Addressing Uncertainties in Climate Change Assessments

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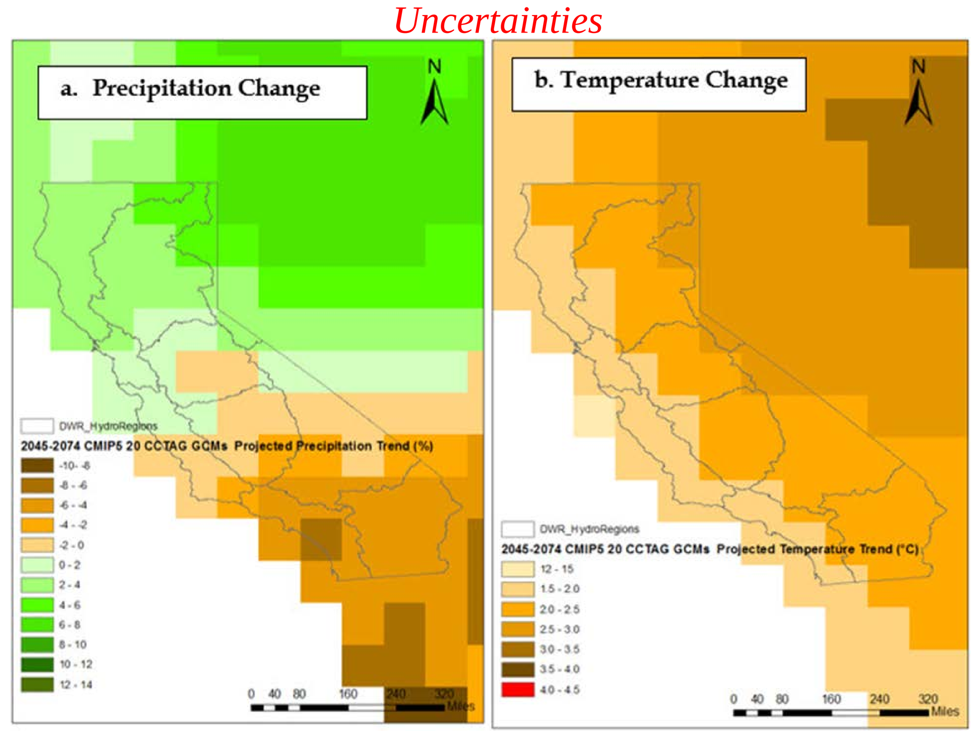
ABSTRACT

This study uses the California Department of Water Resources' (DWR's) newly developed water planning model, CalSim 3.0, as a risk assessment tool. Impacts were assessed for 20 climate change scenarios (10 global climate models and two emission scenarios, representative concentration pathway (RCP) 4.5 and RCP 8.5)., To address uncertainties with the impact assessment based on 20 climate change scenarios, a series of sensitivity tests were implemented to assess individual impacts of four climate change factors: flow seasonal pattern shift, sea level rise, annual flow volume change, and water demand change on the State Water Project and Central Valley Project operations. It was found that flow seasonal pattern shift is a major climate change factor in half million acre feet of Delta export reduction and a dominating factor in about 25% decrease of North-of-Delta carryover storage in the middle of this century around 2060. It also shows that extra runoff from early snow melting and higher percentage of rain in the precipitation in the winter and early spring, is not able to be conserved in reservoirs to meet higher demand in the summer in the current SWP/CVP system. The extra water is released as flood water in the winter and early spring to become Delta outflow. .

Ensemble Mean Approach IS One Way to Reduce Uncertainties



Projected Precipitation and Surface Air Temperature Change, 2045–2074, by 20 CCTAG Climate Model Projections, based on 1°×1° re-gridded GCM Projections

GCMs Predicts More Consistent Temperature Change and SLR than Precipitation and Flow Change

