Probabilistic Reservoir Inflow Forecasting

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Jason Lillywhite, GoldSim Technology Group
Carly Hansen, University of Utah

Introduction

Need for hydrologic prediction that incorporates risk

Use a probabilistic prediction model

Test this model on a real site

Calculate risk based on current conditions

Evaluate the effectiveness of the current operating scheme

Similar to the AHPS – Advanced Hydrologic Prediction Service created by the National Weather Service (https://water.weather.gov/ahps)

Model Process Overview

Predict risk of flood due to uncontrolled flows over spillway

14-day weather forecast

Stochastic weather generator (for > 14 days)

Transition from weather forecast to long-term stochastic weather generator

Include snowmelt and hydrologic runoff modeling

Input current conditions and planned operating scheme

Predict risk based on operating scheme

Use GoldSim as the modeling platform

Model Platform - GoldSim

What is GoldSim?

- Highly graphical, object-oriented
- Generic and flexible (like a spreadsheet or programming language)
- Dynamic and probabilistic simulation

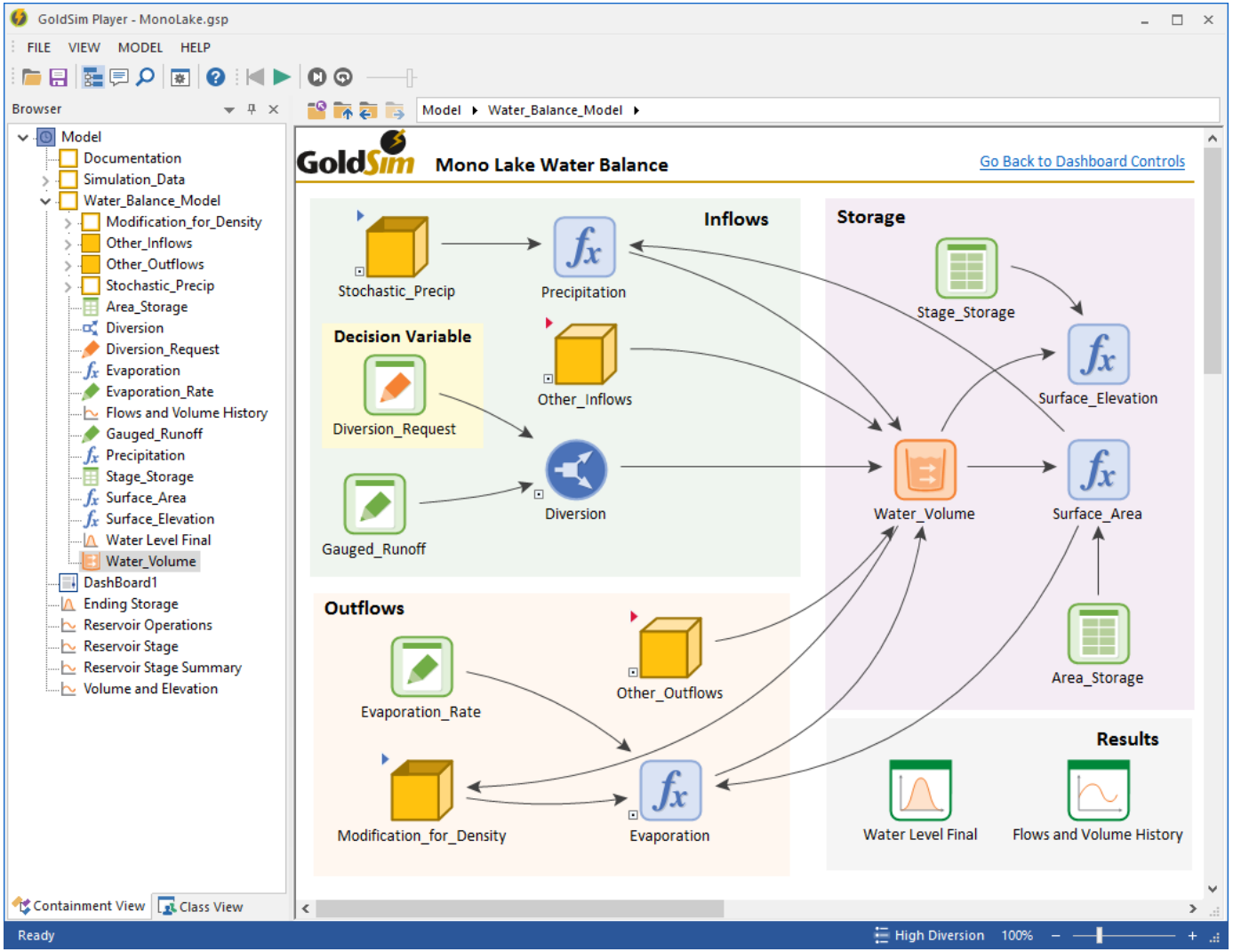
GoldSim born in early 1990s

- Golder Associates
- GUI built in 1998
- Became GoldSim in 2004

Large and diverse user base

- Over 600 organizations in 54 countries worldwide
- Over 2000 current users
- Applications in water, mining, radwaste, energy, economics, and risk

