Reconstruction of Sacramento Valley Hydrology

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Outline

- Objective
- Model Description
- Assimilation Method
  - Mass Balance and Soft Constraint
  - Model Coupling Correction
  - Adjustable Model Parameter
- Summary

Objective

To reconstruct historical hydrological datasets that are consistent with CalSim 3.0 stream network in Sacramento Valley.

Model Description

Why do we need to reconstruct historical datasets?

Inconsistency in historical hydrological datasets due to

- Span extended period of time
- Measurement error
- Different Methodology
- Different Model
- Missing data
- Originated from different agencies

Model Description

Why do we need to reconstruct historical datasets?

Many historical hydrological datasets developed by DWR, USGS, USBR, and other agencies **may not be compatible** with each other and **may not be suitable for direct use** in CalSim 3.0.

Model Description

How to reconstruct historical datasets that are consistent with CalSim 3.0 stream network?

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

- CalSim 3.0 Stream Network
- CalSimHydro and Conveyance Loses
- Groundwater and surface water interaction
  by groundwater DLL

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

- Boundary Conditions:
  - Rim Inflows
  - Inflows to Delta

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

Input

- Observations:
  - Stream Flow Records
  - Diversions
  - Reservoir Storages
  - Reservoir Releases
- Model Results
  - Applied Water Demands
  - Surface Runoff
  - Tailwater/Wastewater
  - Stream Gain/Loss

Assimilated Output

- Consistent Flow Conditions:
  - Channel Flow
  - Diversions
  - Reservoir Storage
  - Reservoir Release
  - Return Flow
  - Stream Gain/Loss
  - Conveyance Losses
  - Closure Term

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

Assimilation Method

- ❑ Mass Balance and Soft Constraint
- ❑ Model Coupling Correction
- ❑ Adjustable Model Parameters

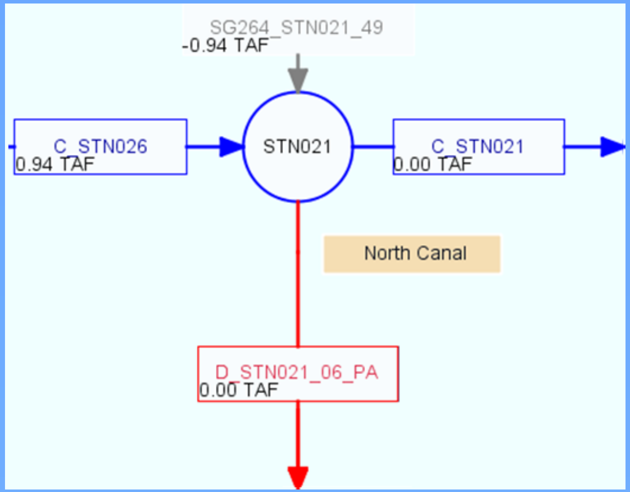
Assimilation Method

- Mass Balance and Soft Constraint

1. Continuity equations of CalSim 3.0 schematic ensure mass balances at all stream nodes in the Sacramento Valley.

2. Soft constraints push flows in the system to be close to the observed or modeled historical amounts (input), and flows in the system (output) to deviate from the input amounts.

3. Constraints can be adjustable for different locations, different time periods, and different value ranges.



Assimilation Method

- Mass Balance and Soft Constraint

A example of a sequence of penalties used in Sacramento River from upstream to downstream

Assimilation/Gage Location	Channel Arcs	Constraint Penalty
	C_SSSmmm	CP_SSSmmm
Bend Bridge	C_SAC256	256000
Butte City	C_SAC169	169000
Wilkins Slought	C_SAC120	120000
Freeport	C_SAC049	49000

The set of penalties allow inconsistent data sets at those gages to be assimilated, which assumes upstream observation is more accurate than downstream observations.

