Memo: Future climate scenarios used in the 2019 Re-initiation of Consultation on long-term operations of the Central Valley Project (CVP) and State Water Project (SWP) (ROC on LTO).

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Table 1: Comparison of different aspects of the future climate scenarios used in the 2019 ROC on LTO and California's 4th Climate Assessment.

	2019 ROC on LTO (from Cal Water Fix App. 5.A, also see DWR 2010)	**CA 4th Climate Assessment: He et al (2018)**	**CA 4th Climate Assessment: Pierce et al (2018)**
International Climate Model Experiment	CMIP3: produced more than 10 years ago, no longer represents the latest climate science	CMIP5 (supercedes the CMIP3 archive of climate model scenarios used in the previous California Climate Assessment)	CMIP5
Number of climate models	16 climate models	10 climate models, screened for fidelity to global, regional, and California climate	10 climate models, screened for fidelity to global, regional, and California climate
Emissions Scenarios	A2, A1B, B1	RCPs 4.5 and 8.5	RCP 4.5 and 8.5
Historical Reference Period	1971-2000	1951-1990	1976-2005
Future Scenario Periods	"2025" (2011-2040) early long term "2060" (2046-2075) late long-term	2020-2059 2060-2099	2006-2039 2035-2065 2070-2099
Scenario's Selected	**Q5:** the 25th to 75th quartile	20 scenarios (10 climate models, 2 emissions scenarios)	4 climate model scenarios were selected to span the range of the 10 screened model scenarios
Downscaling Approach	Bias-Correction with Spatial Disaggregation (BCSD) to 1/8° (~12km); this method is prone to introducing errors in century-long trends on the order of 1 to 2 °C and precipitation by 20% over a century	Localized Constructed Analogs (LOCA) to 1/16° (~6km); this method is trained on historical data, and is not prone to introducing errors in the way BCSD downscaling is	Same as He et al. (2018)
Temperature change	Q5: 2025: +0.7 to +1.4 °C	2020-2059: 1.9 °C 2060-2099: 2.3 °C	
Precipitation change	Q5: -6% to + 6%	From Table 2, Fig. 5: Sac. R. 2020-2059: +7.6% (-6 to +24%) 2060-2099: +9.0% (-10 to +38%)	
SLR	2025: 15cm (12-18cm) 2045: 45cm (30-60cm)		2030: 1-15cm 2050: 10-38cm 2100: 72-240cm
Notes		Focused on the 10 hydrologic regions defined by the California Department	Downscaled meteorological fields were applied to VIC

		of Water Resources for water resources planning and management purposes. Three are in the Central Valley: Sacramento River, San Joaquin River, and Tulare Lake). Projections developed here have been applied in DWR's and the California Water Commissions' planning activities, including the Central Valley Flood Protection Plan and the Water Storage Investigation Program.	land surface model to develop snow cover, soil moisture, runoff, and water loss from plants. Naturalized streamflows were simulated for major river basins.
Notes			20 year "dry spell" scenario from 1 model - HADGEM2-ES, RCP8.5, 2051-2070 - translated back to 2023-2042 by detrending temperature back to the earlier period
Data availability		Data available from cal-adapt.org	Data available from cal-adapt.org

BA Appendix D: Modeling

Uses *projected Year 2030* climate conditions

- 15cm sea level rise, early long-term (ELT) Q5 projected changes in temperature and precipitation; Q5 scenario that represents the central tendency of the climate projections (p42, Appendix D);

Notable passages from the California Climate Assessment Reports:

He et al. 2018:

Page 1: *In light of its importance, a large number of studies have focused on characterizing potential future hydroclimatic events in California [19-29]. These studies mostly used climate model projections from the Coupled Model Intercomparison Project Phase 3 (CMIP3) [30], which were produced more than a decade ago and no longer represent the latest climate science.*

Page 2: *The objective of this study, from an operational perspective, is to provide an assessment of the changes (from historical baseline) and trends of projected precipitation and temperature, along with the trends in projected drought over California. This study extends beyond relevant previous studies in terms of (1) focusing on the spatial scale consistent with the water resources planning and management practices in the State, (2) using climate projections that reflect the latest climate science, and (3) applying the widely-used non-parametric Mann-Kendall approach in trend analysis. Compared to the traditional linear regression method, this method requires less assumption on data distribution and is less affected by the beginning and ending values of the study data. This study offers insight into potential changes to California's hydroclimate on the scale meaningful for water resources management practices and informs decision-makers in developing strategies to cope with these changes.*

