Future Scenarios Project Update: Vulnerability Study of the Central Valley under Likely 2020 Conditions

Acknowledgements

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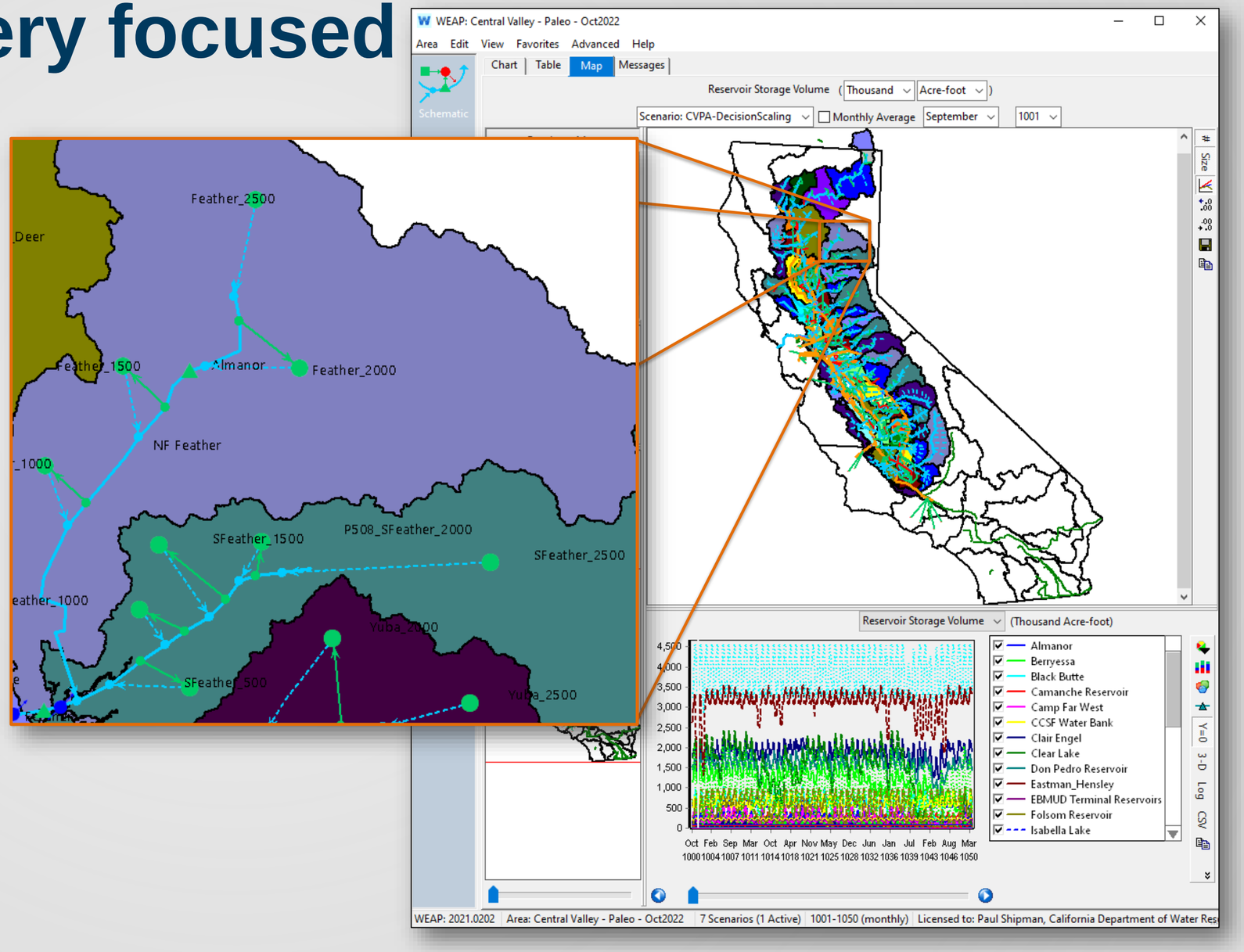
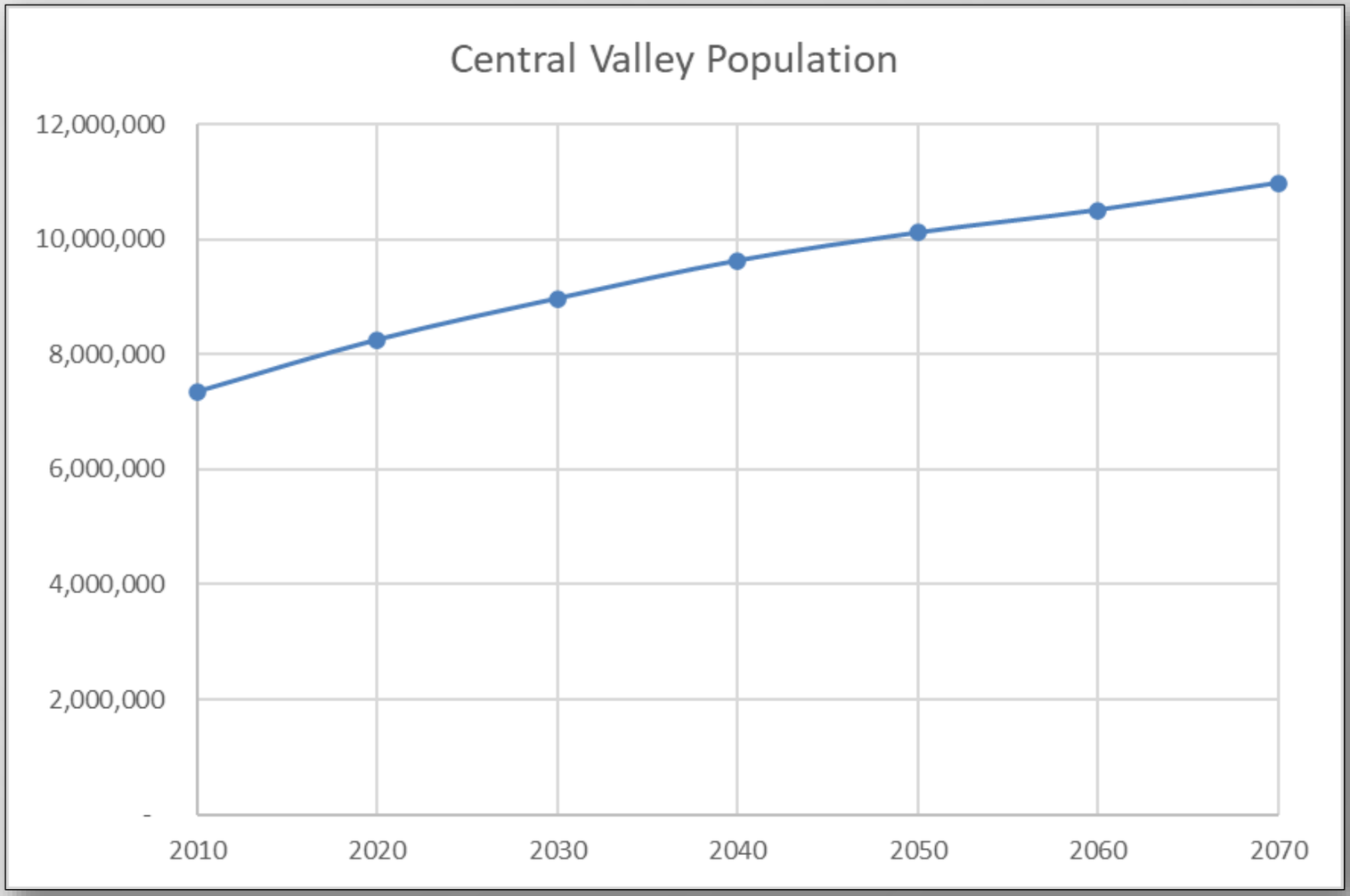
Many existing climate change studies are either very general, or very focused