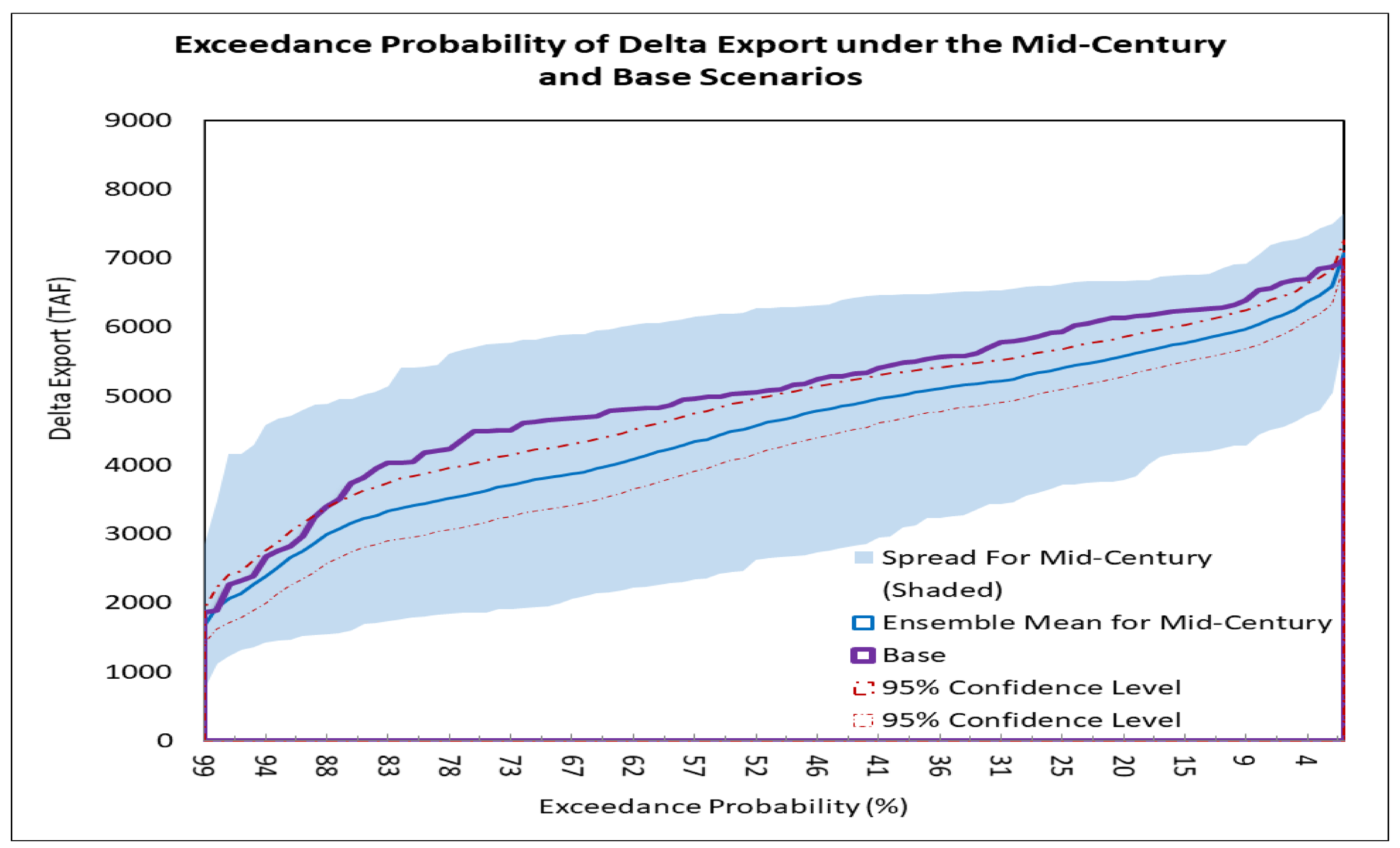
Table 2: Projected Mid-Century (2045–2074) Surface Air Temperature Change and Sea Level Rise at San Francisco Bay

CCTAG CMIP5 GCM Projection	Temperature Change (°C)	Sea Level Rise (feet)
CESM1-BGC_rcp45	1.1	0.5
CNRM-CM5_r1p1i1_rcp45	1.1	0.5
CCSM4_r1p1i4_rcp45	1.2	0.5
MIROC5_rcp45	1.4	0.5
HadGEM2-CC_rcp45	1.6	1
CMCC-CMS_rcp45	1.6	1
ACCESS1_0_rcp45	1.7	1
CCSM4_r1p1i5_rcp85	1.8	1
CESM1-BGC_rcp85	1.8	1
MIROC5_rcp85	1.9	1
CNRM-CM5_r1p1i1_rcp85	1.9	1
GFDL-CM3_rcp45	2.0	1
CANESM2_r1p1i1_rcp45	2.1	1
HadGEM2-ES_r1p1i1_rcp45	2.2	1
CMCC-CMS_rcp85	2.2	1
ACCESS1_0_rcp85	2.3	1.5
GFDL-CM3_rcp85	2.6	1.5
HadGEM2-CC_rcp85	2.7	1.5
CANESM2_r1p1i1_rcp85	3.0	1.5
HadGEM2-ES_r1p1i1_rcp85	3.0	1.5
RCP 4.5	**1.6**	**0.8**
RCP 8.5	**2.3**	**1.25**
Mean	**2.0**	**1**

