Modeling The Evolution Of A Regional Aquifer System With The California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM)

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Introduction

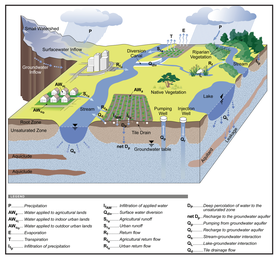
A groundwater-surface water simulation of California's Central Valley with a monthly time step from October 1921 through September 2003 was developed using the Integrated Water Flow Model (IWFM) application. The model simulates groundwater flow, surface water flow and land use processes over an area of approximately 20,000 mi^2. Model results are being used to calibrate discrete kernels to simulate groundwater responses to pumping in CALSIM-III, a water resources planning model used to simulate operation of the California State Water Project and Federal Central Valley Project.

C2VSIM is being calibrated in three phases. In the first phase, tools were developed to link IWFM and the PEST parameter estimation suite. The second phase involved refining the conceptual model and calibrating horizontal and vertical hydraulic conductivities, specific yield and stream-bed conductances for 1975-1998 using the PEST pilot point framework. The third phase, currently in progress, involves calibrating the remaining hydrologic parameters and extending the calibration time-frame to 1921-2003. Results of the second phase are presented in this poster, including model verification against observations taken prior to the calibration period.

A calibrated groundwater-surface water flow model can provide robust estimates of important water resources properties that are not currently available. These include groundwater pumping rates, changes in groundwater storage, and groundwater-surface water interaction. In addition, the model can be used for a variety of purposes, including analyzing conjunctive use projects and assessing the impacts on the Central Valley's streams and aquifers resulting from changes in surface water flows (for example due to climate variability).

Integrated Water Flow Model (IWFM)

IWFM couples a 3-D finite element groundwater flow process with1-D land surface, lake, stream flow and vertical unsaturated-zone flow processes.



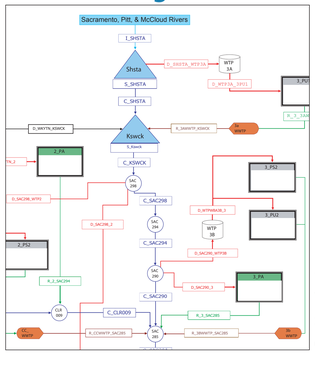
The groundwater flow process can simulate pumping wells, injection wells, tile drains and subsidence.

The surface water flow and lake processes route flows through the stream and lake network, calculating groundwater-surface water interactions and inflows from runoff, and allocating available stream flows to meet specified deliveries.

The land surface process simulates agricultural, urban, native and riparian areas. Agricultural areas can have multiple crops. Areal land use can change through time.

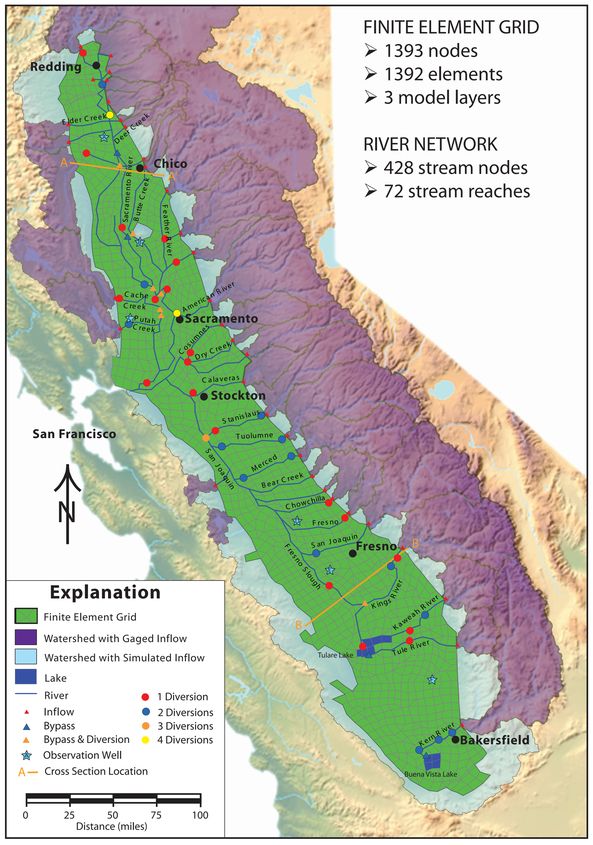
Distributed soil properties, land use and crop data, precipitation and evapotranspiration rates are used to dynamically calculate water demands, runoff to streams and deep percolation through the unsaturated zone. Surface water diversions and groundwater pumping can each be either specified or calculated at run time.

CALSIM Integration



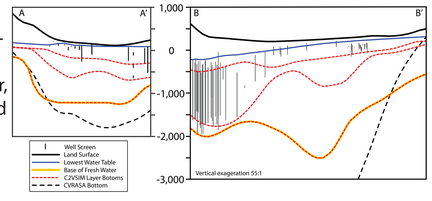
The linkage between C2VSIM and the CALSIM-III water resources planning model is accomplished by mirroring stream nodes in the two models. For example, the circles labeled SAC correspond to C2VSIM stream nodes. A discrete kernel is calibrated for each of these points using C2VSIM. These discrete kernels provide CALSIM-III with a robust and rapid estimation of the groundwater-surface water interaction at each of these points in response to decision variables such as groundwater pumping rates.