The WEAP modeling system provides a physically based integrated model to assess climate change impacts on California's water at regional and statewide scales.



Population growth will affect demands on water supply in ways not yet considered

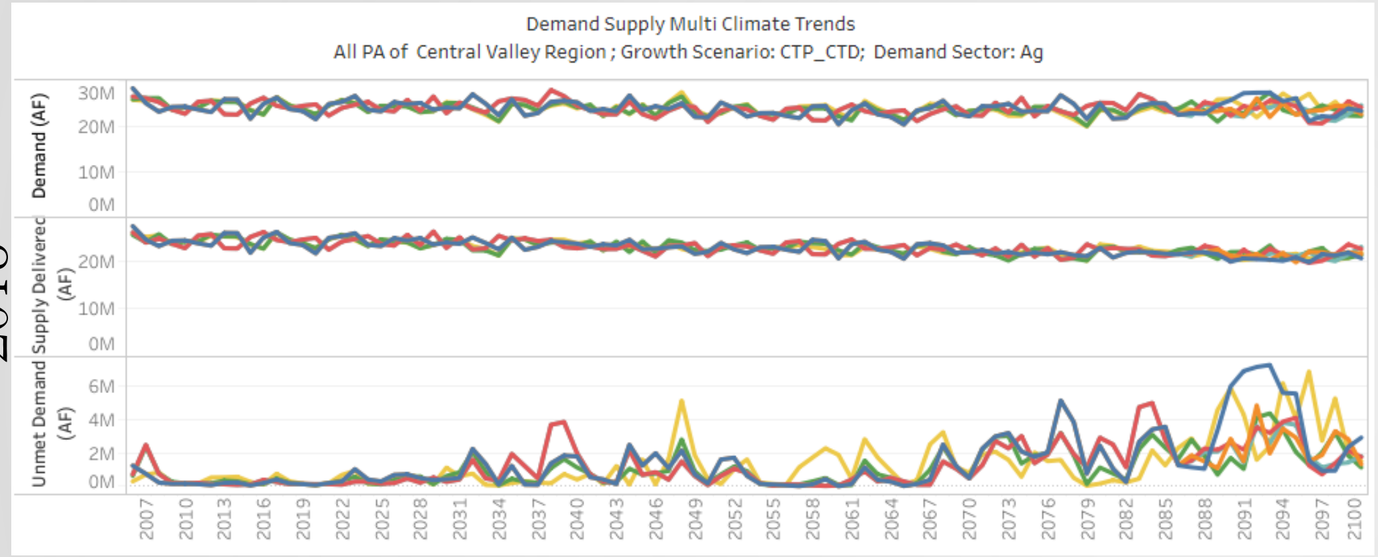
The future scenarios project uses population growth numbers as forecasted by the California Department of Finance and informed by local government development plans.