Assimilation Method

- Mass Balance and Soft Constraint

A generalized goal statement for positive channel flow at river locations:

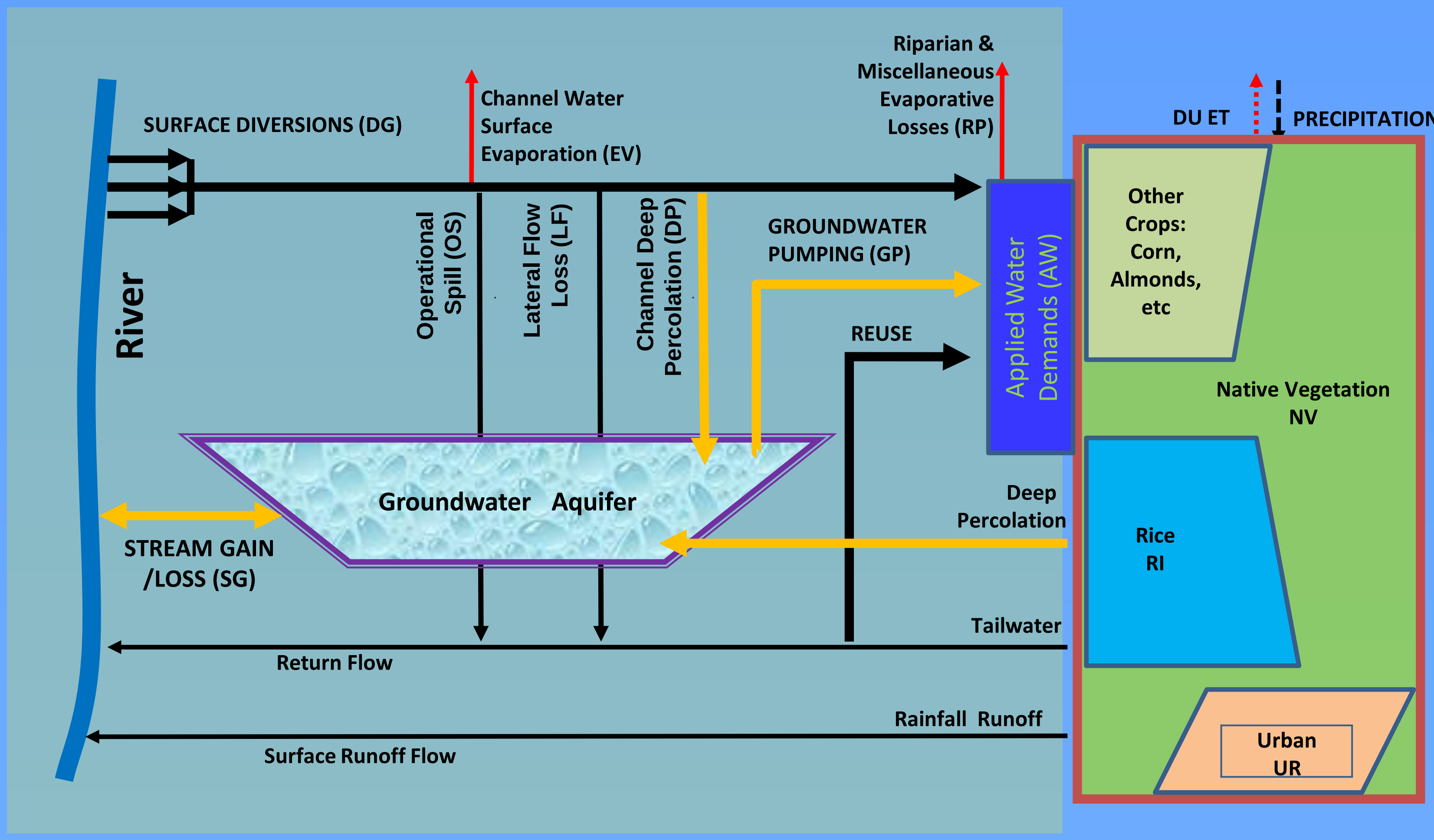
```
goal setC_SSSmmm     { lhs C_SSSmmm
 case NONZERO {condition C_SSSmmm_HT>=0
                         rhs C_SSSmmm_HT
           lhs>rhs penalty CP_SSSmmm
           lhs<rhs penalty CP_SSSmmm} }
```

where C_SSSmmm is the channel arcs of stream “SSS” and river mile “mmm”,
C_SSSmmm_HT is the historical observation, and
CP_SSSmmm is the soft constraint penalty.

The value of the penalty CP_SSSmmm can vary with locations.

