

Water Storage Investment Program

Climate Change and Sea Level Rise Data and Model Products

Update

To aid applicants with quantification and monetization of benefits of proposed water storage projects, the California Water Commission (Commission) developed a Technical Reference which was released in August 2016 and is found on the Commission website at:

https://cwc.ca.gov/Documents/2016/WSIP/WSIP_Draft_TechRefDoc_Compiled.pdf.

These data and model products are companion information to the Technical Reference and are meant to assist applicants in the analysis of their project benefits for the Water Storage Investment Program (WSIP). The WSIP requires applicants for public funding to analyze their proposed projects using climate and sea level conditions for California projected at years 2030 and 2070.

These products were first published on September 9, 2016. Throughout the development period and following publication, the WSIP technical team has been conducting extensive review of the products. As a result of the review, the products have been refined and updated. The products published in this release, dated November 1, 2016, supersede those previously published. The WSIP technical team recommends that the November 1, 2016, products be used for preparation of WSIP applications.

The data and model products contained in this release provide the most utility to a broad array of applicants. As discussed later in this document, there are other climate data related products available for applicant use. These related products are not necessary to complete the required analysis, but will be provided by the Commission upon request.

To assist applicants with their analysis, data and model products were developed for the following climate and sea level conditions:

- Without-Project 2030 Future Conditions – Year 2030 future condition with projected climate and sea level conditions for a thirty-year period centered at 2030 (climate period 2016-2045),
- Without-Project 2070 Future Conditions – Year 2070 future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (climate period 2056-2085), and
- 1995 Historical Temperature-detrended Conditions (reference) – Year 1995 historical condition with climate and sea level conditions for a thirty-year period centered at 1995 (reference climate period 1981-2010).

Figure 1 shows how each data and model product relates to the others. For each climate and sea level condition, the data and model products provided include:

- Climate inputs of precipitation and temperature, plus Variable Infiltration Capacity (VIC) model simulation results of runoff, snow water equivalent, evapotranspiration, and soil moisture. These data and VIC results are provided at a spatial resolution of 1/16th degree (approximately 6 kilometers [km], or approximately 3.75 miles) over California for calendar years 1915 through 2011,
- CalSim-II model simulations of storage, flows, and diversions for the major tributaries of the Central Valley for water years 1922 through 2003, and
- DSM2 model simulations of Sacramento-San Joaquin River Delta flows and salinity conditions for water years 1922 through 2003.

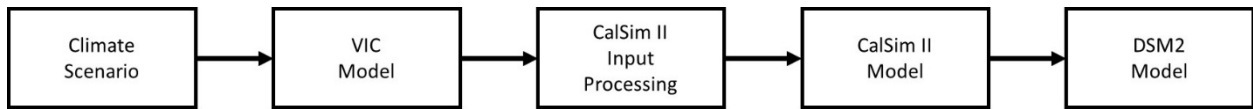


Figure 1. Process to Develop Climate and Sea Level Condition Data and Model Products

The following is a list of product archive files included in the **November 1, 2016** release:

- Without-Project 2030 Future Conditions:
 - Climate and VIC results: WSIP_2030_Statewide_Grid_Monthly_9-3-16.zip
 - CalSim-II model and output: WSIP_2030_CALSIM_10-24-16.zip
 - DSM2 model and output: WSIP_2030_DSM2_10-24-16.zip
- Without-Project 2070 Future Conditions:
 - Climate and VIC results: WSIP_2070_Statewide_Grid_Monthly_9-3-16.zip
 - CalSim-II model and output: WSIP_2070_CALSIM_10-24-16.zip
 - DSM2 model and output: WSIP_2070_DSM2_10-24-16.zip
- 1995 Historical Temperature-detrended Conditions (reference):
 - Climate and VIC results:
 - WSIP_1995_HistTdetrended_Statewide_Grid_Monthly_9-3-16.zip

The effects of climate change are reflected in these data and model products. The combined effects of climate change and sea level rise are reflected in the CalSim-II and DSM2 model products. Additional description of these data and model products is included in the following sections of this document and in Section 2.12 and Appendix A of the WSIP Technical Reference.

Changes in climate conditions, water system operations, and Delta conditions can be assessed by calculating the change in data and model results between any two conditions. Calculating the change in Climate and VIC results between one of the future climate conditions and the 1995 Historical Temperature-detrended Condition (reference) is particularly useful when modifying other models and analyses to assess the effect of climate change. Various techniques for incorporating climate change information into other models and analyses are discussed in Appendix A of the WSIP Technical Reference.