GoldSim Interface Example



Application – Little Dell Reservoir

Located in the Wasatch mountains east of Salt Lake City, Utah

Dam is operated by SLCPU

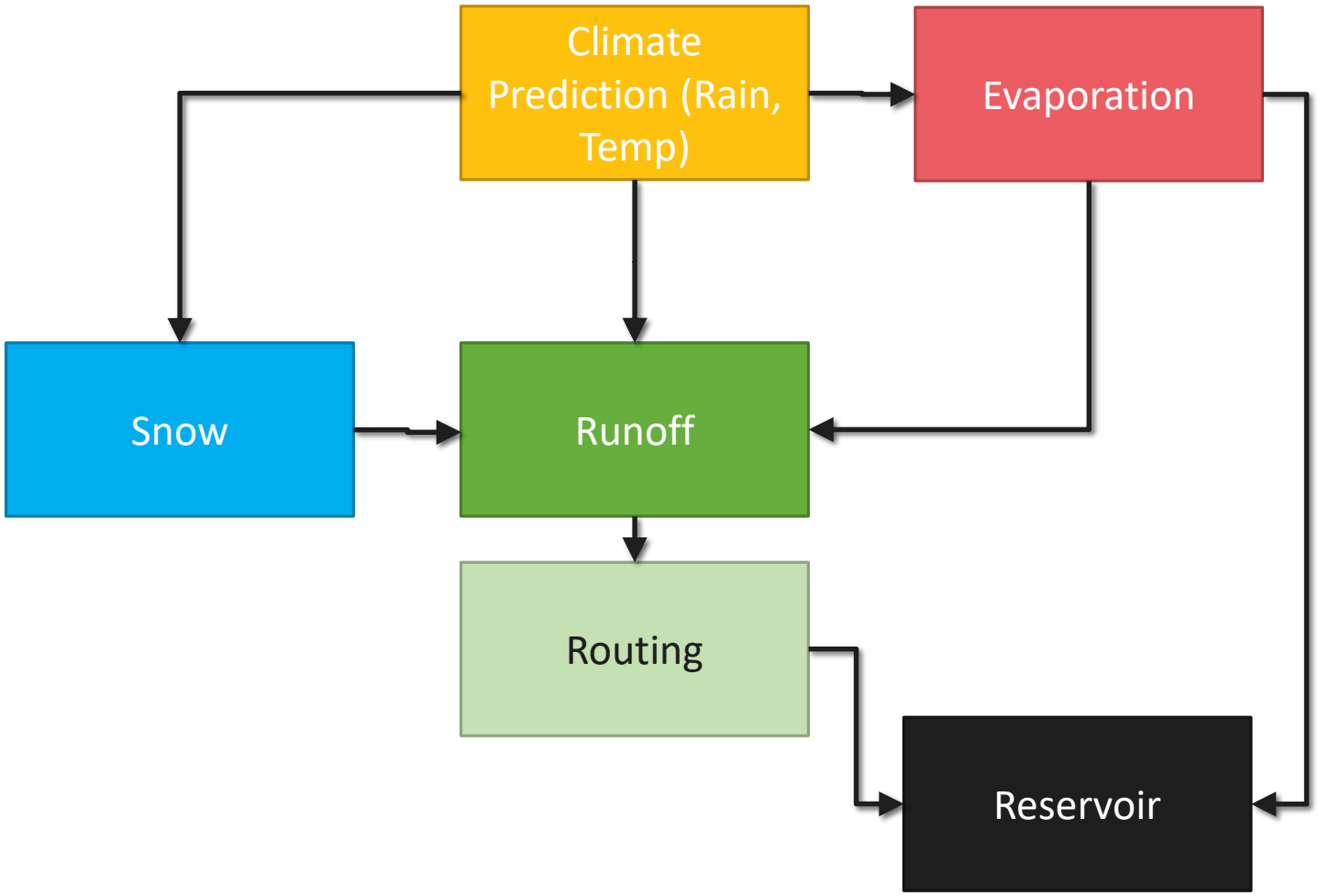
Provides flood control and drinking water supply

Constructed finished in 1993

Capacity = 20,500 AF

Earthfill dam with height = 224 ft

Model Components



Model Components

Precipitation & Temperature

- 14-day forecast with correlation to watershed
- Markov based simulator (WGEN)

Evaporation

- FAO Penman-Monteith

Snowmelt

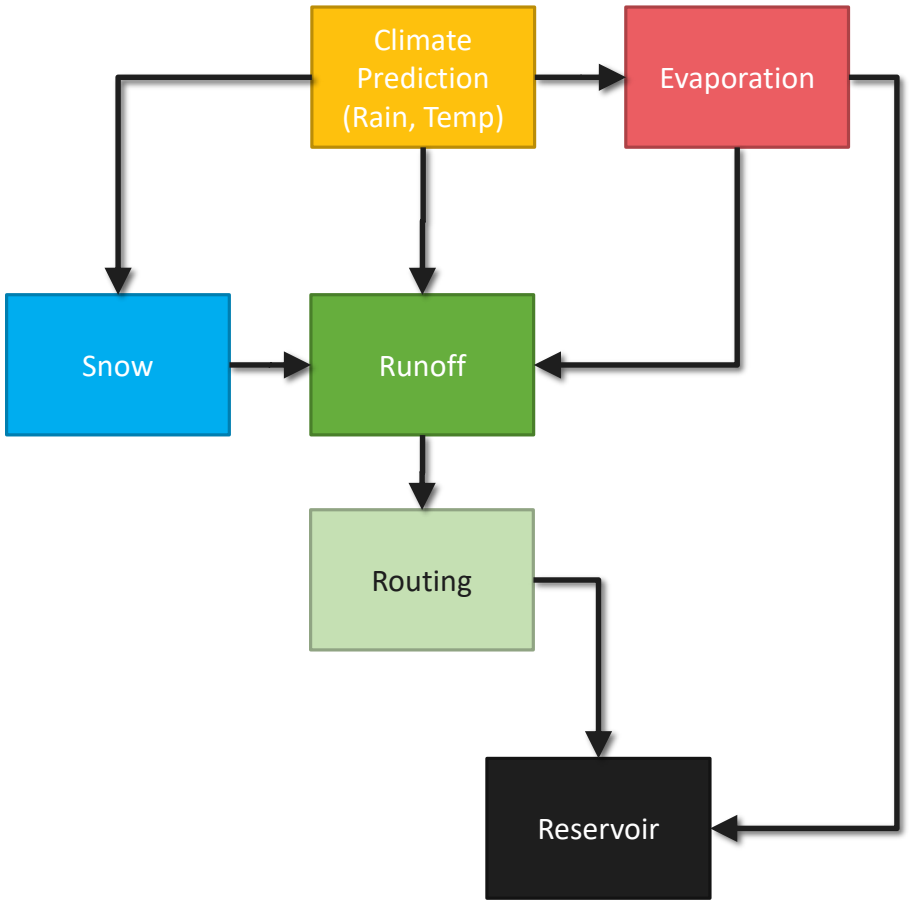
- Snow accumulation and ablation model (Snow17)