Assimilation Method

- Model Coupling Correction



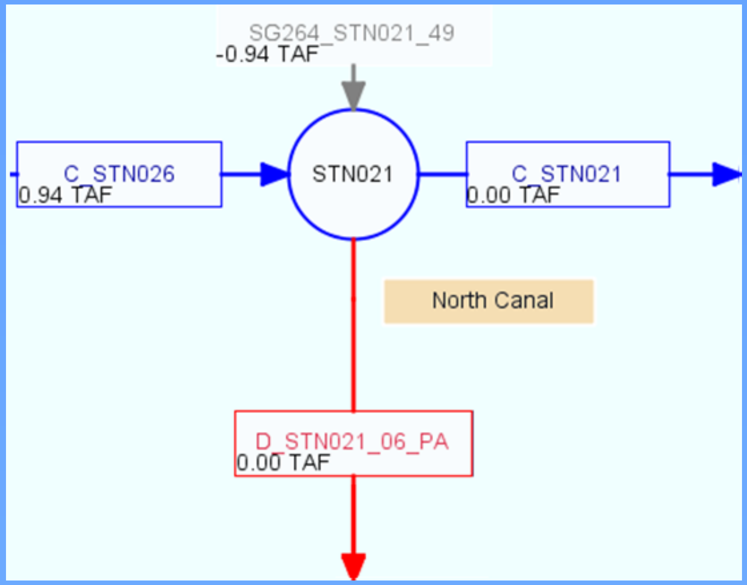
CalSim 3.0

CalSimHydro

Assimilation Method

- Model Coupling Correction

An Example of Model Coupling Correction



	GW DLL Amounts	Assimilated Flows			
		Inflow		Outflow	
	SG264_ STN021 _DLL	**SG264_ STN021**	C_STN026	C_STN021	D_STN021 _ 06_PA
Apr-77	-0.94	-0.94	0.94	0.00	0.00
May-77	-1.55	-1.55	1.55	0.00	0.00
Jun-77	-0.34	0.00	0.00	0.00	0.00
Jul-77	-0.04	0.00	0.00	0.00	0.00
Aug-77	-0.05	0.00	0.00	0.00	0.00
Sep-77	-0.13	-0.13	0.26	0.00	0.13
Oct-77	-0.25	0.00	0.00	0.00	0.00
Nov-77	-2.45	-2.45	3.54	1.09	0.00
Dec-77	-6.92	-6.92	48.28	41.36	0.00
Jan-78	-10.59	-10.59	317.34	306.75	0.00
Feb-78	-2.66	-2.66	189.86	187.21	0.00
Mar-78	**0.15**	**0.15**	146.37	146.52	0.00
Apr-78	**1.03**	**1.03**	57.50	58.52	0.00
May-78	**0.79**	**0.79**	16.21	17.00	0.00
Jun-78	**0.26**	**0.26**	0.00	0.01	0.25
Jul-78	**0.74**	**0.74**	0.00	0.00	0.74
Aug-78	-0.23	0.00	0.00	0.00	0.00
Sep-78	-0.66	-0.66	1.34	0.00	0.68