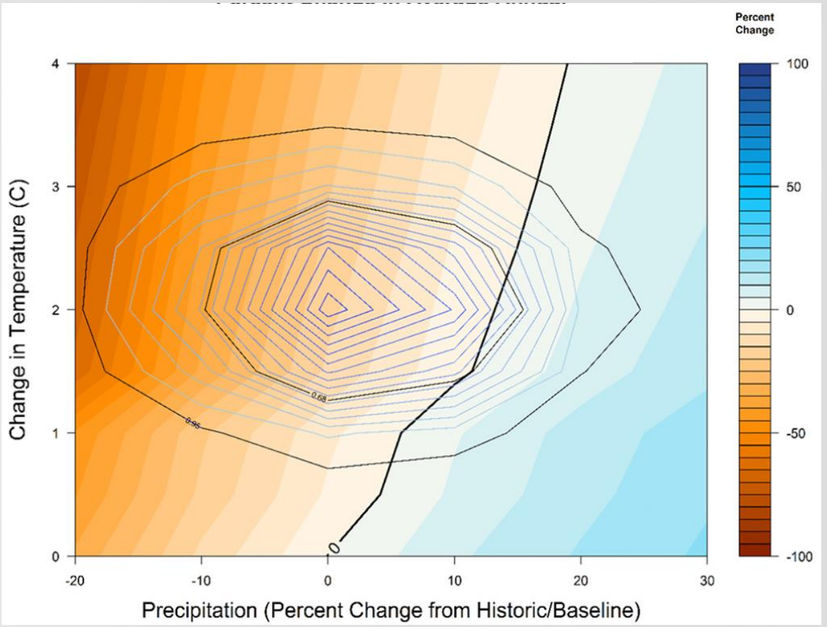
ENHANCEMENTS TO FUTURE SCENARIOS FROM WATER PLAN 2018 TO WATER PLAN 2023

Analysis Technique

2018



2023



Downscaled GCMs provided high level trend analysis from 2006-2100

Decision scaling provides regional risk-based insights at current (2020) and future (2070) level of development

Delta Representation

Update 2023 includes:

- Delta Biological Opinions
- Coordinated Operations Agreement
- Sea level rise ANN used by Cal-SIM (1.8 feet) for 2070 level of development