Runoff and Routing

- Australian Water Balance (AWBM)

Reservoir

- Dynamic, level pool simulator
- Orifice controlled discharge
- Weir flow for spillway



Input Data

Historic Precipitation, Temperature, Snow pack (SWE)

- Parley's Summit and Lookout Peak Snotel Gages
  - Located within watershed and very near
- Operated by NRCS
- 1981 – Current data

Historic streamflow

- Salt Lake City Public Utilities (1980 – 2014)

Forecast

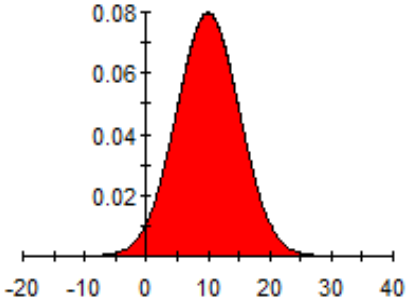
- www.weather.com (14-day)
- Chance of rain
- Min/max temperature
- Correlation between SLC – Snotel sites used
- Calibrated WGEN model

Monte Carlo Simulation

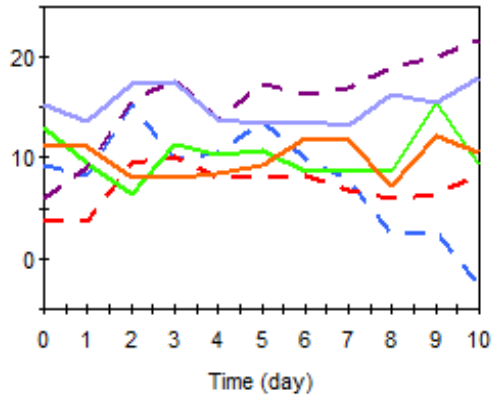
Random Inputs

Computations

Store Aggregate Results



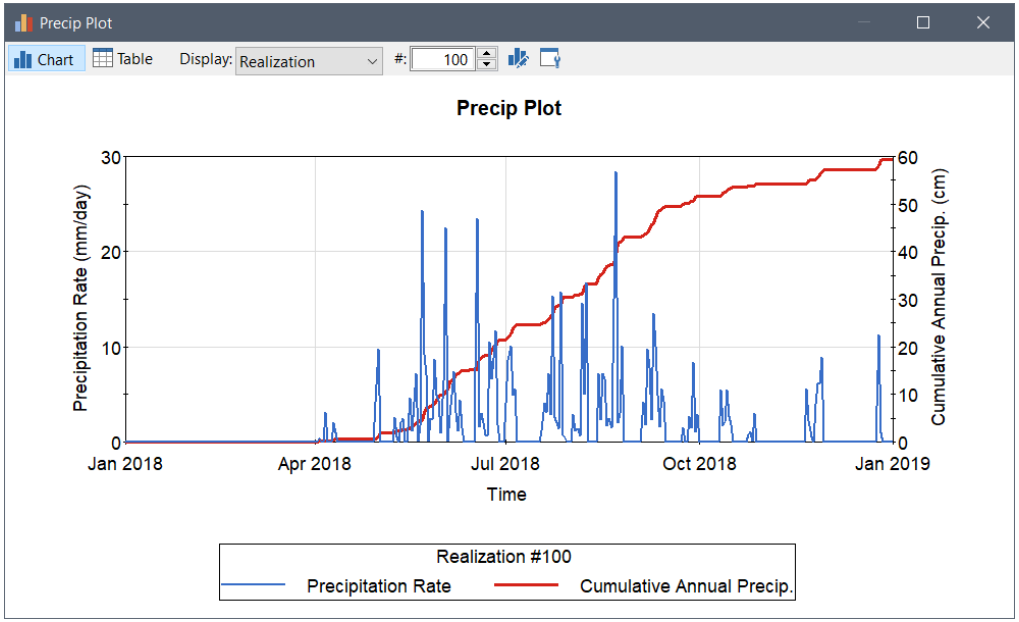
Perform a simulation that uses inputs sampled from the distribution



Markov Process Rain Simulator

Inputs:

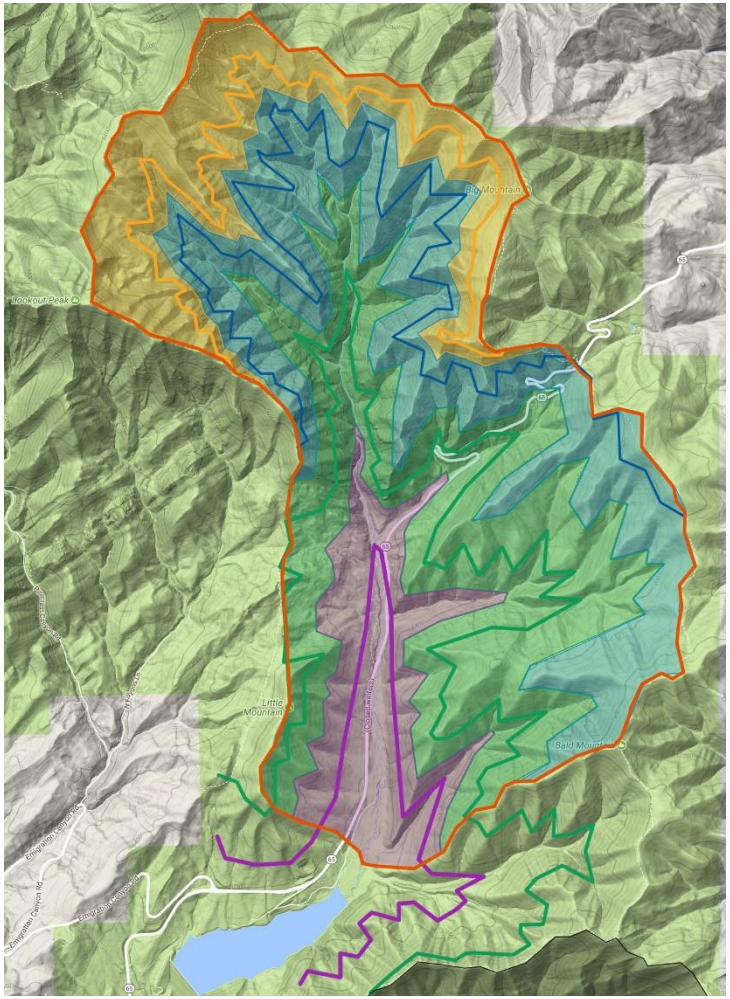
- Probability of being wet (can change through the year)
- Average length of wet periods
- Average monthly rain depth