Page 5: *Specifically, 20 individual projections from 10 general circulation models (GCMs) under two future climate scenarios named Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 [32] are selected for the* *analyses. These 10 GCMs were chosen by DWR Climate Change Technical Advisory Group and deemed as the most suitable for California climate and water resources assessment [33]. RCP 4.5 (RCP 8.5) assumes low (high) future greenhouse-gas concentrations.*

These projections are downscaled to a very high spatial resolution at 1/16 degree (approximately 6 kilometers by 6 kilometers, or 3.75 miles by 3.75 miles) to better capture the spatial variability of the climate via the newly developed Localized Constructed Analogs (LOCA) statistical downscaling approach [34]. Compared to previous downscaling methods, LOCA aims to better preserve daily extremes and variability by choosing the single best matching historical analog day in downscaling [34]. However, like all other statistical downscaling methods, LOCA is developed based on the assumption that historically observed relationships between regional and local observations remain unchanged in the future. This assumption may not hold completely true in a changing climate. As such, these LOCA-based precipitation and temperature projections are not free of uncertainty. Nevertheless, this dataset is deemed better than its counterparts developed in previous California Climate Change Assessment studies and is adopted in the latest (current) assessment (http://cal-adapt.org/).

Pierce et al. 2018:

Page 1: *The basic meteorological and land surface data were downscaled for all 32 global climate models. However, we identified a subset of 10 models, and a further refinement to 4 models, that did particularly well in reproducing California's historical climate. The reduced sets can be used by those without the resources to use data from all 32 models. Additional key variables were downscaled from this reduced set of models, including wind speed, humidity, and surface solar radiation. These variables are important to applications that include wind power generation, wildfire, human health, and photovoltaic electricity production. Additionally, future projections of hourly sea level at several California coastal sites were constructed from several of the GCMs.*

Page 2: *The CMIP5 archive, which was the most recent generation of GCMs in place when the Fourth Assessment was launched, supersedes the CMIP3 archive of GCMs used in the previous California Assessment.*

Page 3: *The first option was developed by California Department of Water Resources Climate Change Technical Advisory Group, who evaluated the full set of CMIP5 models to determine which GCMs performed best in simulating historical climate means and variability related to water resources and hydrologic extremes in the California region. As described in their report (California Department of Water Resources Climate Change Technical Advisory Group 2015), 10 GCMs were identified, using a tiered set of selection criteria applied sequentially to winnow down the original CMIP5 GCMs to a set of 10. The criteria included a first screen of GCMs regarding their simulation of global climatology as developed by Gleckler et al. (2008) and provided by IPCC (2013); a second screen that evaluated regional climate and variability patterns affecting the southwestern U.S. following Rupp et al. (2013); and a third screen that evaluated California state hydrology and climate extremes and eliminated a few models whose core dynamical and numerical framework was already represented by other included models (Knutti et al. 2013).*
This screening reduced the larger ensemble of 32 GCMs to a more manageable set of 10, which are listed in Table 1. The advice given to Fourth Assessment study teams was to use the 10 CCTAG GCMs shown in Table 1 if the full set of 32 GCMs was too much data to be managed or analyzed. These models are referred to below as the "10 California GCMs."

Pages 3-4: *For some study teams and users of Fourth Assessment data, even the previously identified set of 10 GCMs may be too much data. Accordingly, in this work we identified 4 of the 10 GCMs from Table 1 whose projected future climate can be described as producing: 1) a "warm/dry" simulation; 2) an "average" simulation;*

3) a "cooler/wetter" simulation; 4) the model simulation that is most unlike the first 3 (for the best coverage of different possibilities).

Page 7: *The widely used quantile mapping approach (which is employed in the Bias Correction with Constructed Analogs, BCCA, and Bias Correction with Spatial Disaggregation, BCSD methods) can alter the projected winter temperature trend by up to 2 °C over a century, and the summer trend by up to 1 °C. Precipitation trends can be altered by up to 20 percentage points over a century in winter, and a similar amount in summer. These are large modifications compared to the original GCM-predicted trends. The trend modification imposed by quantile mapping has no physical basis, instead being a numerical artifact (Maurer and Pierce, 2013). These errors arise because quantile mapping was developed for seasonal prediction applications rather than situations where the climate is non-stationary, such as climate change over many decades.*

References

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