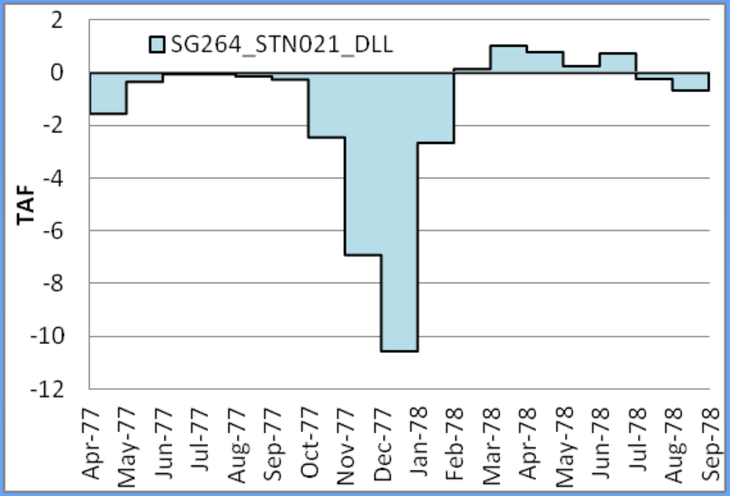
Model Coupling Correction

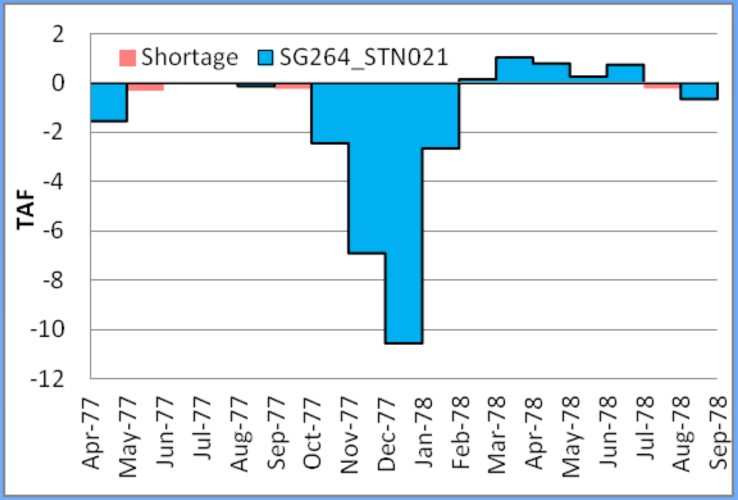
Three Goal Approach for SG

Goal#1 is to push **SG264_STN021** to the value of **SG264_STN021 _DLL** when **SG264_STN021 _DLL** is negative.

Goal#2 is to set the upper limit of the value of **SG264_STN021** to be zero when **SG264_STN021 _DLL** is negative.

Goal#3 is to constrain **SG264_STN021** to the value of **SG264_STN021 _DLL** when **SG264_STN021 _DLL** is positive.





Assimilation Method

- Model Coupling Correction

A set of generalized goal statements to assimilate groundwater DLL SG output.

goal setNegSGnnn_CCCmmm_rr {lhs **SGnnn_SSSmmm_rr**
case negative {condition **SGnnn_SSSmmm_rr_DLL** < 0
rhs **SGnnn_SSSmmm_rr_DLL**
lhs>rhs penalty **SGPHIGH**}}

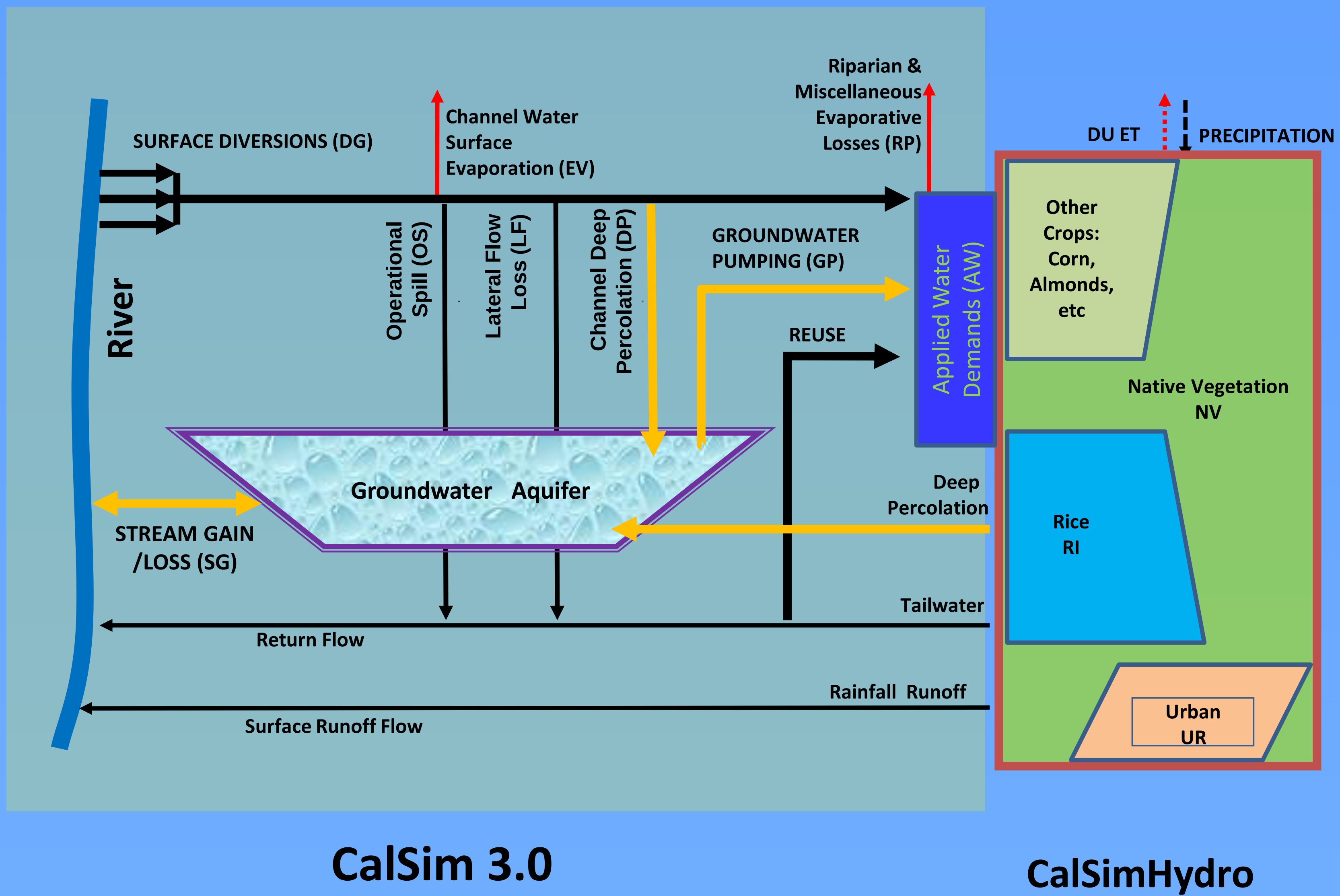
goal setNeg2SGnnn_CCCmmm_rr {lhs **SGnnn_SSSmmm_rr**
case negative {condition **SGnnn_SSSmmm_rr_DLL** <= 0
rhs **0**
lhs<rhs penalty 0} }