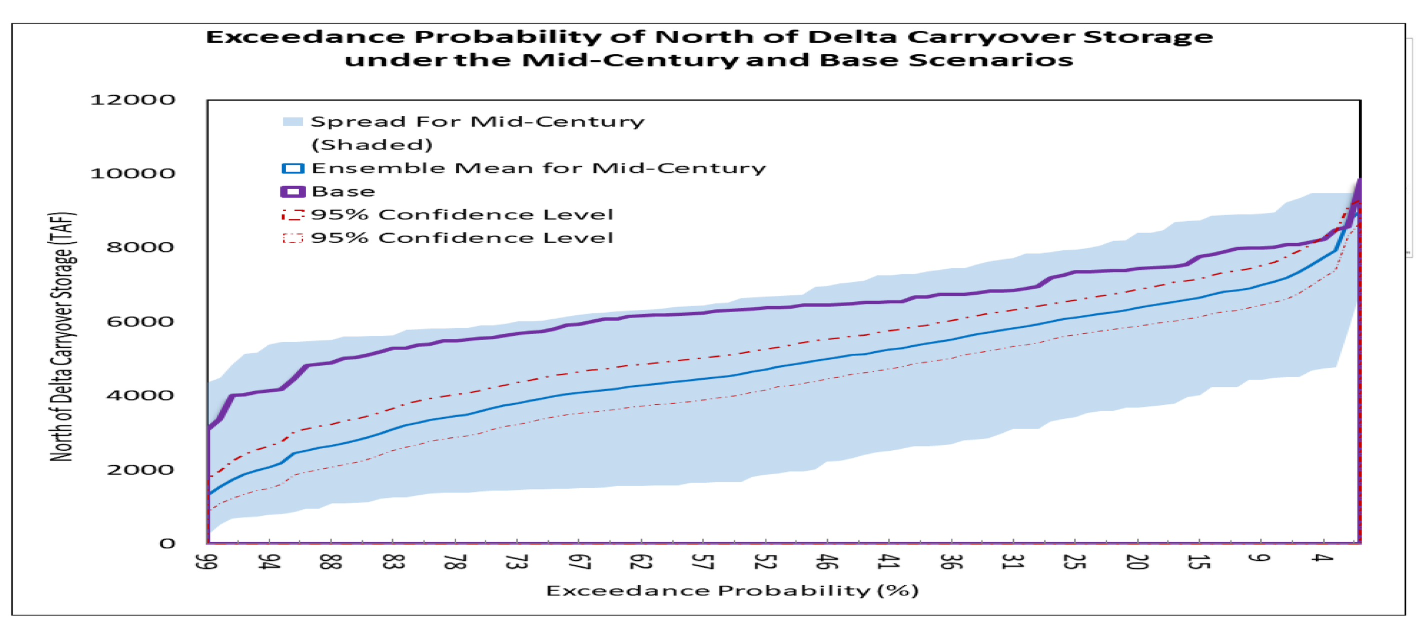
Uncertainties in the Change of Delta Export, Carryover Storage and Reliability in Mid-Century Caused by Climate Change

CCTAG CMIP5 GCM Projection	Percent Change in Performance Metric: Climate Change Scenario minus Base Scenario			
	Delta Export Change	Carryover Storage Change	Rim Inflow Change	Reliability Change
CANESM2_r1i1p1_RCP85	21%	7%	52%	7%
CANESM2_r1i1p1_RCP45	12%	7%	31%	8%
CMCC-CMS_rcp45	-23%	-33%	-15%	-29%
CMCC-CMS_rcp85	-18%	-31%	-6%	-22%
CCSM4_r1i1p1_rcp45	-8%	-23%	4%	-9%
CCSM4_r1i1p1_rcp85	-4%	-20%	13%	-3%
CNRM-CM5_r1i1p1_rcp45	10%	-2%	36%	4%
CNRM-CM5_r1i1p1_rcp85	13%	-2%	45%	6%
MIROC5_rcp45	-20%	-34%	-9%	-22%
MIROC5_rcp85	-27%	-41%	-12%	-32%
GFDL-CM3_rcp45	-12%	-25%	-4%	-8%
GFDL-CM3_rcp85	-7%	-21%	3%	-3%
HadGEM2-CC_rcp45	-9%	-25%	7%	-16%
HadGEM2-CC_rcp85	-10%	-29%	2%	-13%
ACCESS1_0_rcp85	-44%	-62%	-29%	-74%
ACCESS1_0_rcp45	-9%	-25%	-2%	-3%
CESM1-BGC_rcp45	-4%	-17%	-3%	-6%
CESM1-BGC_rcp85	-15%	-32%	-5%	-23%
HadGEM2-ES_r1i1p1_rcp45	-16%	-30%	-5%	-26%
HadGEM2-ES_r1i1p1_rcp85	-37%	-55%	-19%	-68%

