Hydrologic Modeling Scientific Studies for Forecast Informed Reservoir Operation (FIRO)

Charles Downer, Ph.D., PE, PMP Stephen Turnbull, PG, CHG Coastal and Hydraulics Laboratory, U.S. Army ERDC Waterways Experiment Station Stephen.J.Turnbull@usace.army.mil

August 3, 2022









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Research Question

- Can advanced forecasting tools produce improvements to rainfall, runoff, and reservoir forecast over existing methods in use?
 - Hydrologic forecasting tool being researched is the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) physicallybased distributed watershed model with the watershed, stream network, and reservoir integrated in a single simulation model.
 - The GSSHA hydrologic forecasting tool uses CW3E WestWRF forecast/hindcast as forcings (rainfall, windspeed, relative humidity, cloud cover, etc.) such that advances in WestWRF weather forecast immediately improve GSSHA hydrologic forecast.





What We Are Doing

- Developing an integrated physics based model of the Santa Ana River and Prado Dam.
- Researching the effects of different rainfall products including an extensive existing gage network, West-WRF forecast/hindcast, and other rainfall forecast products produced by CW3E/UCSD on hydrologic forecast.
- Investigating hydrologic model calibration strategies for coupling with different forcing products.
- Assessing model outputs: stream flows and lake levels, with an emphasis on the change in Prado Lake water level.
- Producing an prototype forecasting tool for reservoir operations performed by the Los Angeles District of the Army COE.



Desired Product

 Meteorological, hydrologic simulation system developed and tuned to local conditions, that can provide short term hydrologic forecast that represent state-of-art capability in hydrologic forecasting for use in reservoir operations.





Santa Ana Watershed GSSHA Modeling



Model Formulation:

- Multi layer infiltration, ET, and soil moisture accounting
- 2D overland flow
- 1D stream routing network
- Prado Dam Reservoir



Reservoir Simulations

- Reservoirs exist in both the 1D stream network and 2D overland.
- Reservoirs are dynamic (expand/contact in both domains)
- Exchange with overland, stream, groundwater, and atmosphere
- Stage, area, volume from USACE SPL.
- USACE Los Angeles District surveys used to define elevations within the lake.









Coupling to Meteorological Forecast



Santa Ana River Watershed/Prado Dam



USACE & OCWD cooperate to store and capture up to 20,000 acre-feet of storm water at a time





Santa Ana River/Prado Dam GSSHA Model



- 2018-2020 Full Coverage
 2009-2010 Full Coverage
 2004-2005 Full Coverage
 Prado Dam Model Domain
 - Prado Dam Model Domain 2-Mile Buffer
 - Prado Dam Model Domain 10-Mile Buffer • Preliminary Streams

PRADO DAM MODEL DOMAIN AND PRECIPITATION GAGE LOCATIONS All gages that span the periods of interest:

2004 - 2005, 2009 - 2010, and October 2018 - March 2020





Rain Gages Used for Model Calibration





Santa Ana River/Prado Dam GSSHA Model



Santa Ana River/Prado Dam GSSHA Model

Boundary Conditions:

- San Antonio and Seven Oaks Dam prescribed inflow for calibrations/ verification
- Prado Dam prescribed discharge for calibration/ verification, simulated during forecast
- Lake Elsinore zero outflow
- OCWD infiltration basins included for future use







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Santa Ana River/Prado Dam GSSHA Model Soils



All soil types but 24 have bedrock underlying the soil, contributing to runoff for large events that can fill the pore space above

The GSSHA model is being used to help select soil moisture monitoring locations



Santa Ana River/Prado Dam GSSHA Model Percent Impervious





Prado Model Stream Network



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The % impervious area in the Santa Ana watershed changes over time. This effect is easily captured in the GSSHA model by changing the impervious coverage map in the model.



Santa Ana River/Prado Dam GSSHA Model Land Cover



Land cover is primarily developed areas and shrub with smaller areas forested in the headwaters. Land cover affects infiltration, runoff, and ET.





Extent of Lake Behind Prado Dam (Lake expands and contracts)





Santa Ana River/Prado Dam GSSHA Model Calibration/Verification Strategy

- Calibrate to rain gage network with storms in January 2005 and 2010
- Verify to additional storms in January and February 2005 and 2010
- Test/calibrate/verify to CW3E retrospective forcings (PRISM/NLDAS/HRRR/Stage IV+Radar)
- Test/calibrate/verify to WestWRF forcings
 December 2019







Preliminary Model Calibration – January 2005



Experimental Operational Model

- Calibrated and verified GSSHA model that runs continuously with forcings from WestWRF and provides forecasted streamflows and lake levels for Prado Dam.
- Results displayed on web based Tethys app on UMIP







Tethys/UMIP Server for Russian River





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