goal setPosSGnnn_CCCmmm_rr {lhs **SGnnn_SSSmmm_rr**
case positive {condition **SGnnn_SSSmmm_rr_DLL** > 0
rhs **SGnnn_SSSmmm_rr_DLL** }}

where **SGnnn_SSSmmm_rr_DLL** is the SG at CV2SIM stream node "nnn" of the DLL output, which flows to CS3 stream node. **SGnnn_SSSmmm_rr** is the corresponding SG that the CalSim 3.0 accepted. **SGPHIGH** is a adjustable penalty.

Assimilation Method

- Adjustable Model Parameters



Assimilation Method

- Adjustable Model Parameters

CalSim 3.0 Demand Unit Balance Equations

DG+RU+GP = AW +RP +EV +DP +LF +OSF

RP = AW*RPF — Riparian & Miscellaneous Evaporative Losses

EV = DG*EVF — Evaporative loss

DP = DG*DPF — Deep percolation loss

LF = DG*LFF — Lateral flow loss fraction

OS = DG*OSF — Operating spill

RU = Min(TW, AWo*RUFo + AWr*RUFr + AWw*RUFw) — Reuse

GP > GPMINF * { AW + RP –RU } — Minimum GW Pumping

CalSimHydro Demand Unit Balance Equations

AW + PRdu = SR + TW +ETdu +DPdu +ΔPDdu

AW = AWr + AWo + AWw

Assimilation Method

- Adjustable Model Parameters

RPF -- coefficient of Riparian & Miscellaneous Evaporative Losses

EVF -- evaporative loss fraction
DPF -- deep percolation loss fraction
LFF -- lateral flow loss fraction
OSF -- canal operating spill fraction

RUFr -- Reuse factor for rice
RUFo -- Reuse factor for other crops
RUFw -- Reuse factor for wetland

GPMINF -- minimum groundwater pumping fraction

Summary

1. Sacramento Valley Hydrological Data Assimilation Model (SacDAM) has been developed

2. SacDAM Reconstructed dataset is a best fit of CalSim 3.0 stream network to the available observed and model generated data, taking into account observational errors and errors in models

3. Results of SacDAM can be useful in many applications including CalSim 3.0 model calibration