California Water Commission
 P.O. Box 924836
 Sacramento, CA 94236

Additional related products are available upon request. Requests for related products will be responded to through regular mail within 30 days. Requests for additional related products or questions about the use of the data and model products should be directed to:

Joe Yun
 California Water Commission
 P.O. Box 934836
 Sacramento, CA 94236
 (916) 651-0156
 cwc@water.ca.gov

Climate and VIC Statewide Data Product

Each climate condition was simulated with the Variable Infiltration Capacity (VIC) model. A Statewide data product was developed for each condition from the VIC inputs and results. The data product includes climate inputs of precipitation and temperature and VIC simulation results of runoff, snow water equivalent, evapotranspiration, and soil moisture. These data and VIC results are provided at a spatial resolution of 1/16th degree (approximately 6 kilometers [km], or approximately 3.75 miles) over California for each month of calendar years 1915 through 2011. Inputs and assumptions are described in Appendix A of the WSIP Technical Reference.

Product Archive Filename

The Statewide data product archive filename follows the following format:

WSIP_[Climate Condition]_Statewide_Grid_Monthly_[Revision Date].zip.

Statewide Data Product Spatial Extent

The Statewide data product covers the entire state of California and a small portion of California watersheds that extend into Oregon and Nevada. The State is divided into 1/16th degree grid cells for a total number of 11,358 grid cells. The following shapefiles are included in the sub-folder VIC_grid_shapefiles:

- VIC_GridCell_DataPoints.shp – shapefile of point locations representative of each VIC grid cell; contains latitude and longitude information for each grid cell’s representative point
- VIC_Grids_CAORNV_LatLong.shp – shapefile of polygons for each VIC grid cell; contains latitude, longitude, grid cell number, and area in square feet for each grid cell

Data Product Structure

The Statewide data product includes text format files for each grid cell. All the text files for one climate condition are stored in one archive file: WSIP_[Climate Condition]_Grid_Monthly_[Version Date].zip.

Each text file in the archive is named as data_[latitude]_[longitude] with the [latitude] and [longitude] corresponding to the location (center point) of each grid cell. Latitude and longitude are represented in decimal degrees with digits to the 5th decimal place. Example filename: data_32.59375_-116.90625.

Each text file contains 11 columns of data extending from January 1915 through December 2011.

- Column 1: Calendar Year
- Column 2: Calendar Month
- Column 3: Precipitation (mm) – monthly sum
- Column 4: Tmax (degrees C) – monthly average
- Column 5: Tmin (degrees C) – monthly average
- Column 6: Surface Runoff (mm) – monthly sum
- Column 7: Baseflow (mm) – monthly sum
- Column 8: Snow Water Equivalent (mm) – end of monthly value
- Column 9: Potential evapotranspiration (mm) – short grass – monthly sum
- Column 10: Potential evapotranspiration (mm) – tall grass – monthly sum
- Column 11: Soil Moisture (mm) - end of month value, sum of 3 layers

Processing Data

To use the Climate and VIC data product to characterize the climate condition for a watershed area, the data can be aggregated, processed, and summarized in various ways. The first step is to determine grid cell locations that fall within the watershed area of interest. Using the shapefile of the grid cells provided, grid cell locations are queried based on a shapefile boundary associated with the watershed area of interest chosen by the user. Then grid cell data are processed into aggregated values for the area. Individual grid cell data and area aggregated values can be used for a variety of analyses. More discussion of use of this information to modify other models and analyses for future climate conditions is discussed in Appendix A of the WSIP Technical Reference.

Related Products Available by Request

Additional products related to the Climate and VIC November 1, 2016 release are available to applicants upon request:

- Climate and VIC data at a daily time step for each grid cell, and
- Other files and spreadsheet tools used for calibration and simulation of the VIC model.

CalSim-II Model Product

Each climate and sea level condition was simulated with the CalSim-II model. The CalSim-II model is used to simulate storage, flows, and diversions for the major tributaries of the Central Valley for water years 1922 through 2003.

Product Archive Filename

The CalSim-II product archive filename follows the following format:

WSIP_[Climate Condition]_CALSIM_[Revision Date].zip.

CalSim-II Model

The CalSim-II model used for the WSIP product was derived from the model developed and published by the California Department of Water Resources (DWR) as part of the State Water Project Final Delivery Capability Report 2015 (DCR 2015). Inputs and assumptions related to climate change and sea level rise are described in Appendix A of the Technical Reference. All other assumptions are as described in the DCR 2015. Limited, additional modifications were made to the DCR 2015 model to adapt it for the range of climate change and sea level rise scenarios for the WSIP.

The DCR 2015 CalSim-II Model is available to download at the following link:

<https://msb.water.ca.gov/documents/86800/59e74afe-ccd3-4473-beec-a83c1c4c0f49>.

