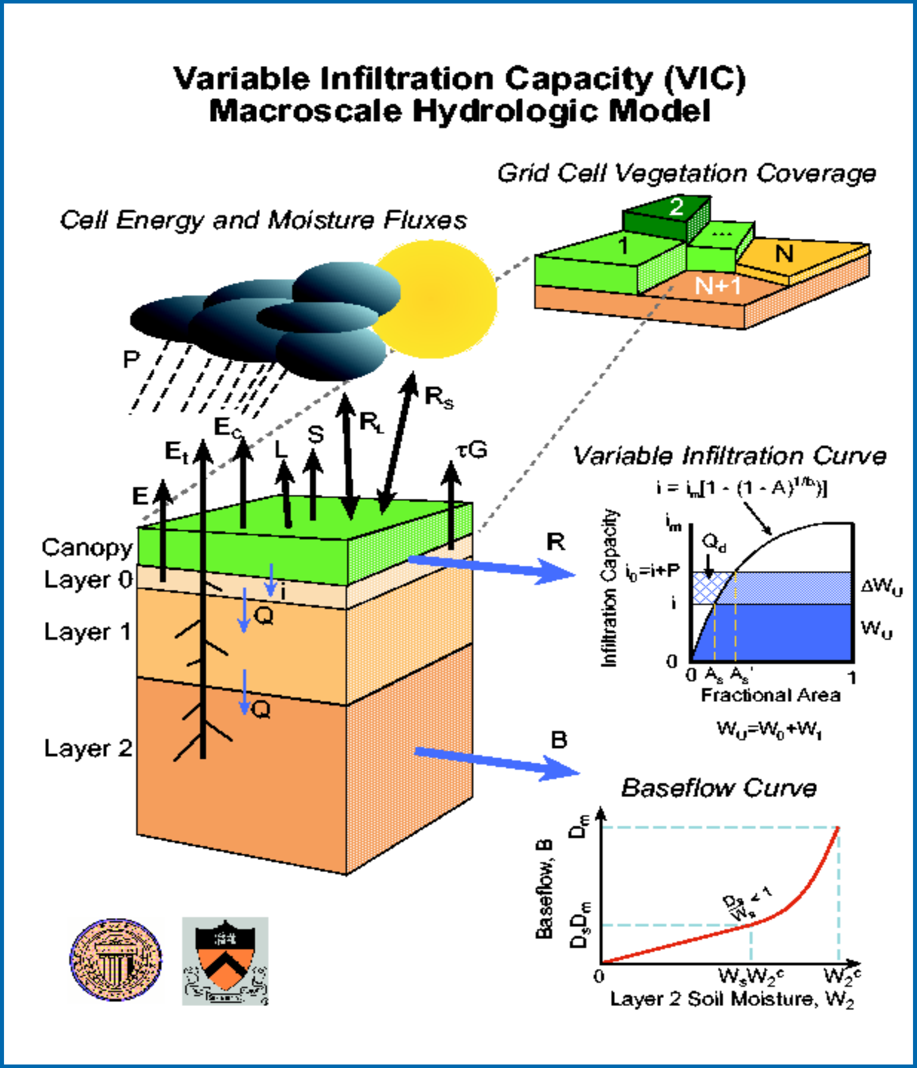
Monthly r2:	0.86
NSE:	0.85
PBIAS:	5.55

Calibration:

Monthly r2:	0.89
NSE:	0.89
PBIAS:	-0.01

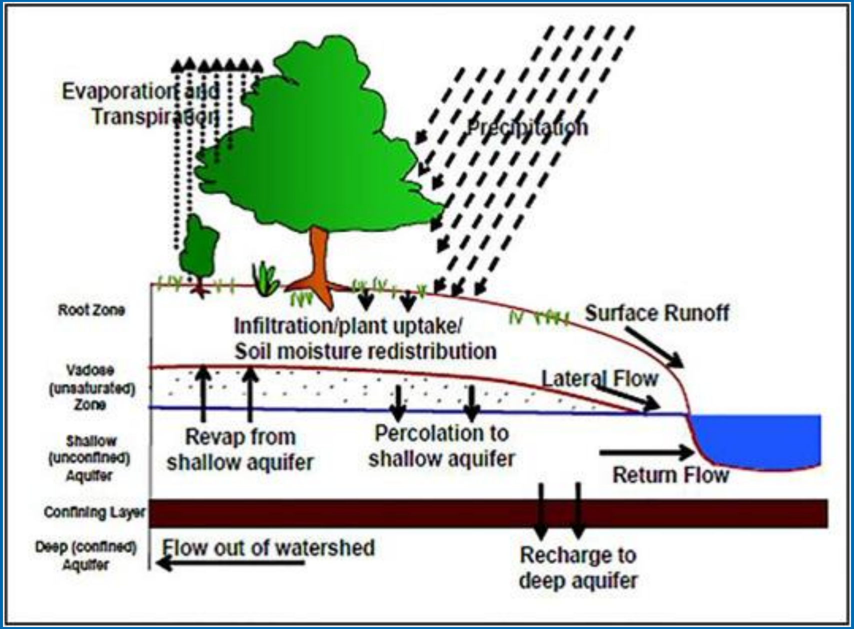
VIC Model

- The VIC model, first developed in 1994 by UW, is a macroscale hydrologic model used to solve full water and energy balances.
- Distributed, 8th or 16th degree
- Daily or subdaily model
- Three vertical soil layers+ canopy
- Daily meteorological data: p, Tmax, Tmin,wind, air and vapor pressure, longwave and shore wave radiation
- Not applicable for small watersheds
- Output: *runoff, baseflow, ET, PET…*
- The routing model is a source-to-sink model that solves a linearized version of the Saint-Venant equations



SWAT model

- The Soil & Water Assessment Tool is a small watershed to river basin-scale model used to simulate the quality and quantity of surface and ground water
- Daily or Subdaily time scale
- Four vertical soil layers
- Semi-distributed, HRU (Hydrologic Response Unit) or watershed based
- Simplified Snow-17, elevation band used
- Curve method or Green-Amp method for infiltration
- Daily gaged meteorological input data: p, Tmax, Tmin, Solar R, wind speed, humidity, and PET
- Provide calibration tool