Model Framework

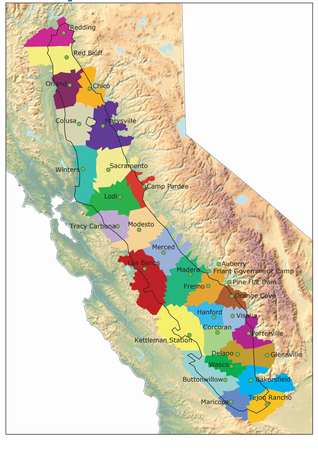


Model Layers

Three layers were delineated to maintain well screens within a single layer, where practical, and to honor aquitards such as the Corcoran Clay.



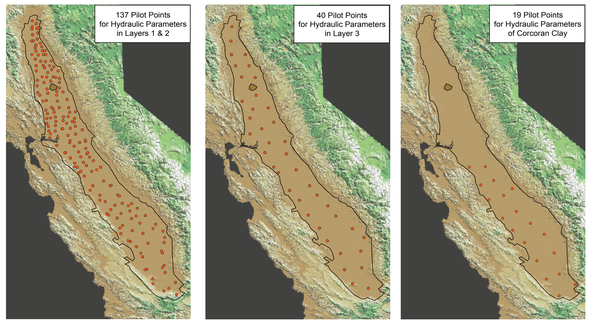
Precipitation Stations & Zones



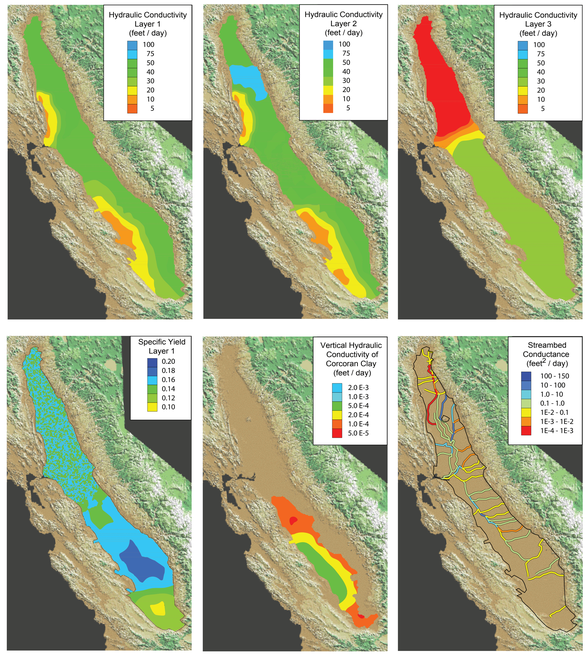
Daily precipitation at 32 sites in the Central Valley was compiled for the period from October 1921 through September 2003. Model elements and simulated watersheds were associated with individual precipitation stations using Theissen polygons. Elemental weighting factors were then computed to match simulated average annual precipitation for 1971-2000 for each element to PRISM annual average precipitation for the same period.

Calibration

Hydraulic parameters were calibrated using the PEST Pilot Point Framework. Nodal parameter values were determined by kriging from the optimum values determined at the pilot points.



Calibrated Parameters



Future Work

C2VSIM is currently being calibrated for the period from October 1921 to September 2003. Model calibration will include:

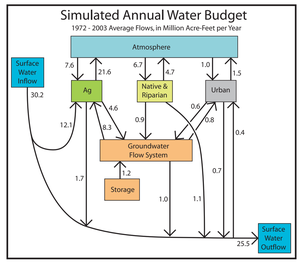
- Local calibration, especially in the Tulare Basin
- Expansion of the streamflow accretion/depletion database
- Review of the crop demand calculations and crop acreage data
- Adjustment of observation weights
- Review of the surface water diversion data to determine why winter diversions are greater than simulated crop water demand

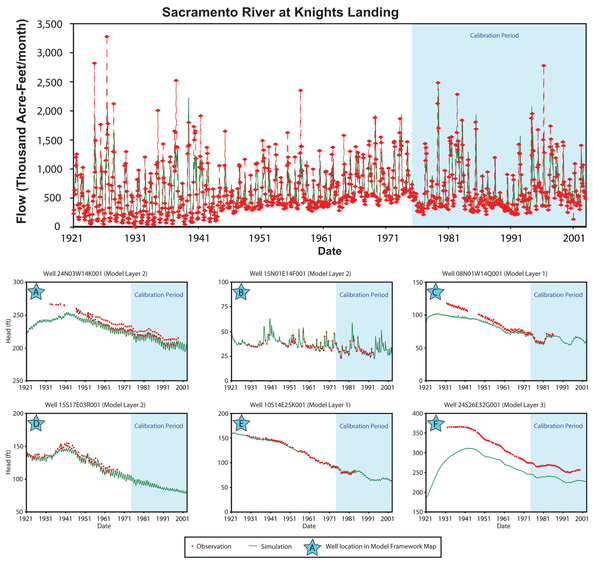
Suggested improvements to the C2VSIM model framework include:

- Developing a rice/managed wetland process in IWFM
- Increasing the horizontal spatial resolution of the model grid
- Increasing the number of water budget areas to better simulate the areal distribution of agricultural crops
- Refining the vertical discretization by increasing the number of model layers, and defining model layer boundaries to encompass geologic units and aquifers

Simulation Results & Model Verification

C2VSIM was calibrated to groundwater head and streamflow measurements for October 1975 to September 2003. The model was then run for the period from October 1921 to September 2003. Simulated heads and flows generally match observed values. This should continue to improve with more locally refined calibration.





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IWFM source code, executables and documentation are freely available. Search for "IWFM" with Google or go to: http://baydeltaoffice.water.ca.gov/modeling/hydrology/IWFM

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