Uncertainties in the Assessment of Climate Change Impact on Delta Export



Uncertainties in the Assessment of Climate Change Impact on Carryover Storage



How to Reduce These Uncertainties in the Assessment

Approach 1: ensemble mean approach-----select as many as GCM models and projections as possible. Ensemble mean is less uncertain than an induvial projection based on the statist $\sigma_M = \frac{\sigma}{\sqrt{N}}$

Approach 2: separation approach,----- separate four climate change effects on the SWP and CVP, and then eliminate relatively highly uncertain effects from the assessment. At the same time, still keep relatively less uncertain effects

Approach 3: Both

Four Climate Change Factors and the Separation of Their Effects

(1). Flow seasonal pattern shifts caused by future warming (less uncertain)

(2). Sea Level Rise due to global warming (less uncertain)

(3). Agricultural water (applied water) demand change due to future warming (highly uncertain)

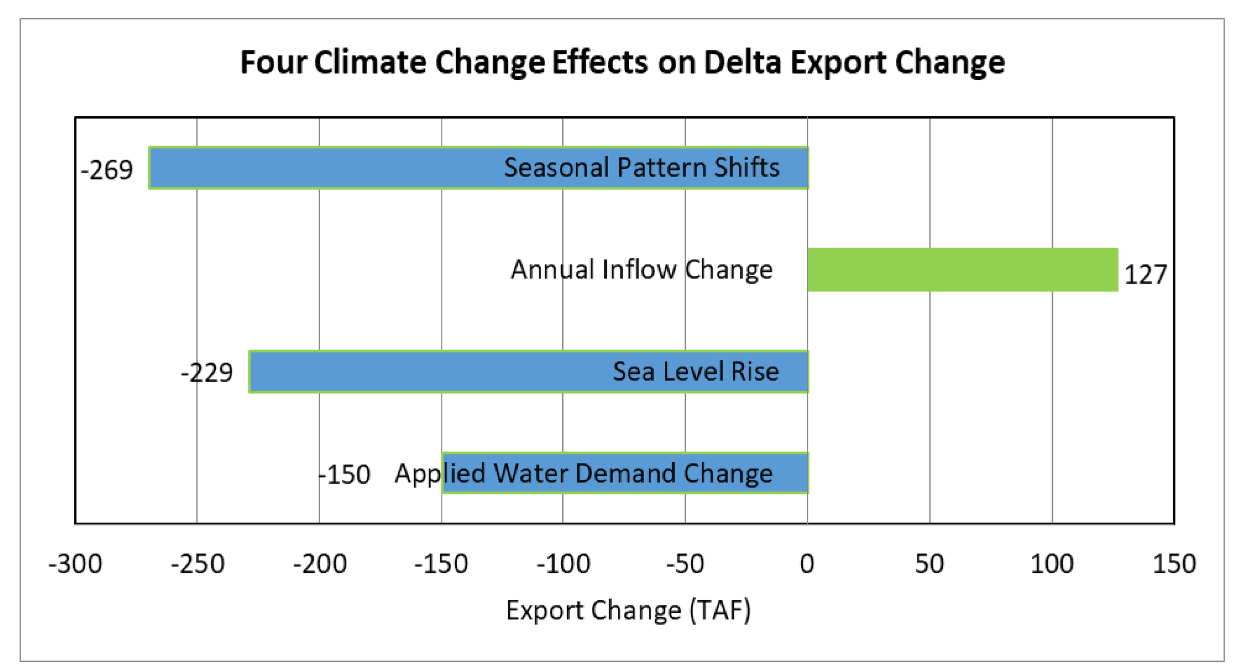
(4). Annual flow Change due to future precipitation changes (most uncertain)

A series of sensitivity experiments are made to separate the contribution of four climate change factors to the climate change impact

Table 4: "Cascading" Sensitivity Experiments for the Separation of Effects of Four Climate Change Factors