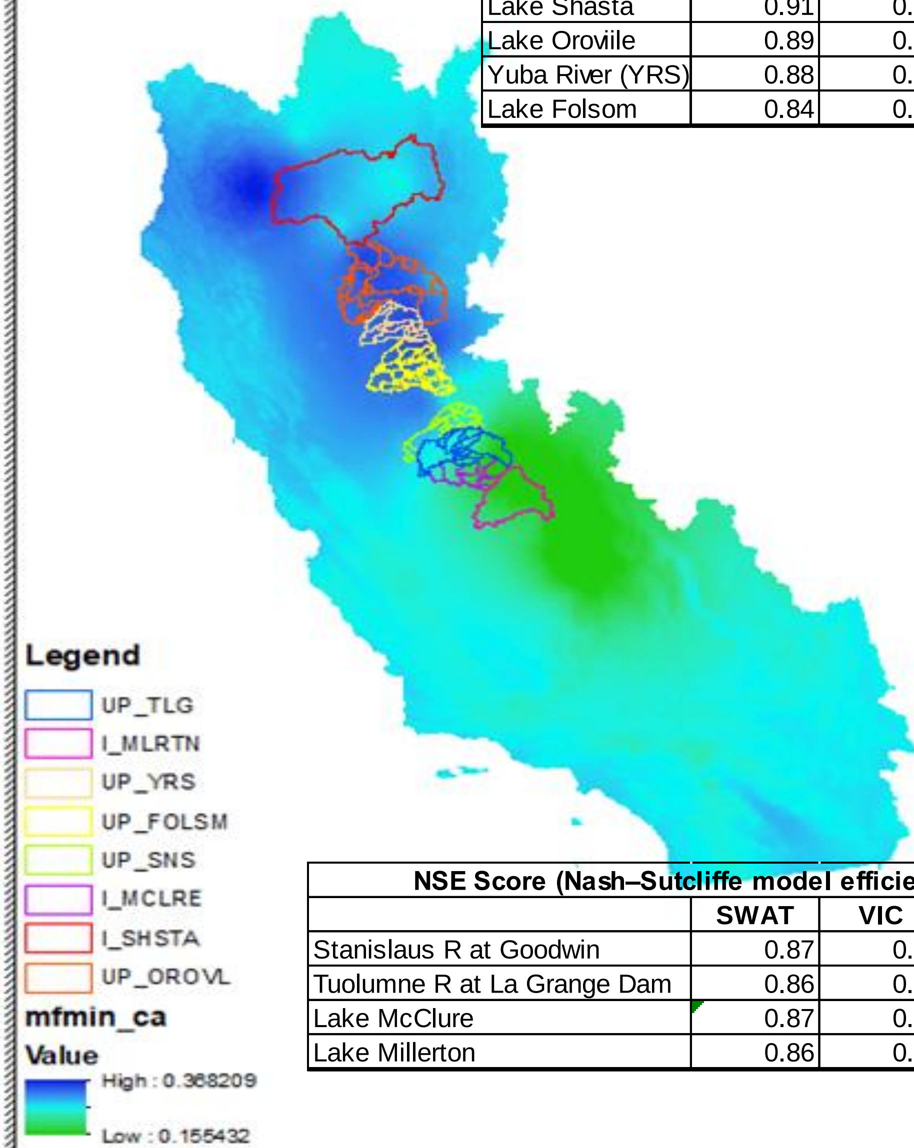


Performance Comparison with other Models (1950-1989)

Data Source:

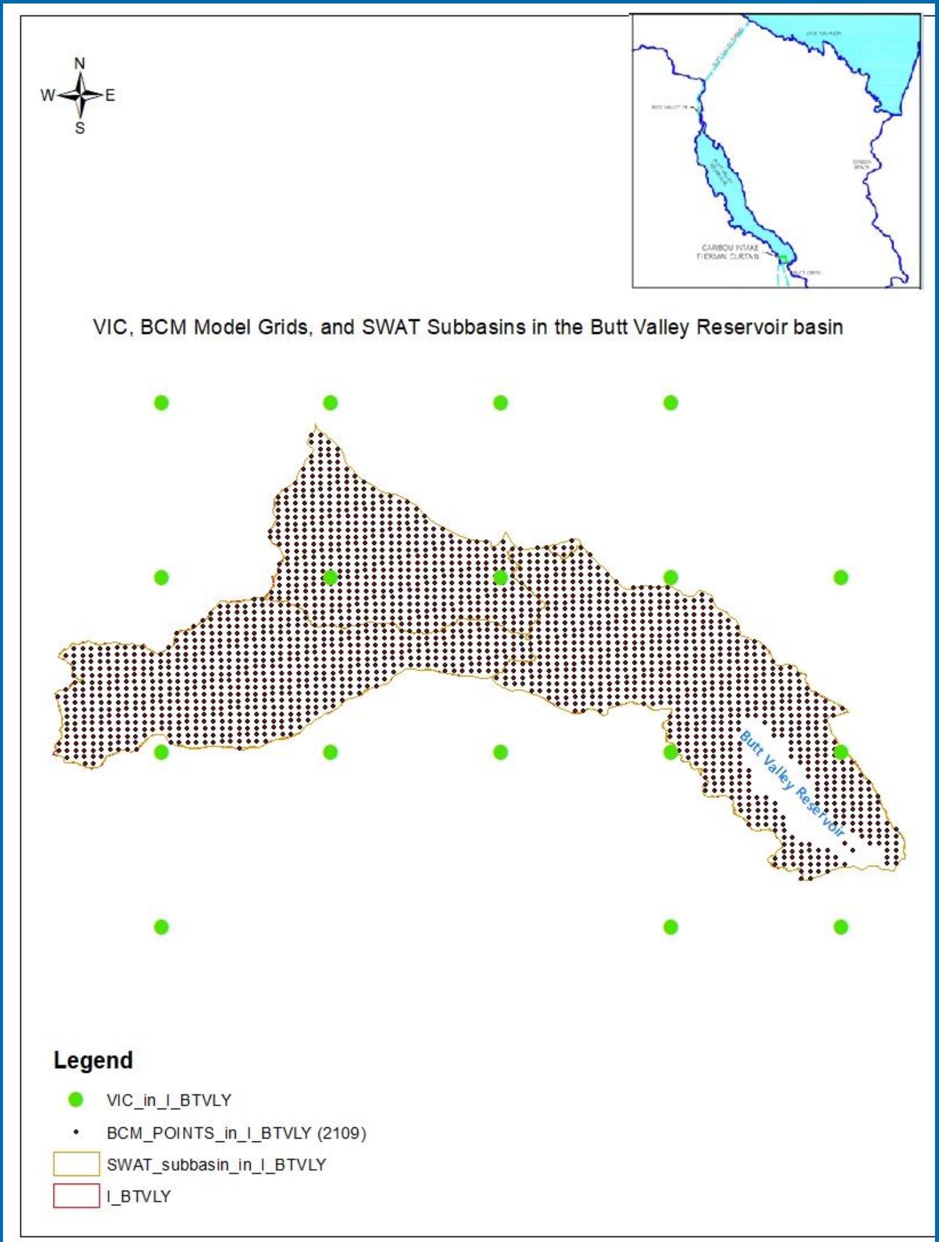
VIC : 8th degree , in house
SWAT: From Guobiao Huang
BCM: in house