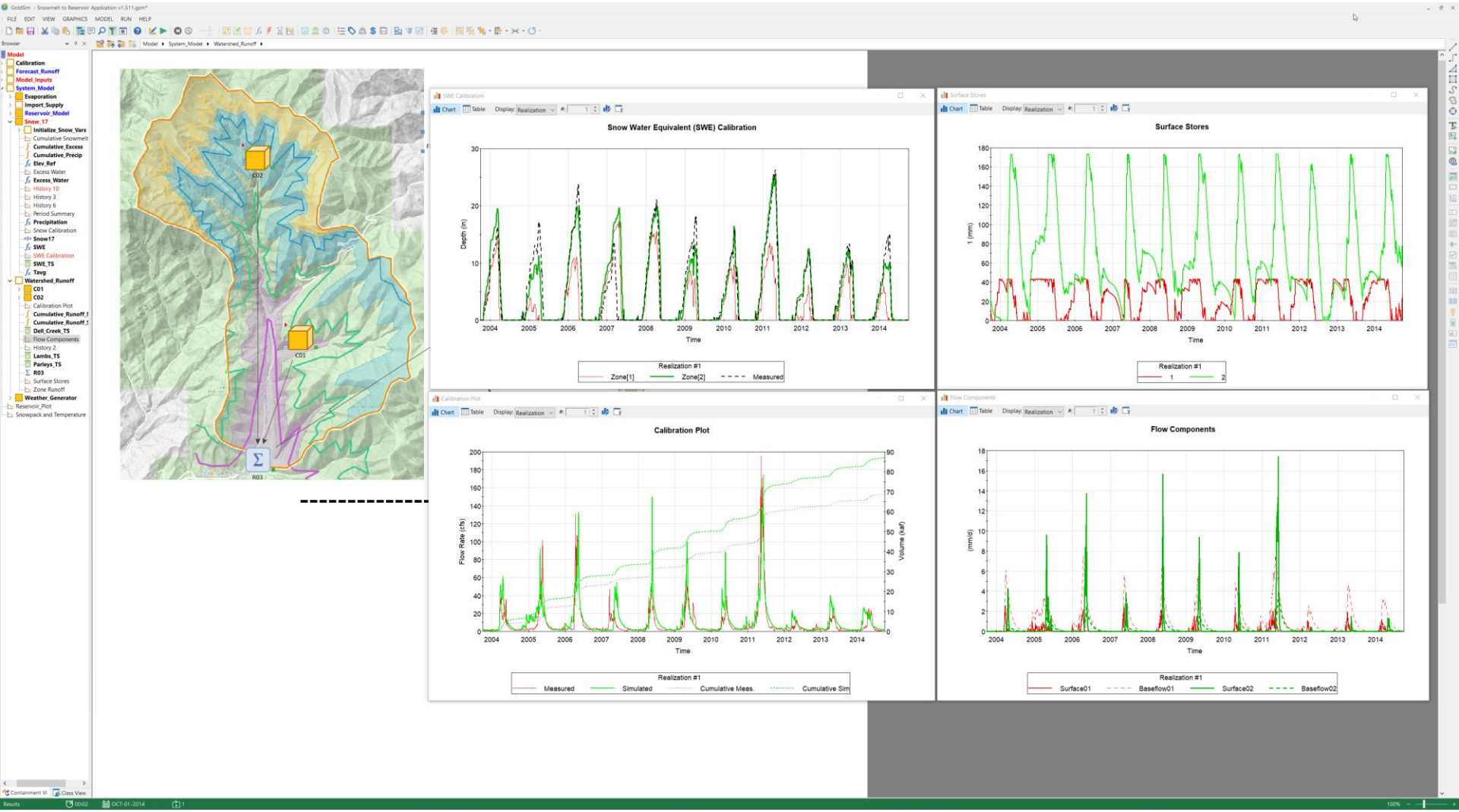
Delineate Watershed

Elevation zones

More is not always better



Manual Results Analysis



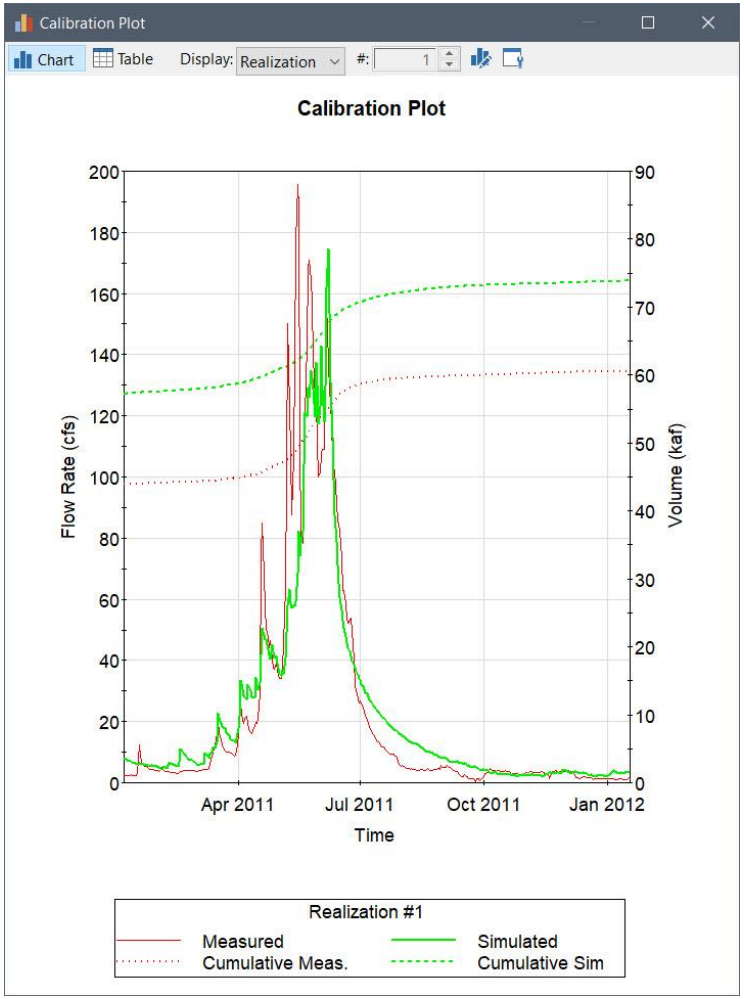
Automate Calibration