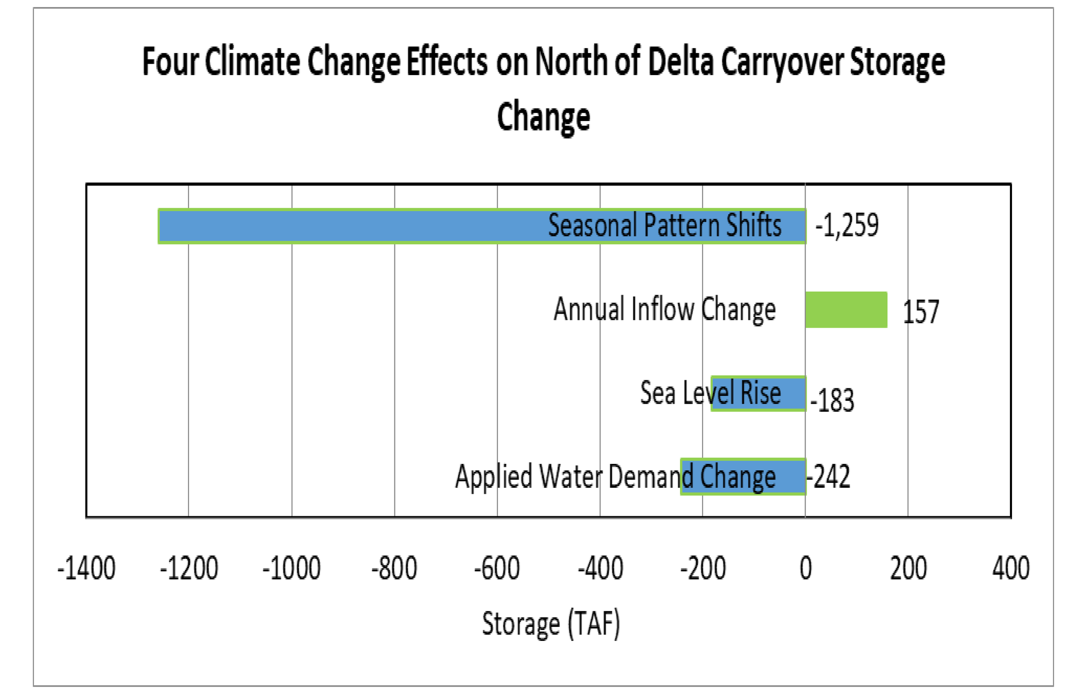
Sensitivity Experiment	Four Climate Change Factors			
	Applied Water Demand	Sea Level Rise	Annual Rim Inflow Change	Flow Seasonal Pattern Change
Experiment 1	Yes	Yes	Yes	Yes
Experiment 2	No	Yes	Yes	Yes
Experiment 3	No	No	Yes	Yes
Experiment 4	No	No	No	Yes
Base Run	No	No	No	No

Individual Effects on Delta Export Change from Four Climate Change Factors



*For the bottom-line estimate (i.e., excluding the effects of annual inflow change and applied water demand change), Delta exports in the middle of this century would reduce by approximately **500 taf, a 10 percent reduction** from the current climate, and under the current SWP and CVP systems.*

Individual Effects on Carryover Storage Change from Four Climate Change Factors



*The bottom-line carryover storage decrease for the SWP and CVP systems caused by climate change in the middle of this century is **1,442 taf, a reduction of approximately 23 percent** from the current climate change (base scenario).*

Summary and Conclusion

- *Ensemble mean approach is still a effective way to reduce uncertainties in the climate change assessment*
- *Isolation of individual effects from climate change factors, "Separation Approach", could effectively reduce uncertainties in the climate change assessment due to the elimination of individual contribution from highly uncertain factors.*
- *The conjunctive use of these two approaches could significantly reduce uncertainties in the climate change assessment*

Limitations and Future work

- *More strict "separation approach" is needed to separate individual contribution from climate change factors*
- *More "good" climate models and their projections, including ensemble runs, are needed to reduce uncertainties in the climate change assessment statistically*

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References

- *Wang J., H. Yin, and F. Chung, 2011: Isolated and integrated effects of sea level rise, seasonal runoff shifts, and annual runoff volume on California's largest water supply. Journal of Hydrology, 405 (2011) 83–92*
- *Wang J., H. Yin, E. Reyes and F. Chung, 2018: Mean and Extreme Climate Change Impact on State Water Project. California Water Commission Meeting. December 19, 2018, Sacramento, California*