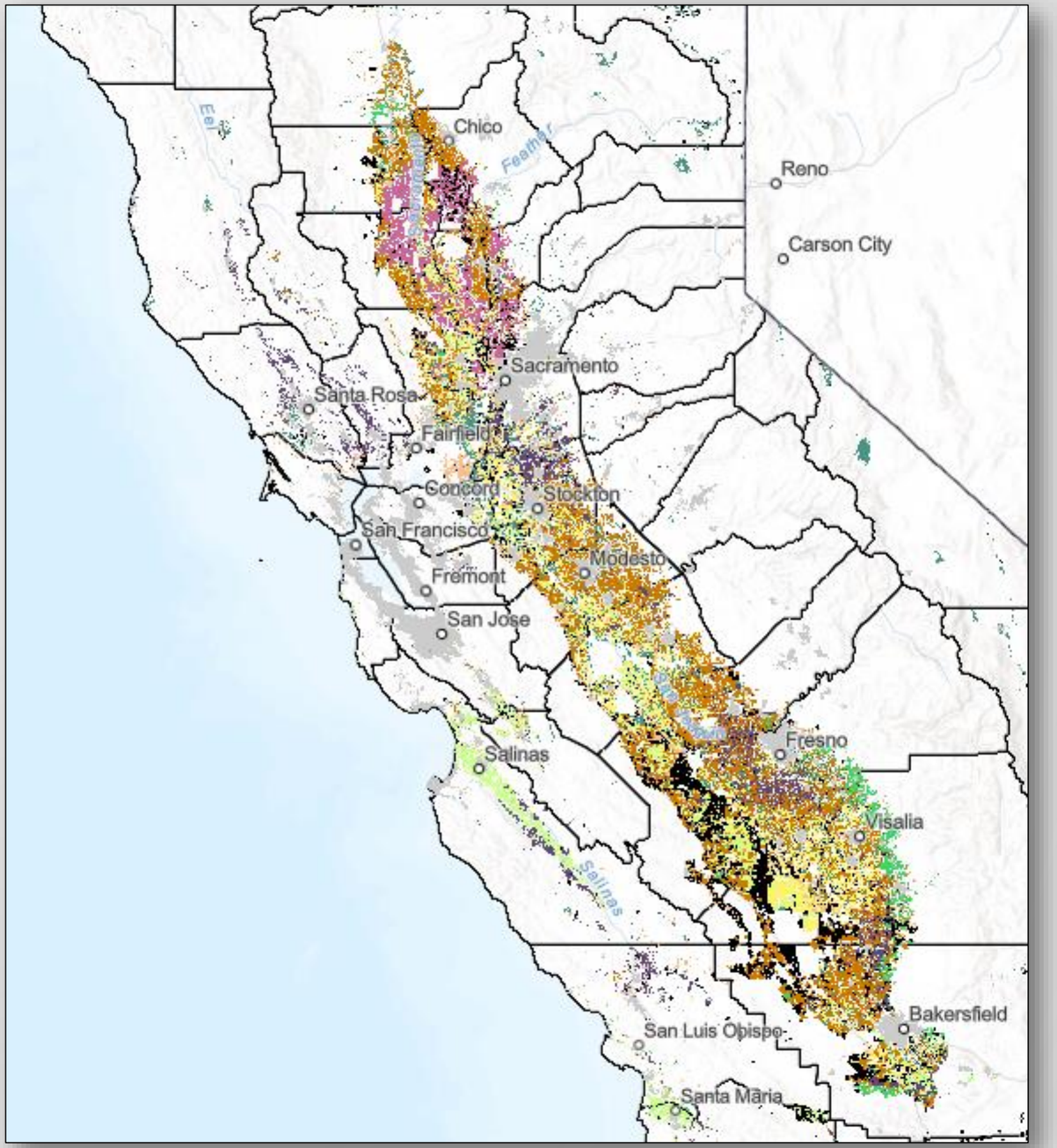
Land Use

Update 2018

- Native lands (NLCD 2006)
- Agricultural lands (county surveys)
- Projected future land use

Update 2023

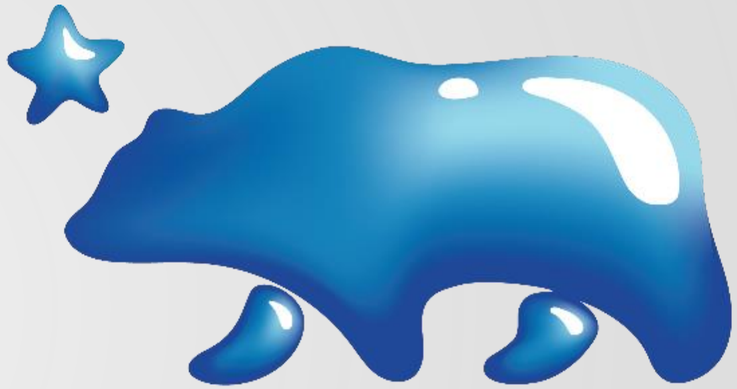
- Native Lands (NLCD 2016)
- Agricultural Lands (Statewide land use 2018 based on Land IQ remote sensing data)
- Projected future land use for urban only



Water Use

Update 2018

- Based on 2006 and 2009 data
- Included background conservation projections for future and different adaptation strategies level of conservation



SAVE OUR WATER

Update 2023

- Updated based on 2015 Urban Water Management plan data