NSE Score (Nash–Sutcliffe model efficiency)			
	SWAT	VIC	BCM
Lake Shasta	0.91	0.80	0.88
Lake Oroviile	0.89	0.89	0.86
Yuba River (YRS)	0.88	0.86	0.88
Lake Folsom	0.84	0.87	0.89



NSE Score (Nash–Sutcliffe model efficiency)			
	SWAT	VIC	BCM
Stanislaus R at Goodwin	0.87	0.81	0.90
Tuolumne R at La Grange Dam	0.86	0.82	0.92
Lake McClure	0.87	0.89	0.90
Lake Millerton	0.86	0.84	0.88

BCM, VIC model Grids and SWAT HRUs



- Total Grid Points or subbasins in the Basin:
  - VIC Model: ~3
  - BCM Model: 2109
  - SWAT Mode : 3 subbasins (25 HRUs)
- SWAT HRUs:
  - Lump regions with similar slope, soil type and land cover into one HRU
  - The same P, Tmax/Tmin, and PET for all HRUs.

Data Need and Availability

- CalSim3 climate input data: 1922-2021
- SWAT the most difficult in acquiring its data, VIC seconds.

	BCM* (grid)	VIC** (grid)	SWAT(gage)
Precipitation	Yes (monthly)	Yes (daily)	Yes (daily)
Max/Min Air Temp.	Yes (monthly)	Yes (daily)	Yes (daily)
PET	Yes (monthly)	Yes (daily, derived***)	Yes (daily)
Air Pressure	No	Yes (daily)	No
Vapor Pressure	No	Yes (daily, derived)	Yes (daily)
Wind Speed	No	Yes (daily)	Yes (daily)
Solar Radiation	Yes (long term averaged)	Yes (daily, derived)	Yes (daily)
Leaf Area Index	No	Yes	Yes
Albedo	No	Yes	No
Partial Vegetation Cover Fraction	No	Yes	No

* PRISM monthly data, 1895-current
** 1/8th or 1/16th daily data developed by UW: 1915-2013
*** VIC uses the MTCLIM algorithms to convert daily min and max temperature to humidity and incoming shortwave radiation.

Scalability

- BCM and VIC
  - California BCM model and VIC are gridded (distributed) model, the preparation of parameters and input data on grid points are straightforward for all 301 CalSim3 watersheds
  - BCM input data is the easiest to be extended to the most recent year
- SWAT
  - SWAT is a semi-distributed model and very large efforts are needed to prepare parameters and inputs to subbasin and HRUs if expanded into all 301 watersheds

Technical Support

- BCM model: maintained by USGS
- VIC model: maintained by University of Washington
- SWAT model: maintained by Texas A&M University
- Easy to get technical support from USGS for the BCM model

Summary of Feasibility of BCM

Criteria	BCM	VIC	SWAT
Performance (NSE)*	0.89	0.85	0.87
Resolution	270m	~7km	subbasin or HRU dependent
Data Need	4 monthly time series	8 daily time series	7 daily time series
Data Availability	PRISM (up to current)	Developed by UW (up to 2013)	Gage Data
Scalability	good	good	fair
Technical Support	better	good	good
* Averaged over 8 major watersheds in the Sacramento River and San Joaquin River basin			

Question?