Compare simulated results to measured data

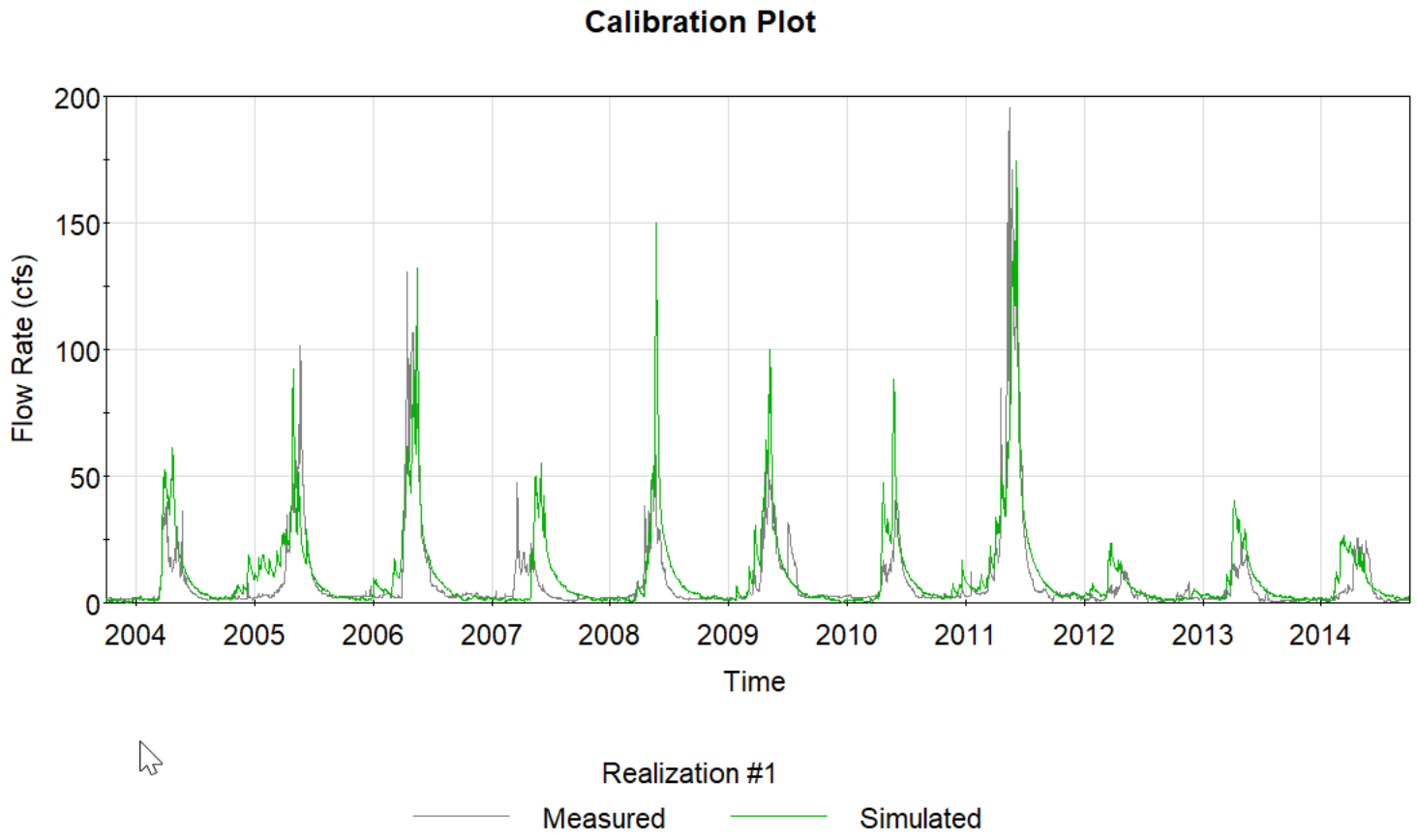
RMSE

- demonstration using Basic Runoff mass balance model

R^2



Final Calibration



Forecast Model (parts added)

Model components:

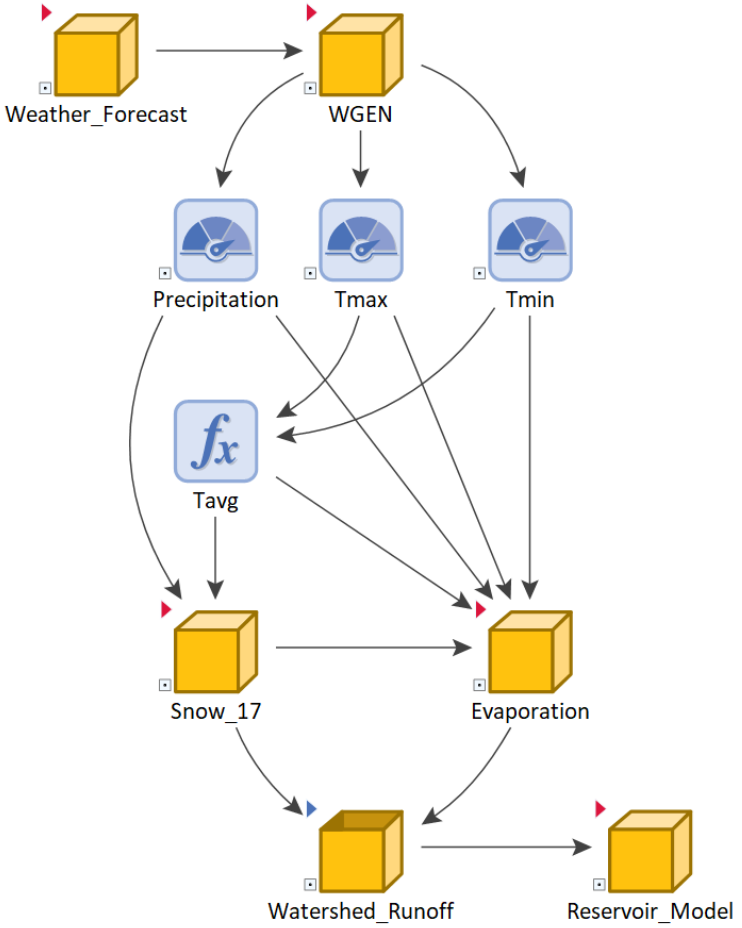
- Weather Forecast
- WGEN

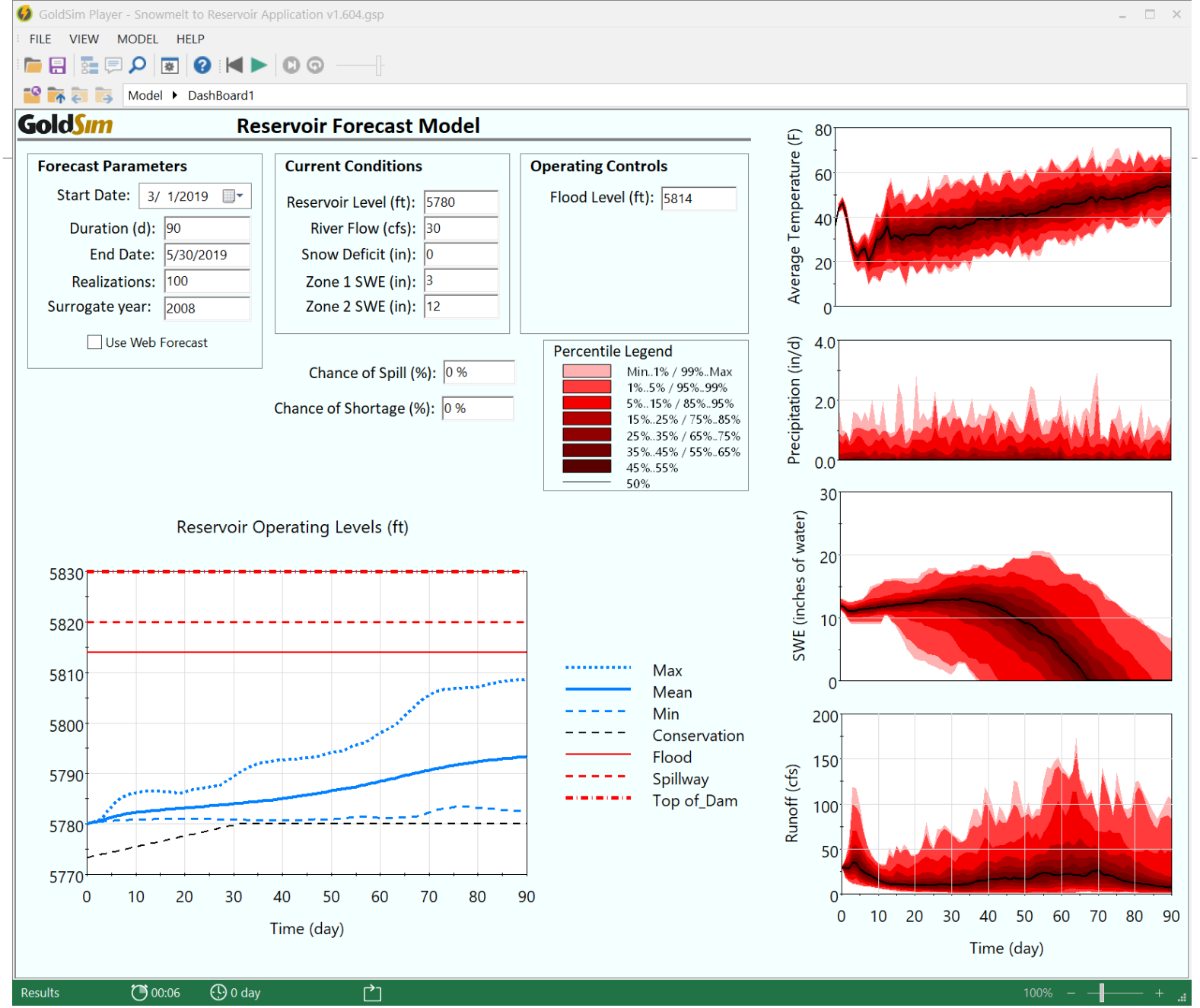
Uncertainty:

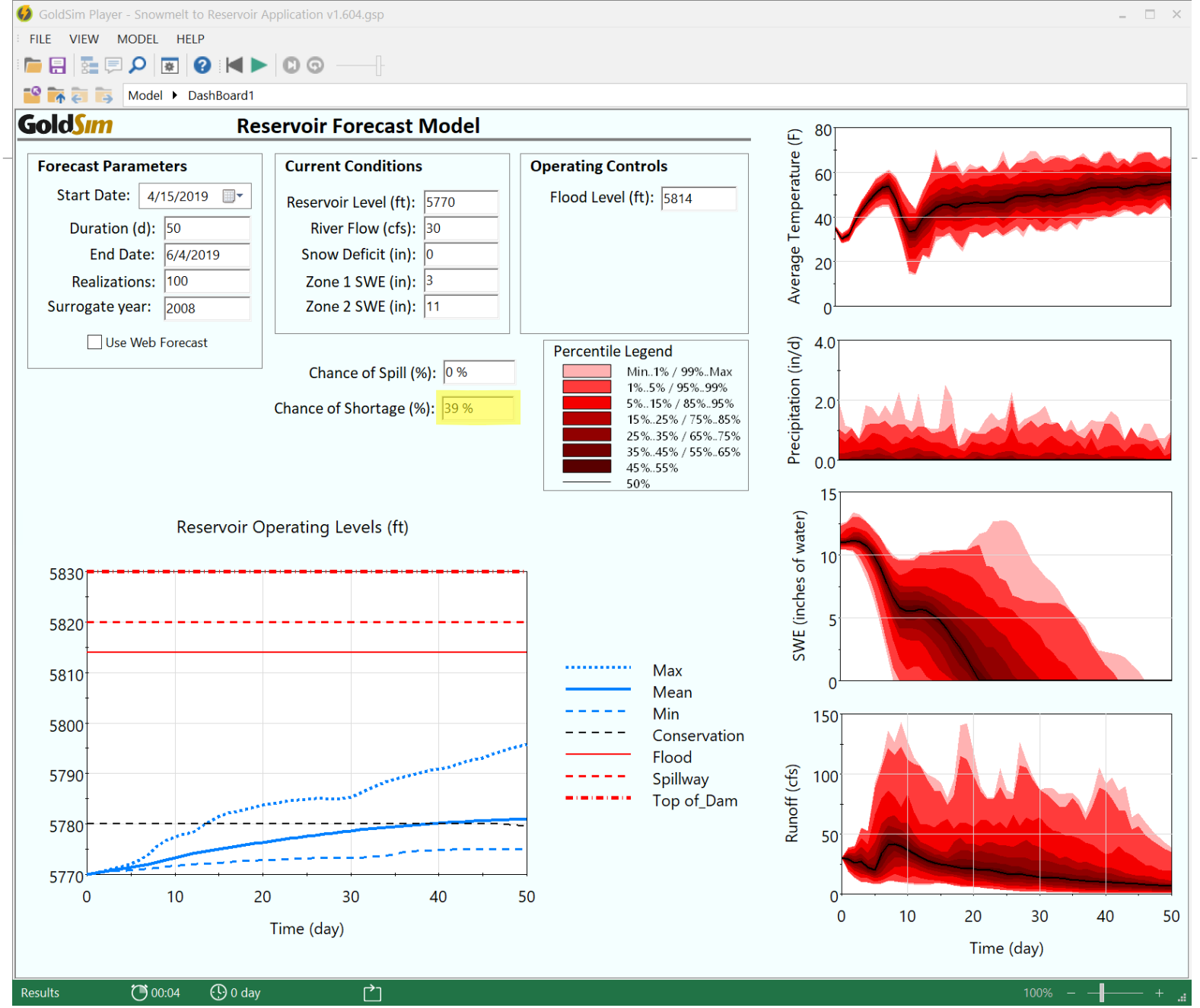
- Static inputs (albedo, recessions, loss factors, etc.)
- Dynamic inputs – “Stochastic” (baseflow, chance of rain, temperature)