- Includes current background conservation as a result of already enacted laws, but does not include adaptation strategies or pending legislation

Water Plan Update 2023 Vulnerability Metrics

1. **Surface Water**: End of water year surface water storage
2. **Environmental**: % of time Instream Flow Requirement met
3. **Agriculture**: % of demand met
4. **Urban**: % of demand met
5. **Flood**: 90th percentile (10% exceedance) monthly flows at control points
6. **Groundwater**: Groundwater % of total supply

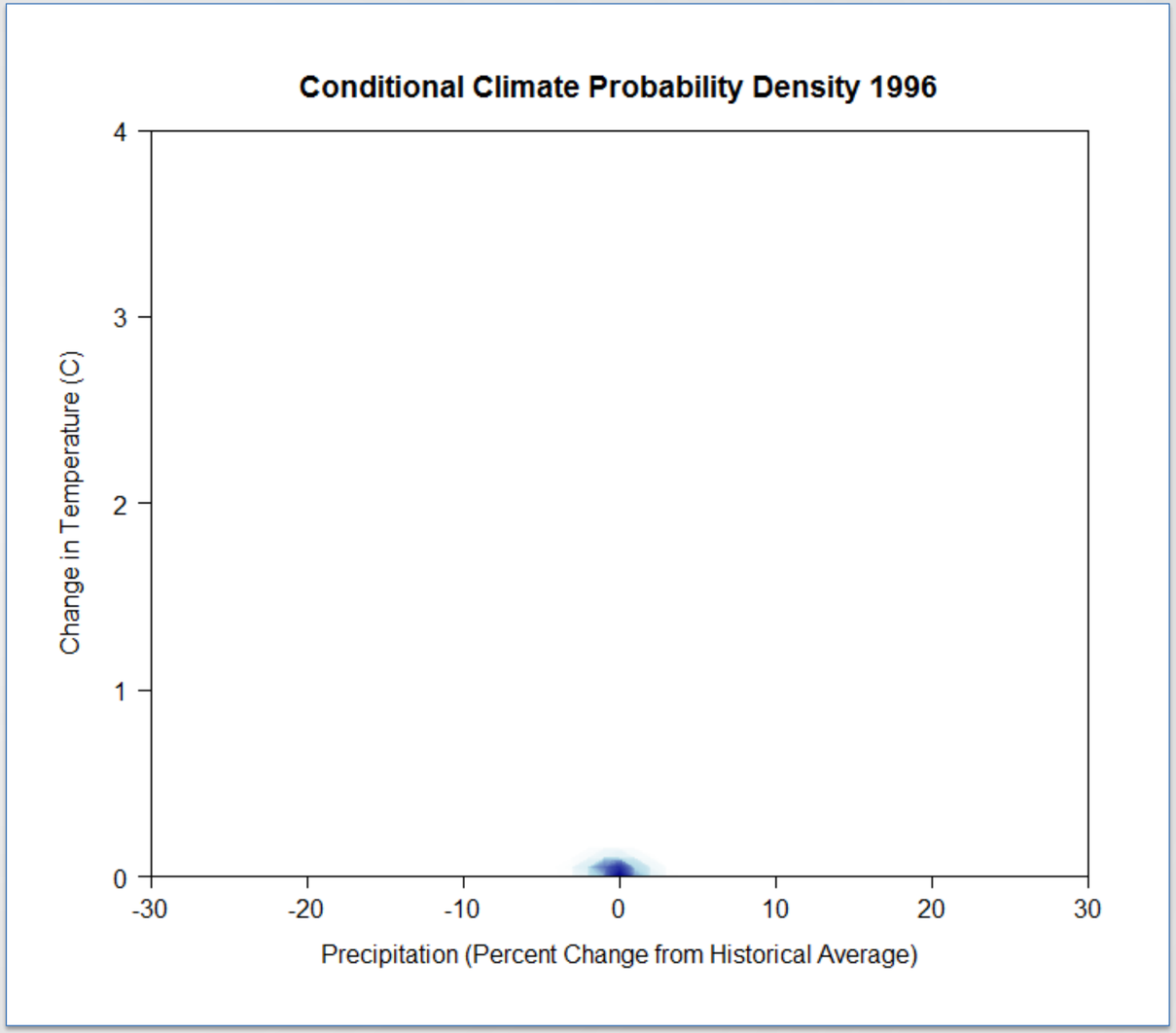
Future Scenarios Update 2023 by the numbers