The State Water Project Final Delivery Capability Report 2015 is available to download at the following link: <https://msb.water.ca.gov/documents/86800/144575dd-0be1-4d2d-aeff-8d7a2a7b21e4>.

WRIMS 2 Software

The WRIMS 2 software is required to run the CalSim-II model. Each climate and sea level condition was simulated using WRIMS 2 GUI/IDE version date 12-11-2015. WRIMS 2 requires an external solver; the XA solver version 16 was used.

The WRIMS 2 GUI/IDE is available to download at the following link:

<https://msb.water.ca.gov/documents/86728/4b84d2df-a87a-4dd5-bf0b-4a56fc5c207>.

The XA solver is available to purchase from Sunset Software Technology. Applicants must make sure that the XA version ordered is specific to the WRIMS2/CalSim-II application. Sunset Software Technology's website is:

<http://www.sunsetsoft.com/index.html>.

Instructions on use of the WRIMS 2 software are available from the DWR Modeling Support Branch (MSB) at the following website:

<http://baydeltaoffice.water.ca.gov/modeling/hydrology/WRIMS2/index.cfm>.

Additional Information

Each climate and sea level rise condition includes CalSim-II model WRESL code, inputs, and simulated outputs. The models are provided with full outputs included. The output HEC DSS database is provided in two forms: as double precision format (2020D09EDV_dp.DSS), which is the native output of this version of WRIMS 2; and in single precision format (2020D09EDV_sp.DSS). This allows applicants to use a variety of output processing/viewing tools that are available in the CalSim-II user community.

The U.S. Army Corps of Engineers' Hydrologic Engineering Center Data Storage System (HEC DSS) software is available at the following website:

<http://www.hec.usace.army.mil/software/hec-dss/>.

Related Products Available by Request

Additional products related to the CalSim-II November 1, 2016 release are available to applicants upon request. These products were developed to process data and prepare inputs for the CalSim-II models:

- Spreadsheets used to process climate condition inputs for CalSim-II,
- Spreadsheets used to process and bias-correct VIC outputs of routed streamflows for CalSim-II (used for boundary condition flows for simulation and for indices, forecasts and other regulatory/operation inputs), and
- Spreadsheets used to process and calculate sensitivities for various Climate and VIC output parameters used for CalSim-II.

DSM2 Model Product

The DSM2 model is used to simulate Sacramento-San Joaquin River Delta flows and salinity conditions for water years 1922 through 2003. Each climate and sea level condition was simulated with the DSM2 model.

Product Archive Filename

The DSM2 product archive filename follows the following format:

WSIP_[Climate Condition]_DSM2_[Revision Date].zip.

DSM2 Model

The DSM2 model was derived from version 8.0.6, version date 11-17-2010, published by the California Department of Water Resources (DWR). The DSM2 software is available at the following website:

<http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm>.

Modifications were made to the version 8.0.6 model configuration to adapt the model to the range of climate and sea level conditions for the WSIP. Inputs related to climate change and sea level rise are described in Appendix A of the WSIP Technical Reference. Additional modifications to input processors are also included.

A detailed protocol document is included in the product archive file with step-by-step instructions on running the DSM2 model specifically for the WSIP.

Additional Information

DSM2 model inputs and simulated outputs are provided for each climate and sea level condition. Partial outputs are included with the DSM2 models provided, but the model can be rerun to generate the full outputs. Post-processed daily and monthly average outputs are provided in the following HEC DSS databases:

- Flow outputs: WSIP_[Climate Condition]_out_flow-A_PostPro.DSS
WSIP_[Climate Condition]_out_flow-B_PostPro.DSS
- Stage outputs: WSIP_[Climate Condition]_out_stage_PostPro.DSS
- Electrical conductivity outputs: WSIP_[Climate Condition]_out_EC_PostPro.DSS

Operations outputs are also provided at the 15-min time period: WSIP_[Climate Condition]_out.DSS

The U.S. Army Corps of Engineers' Hydrologic Engineering Center Data Storage System (HEC DSS) software is available at the following website:

<http://www.hec.usace.army.mil/software/hec-dss/>.

Related Products Available by Request

Additional products related to the DSM2 November 1, 2016 release are available to applicants upon request. Additional DSM2 output HEC DSS databases are available, including outputs for 15-minute, 15-minute tidally-filtered (godin), daily minimum, daily maximum, daily average, and monthly average time scales are available for flow, stage, velocity, electrical conductivity and fingerprinting outputs. Outputs are available to show results at compliance stations and to calculate X2 position. Results at 200 point grid stations allow for visual mapping of results.