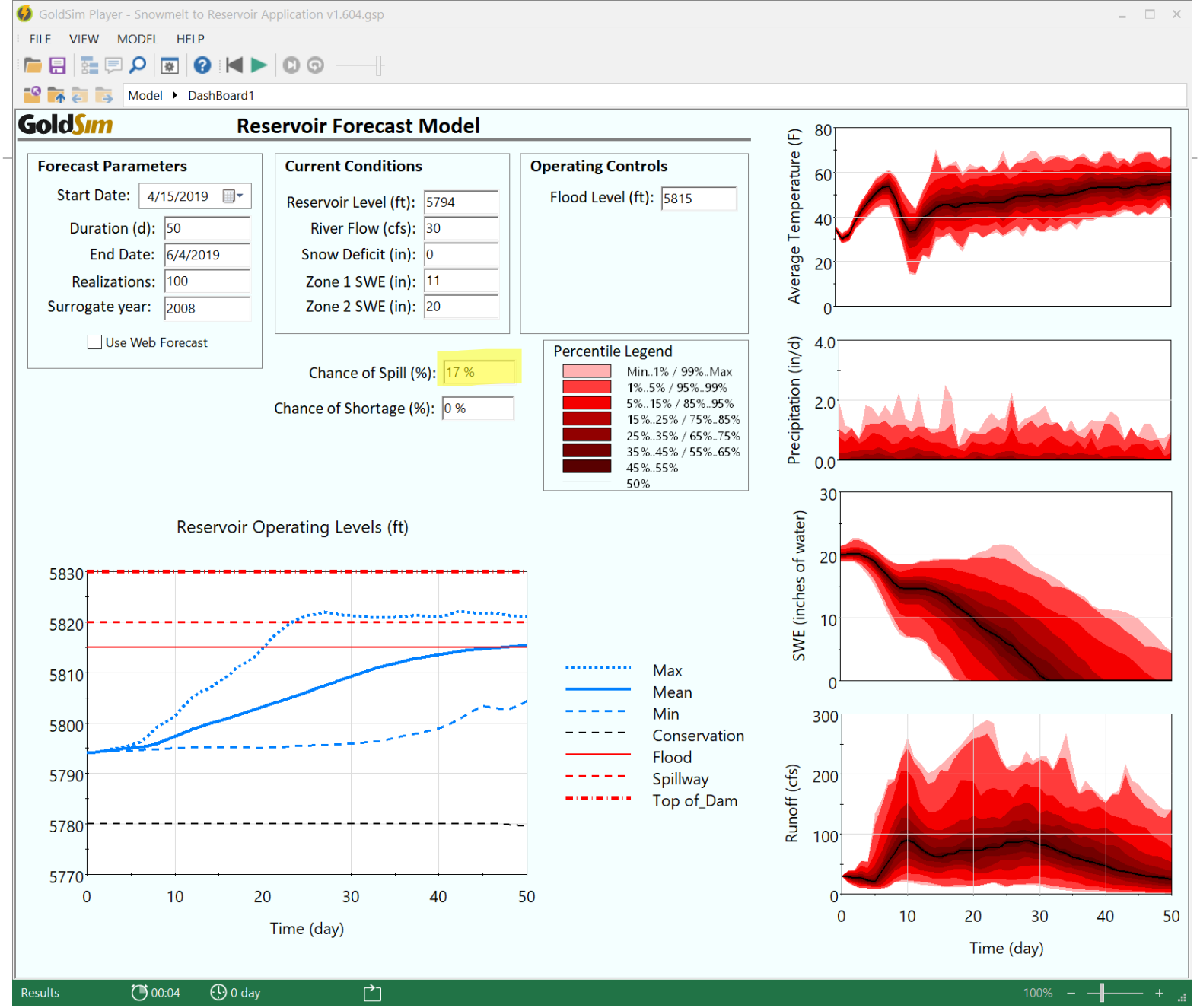
Monte Carlo simulation

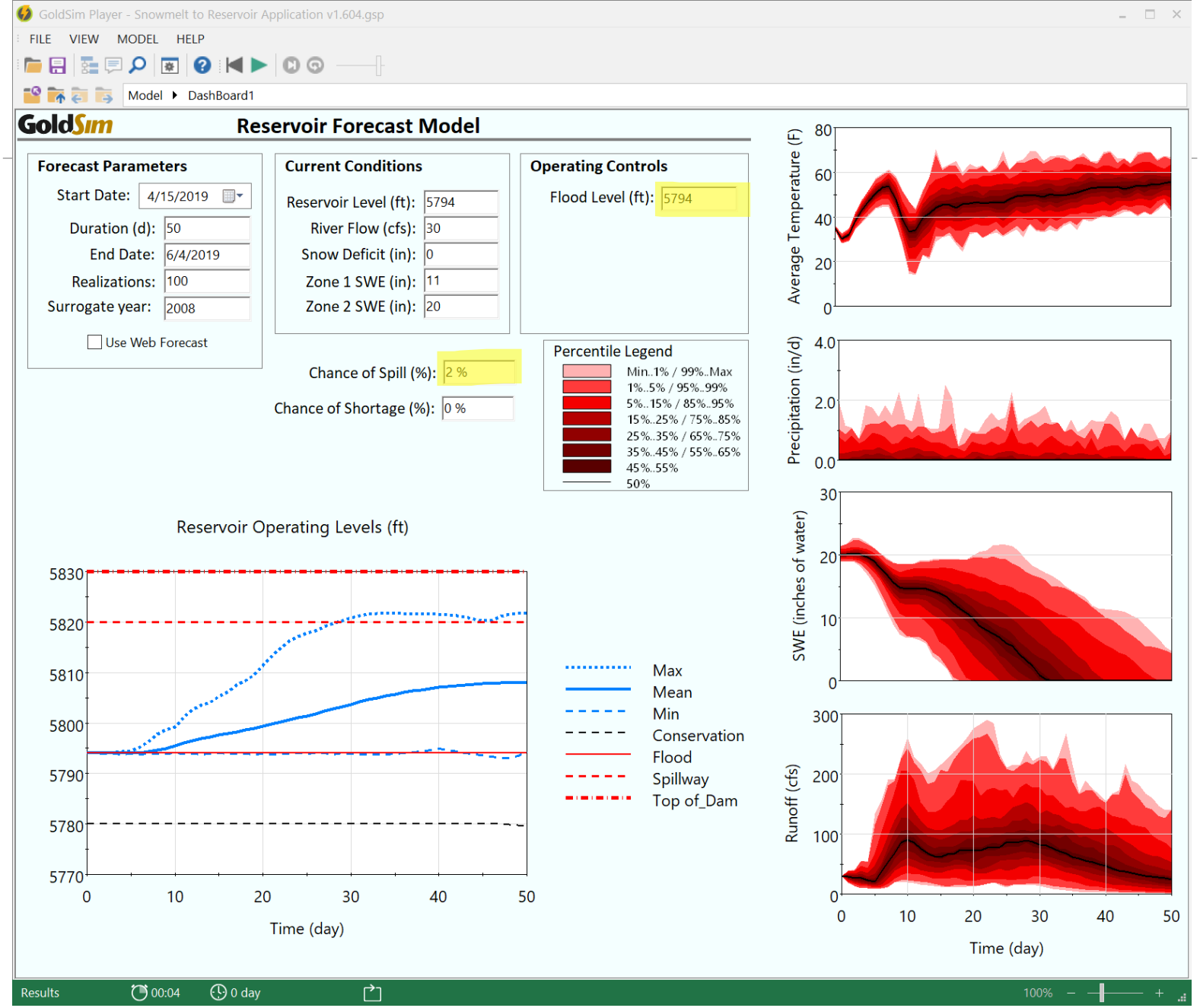
Calculate risk of spillway flow and supply shortage











Conclusion

Calibration

Robust logic

Provides value in guiding operating decisions

Risk allows for more informed decision-making

Questions?