- 1 Integrated Hydrologic Model (CVPA WEAP)
- 1000+ updated model files
- 2 levels of development analyzed (2020 and 2070)
- 946 model runs
  - 43 climates
  - 1100 years of simulation per climate
- 33,000+ output files for post processing
- 138 detailed response surfaces
- 68 GCMs processed for probability weightings
- 1000s of Monte Carlo simulations to develop cumulative probability plots
- 3 Hydrologic Regions with assessments of vulnerability in 6 aspects of water management

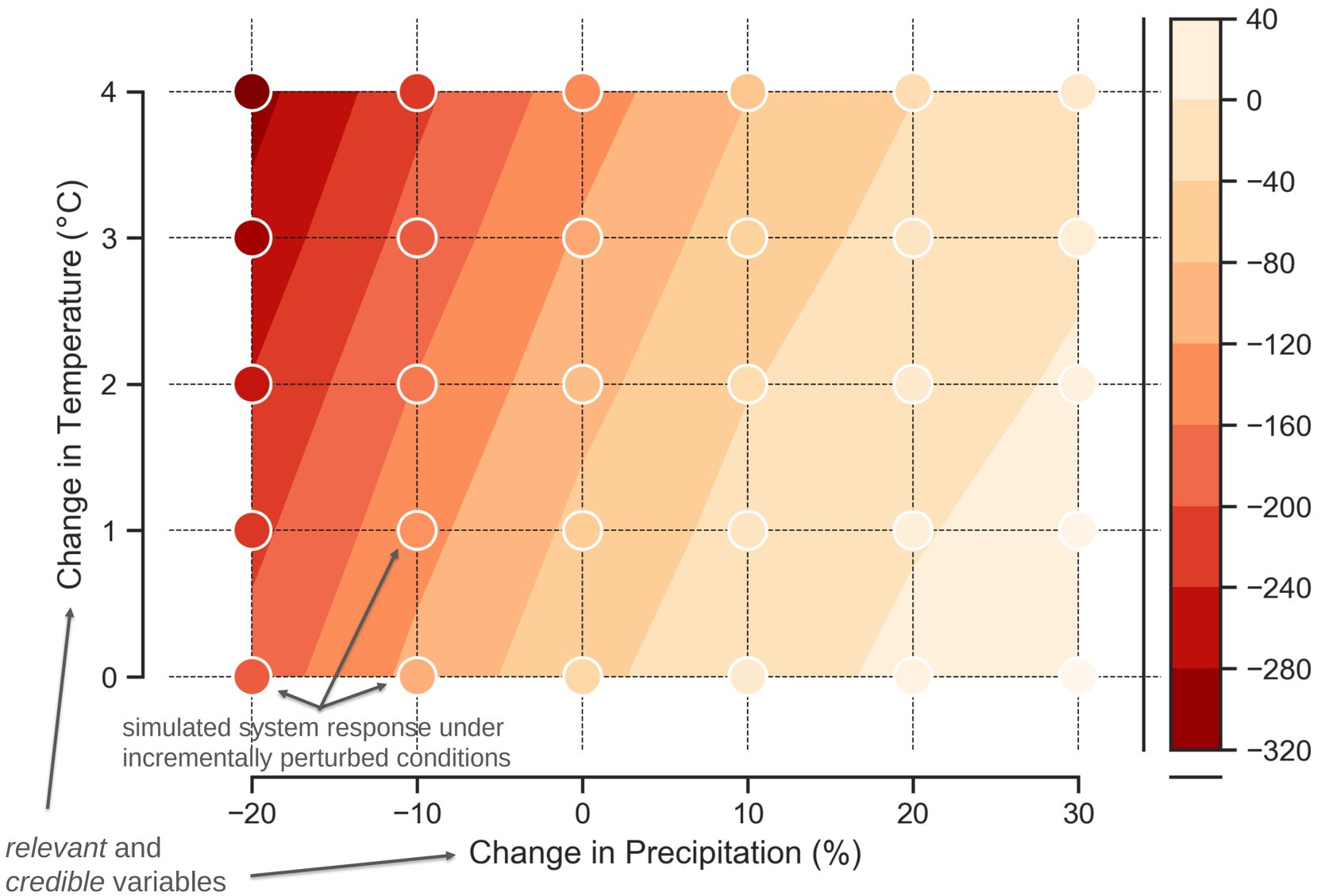
ANALYSIS PROCESS TO DEVELOP METRICS

Decision Scaling

- A stress test under the *full* range of *relevant* and *credible* changes
- Estimate risk conditional on climate projection-based evidence



Some important system metric



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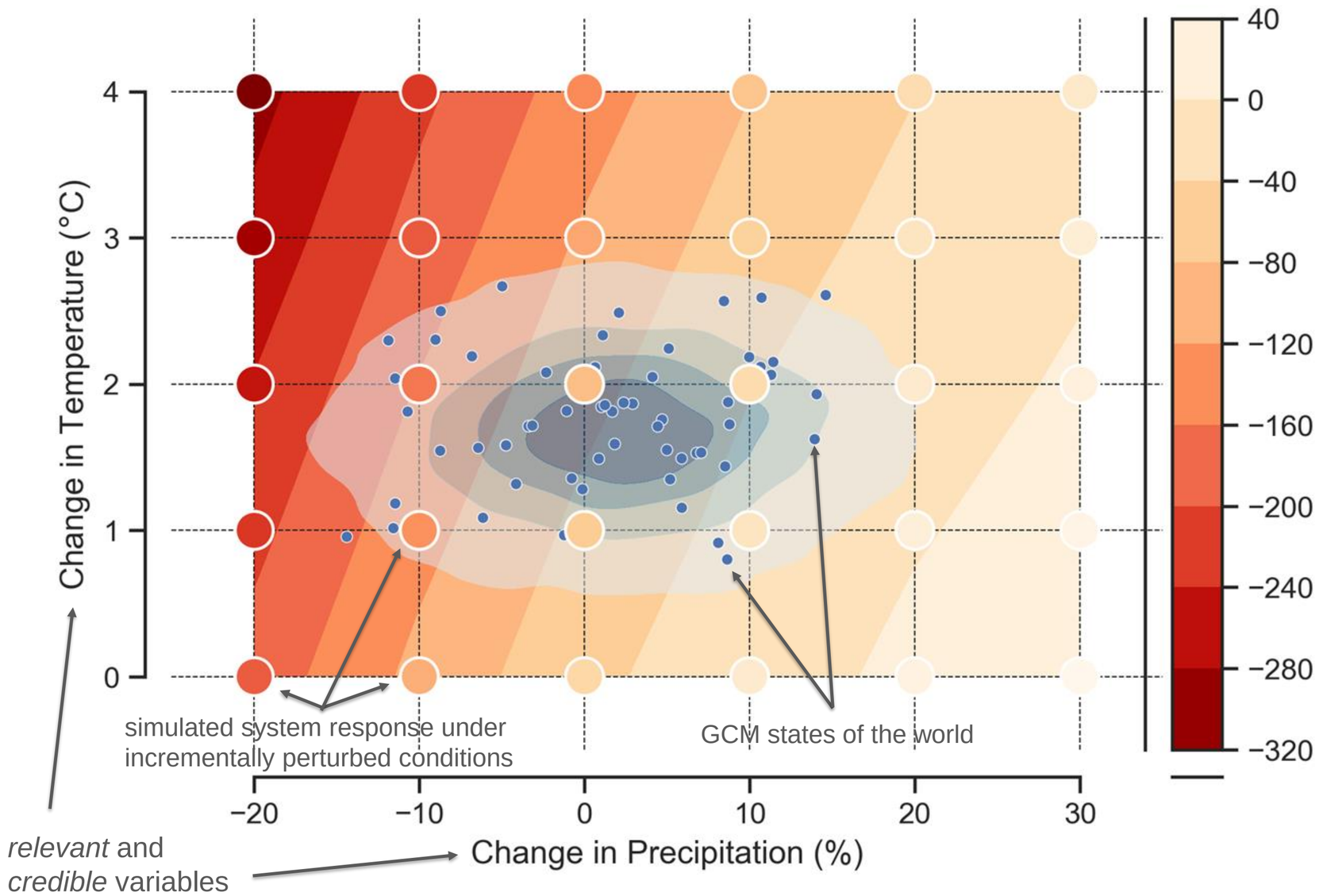
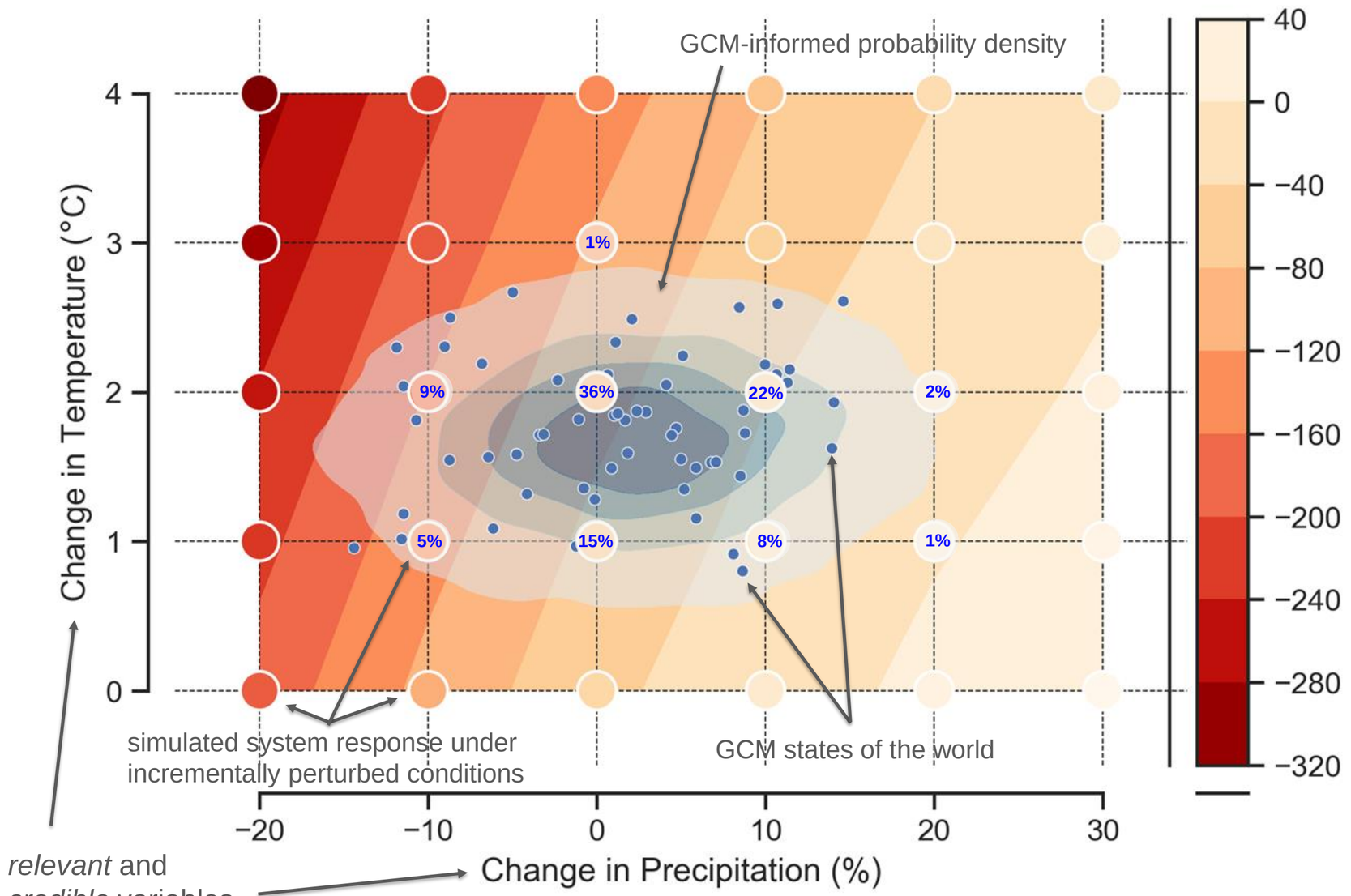
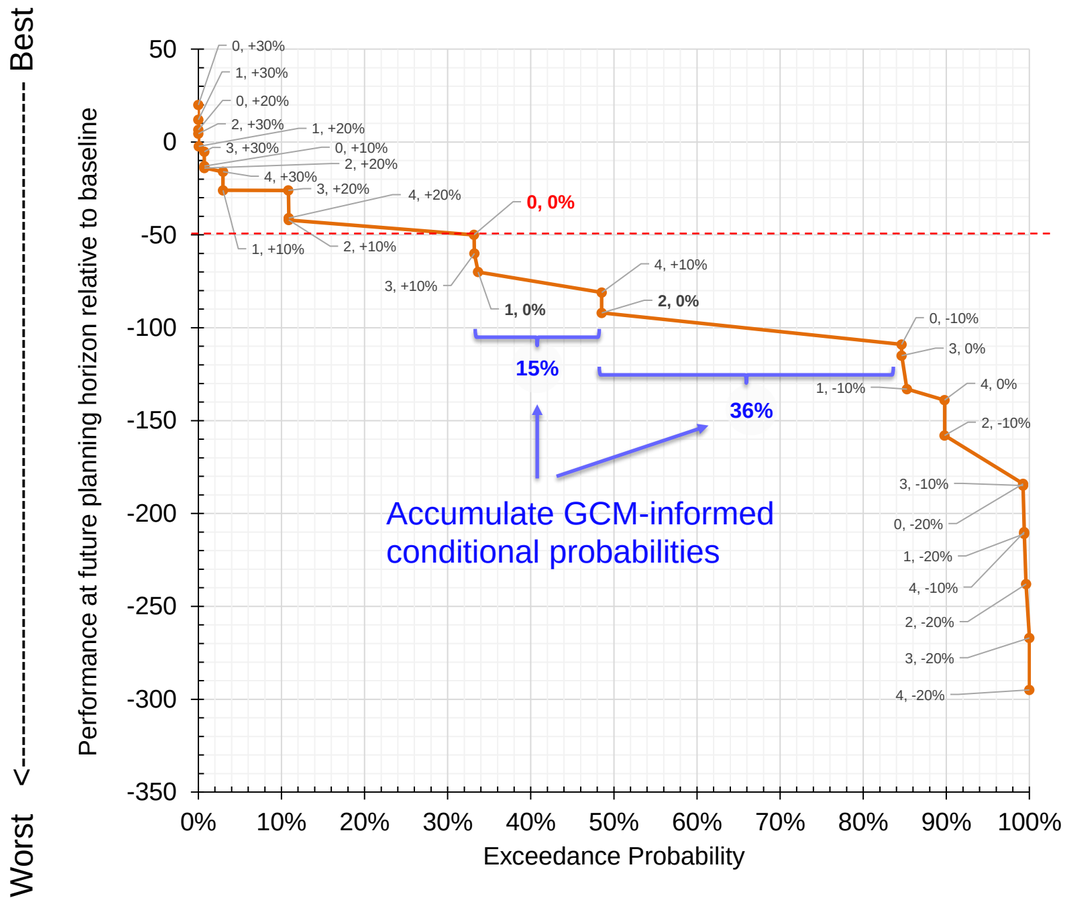
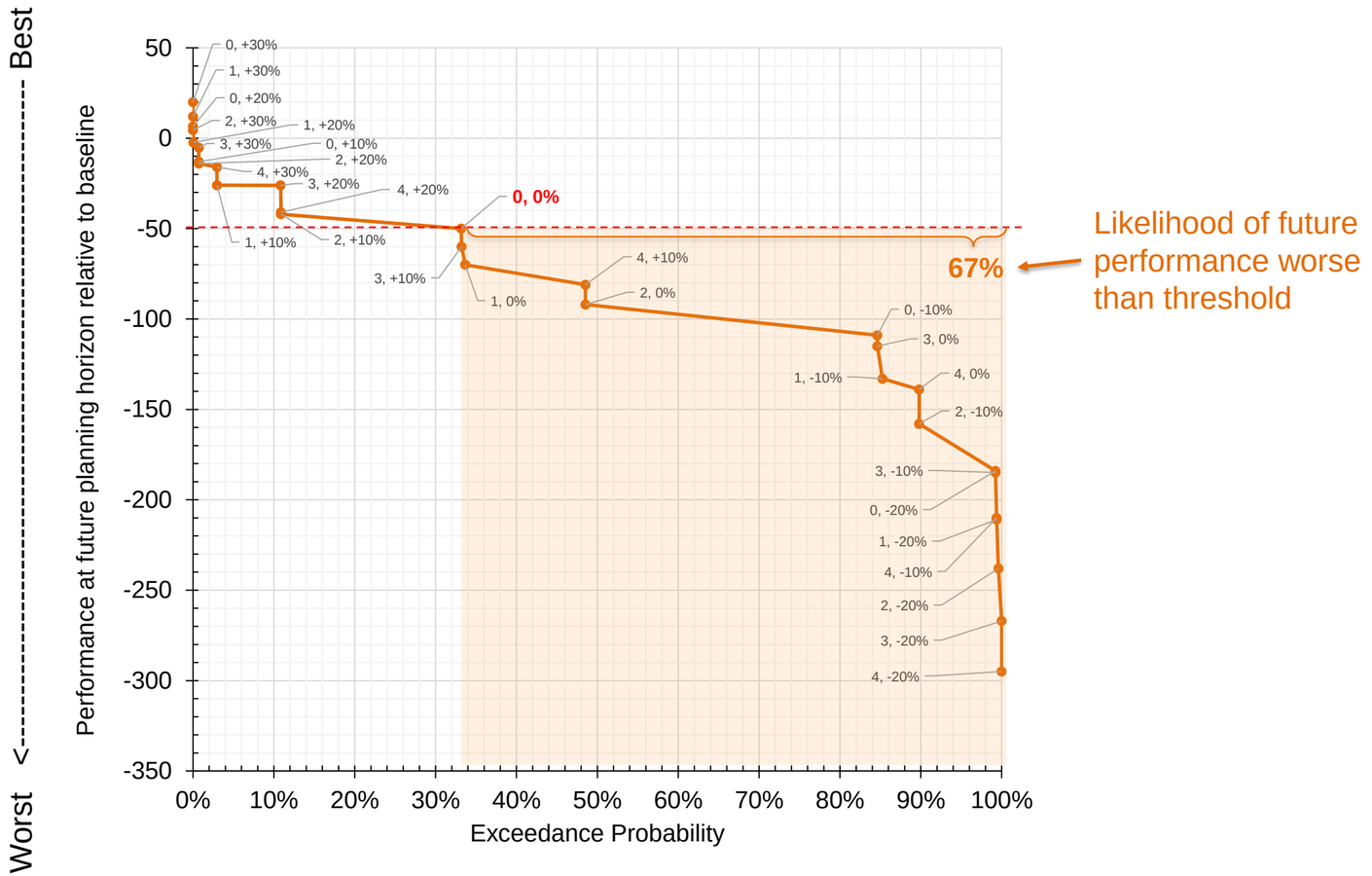


Some important system metric



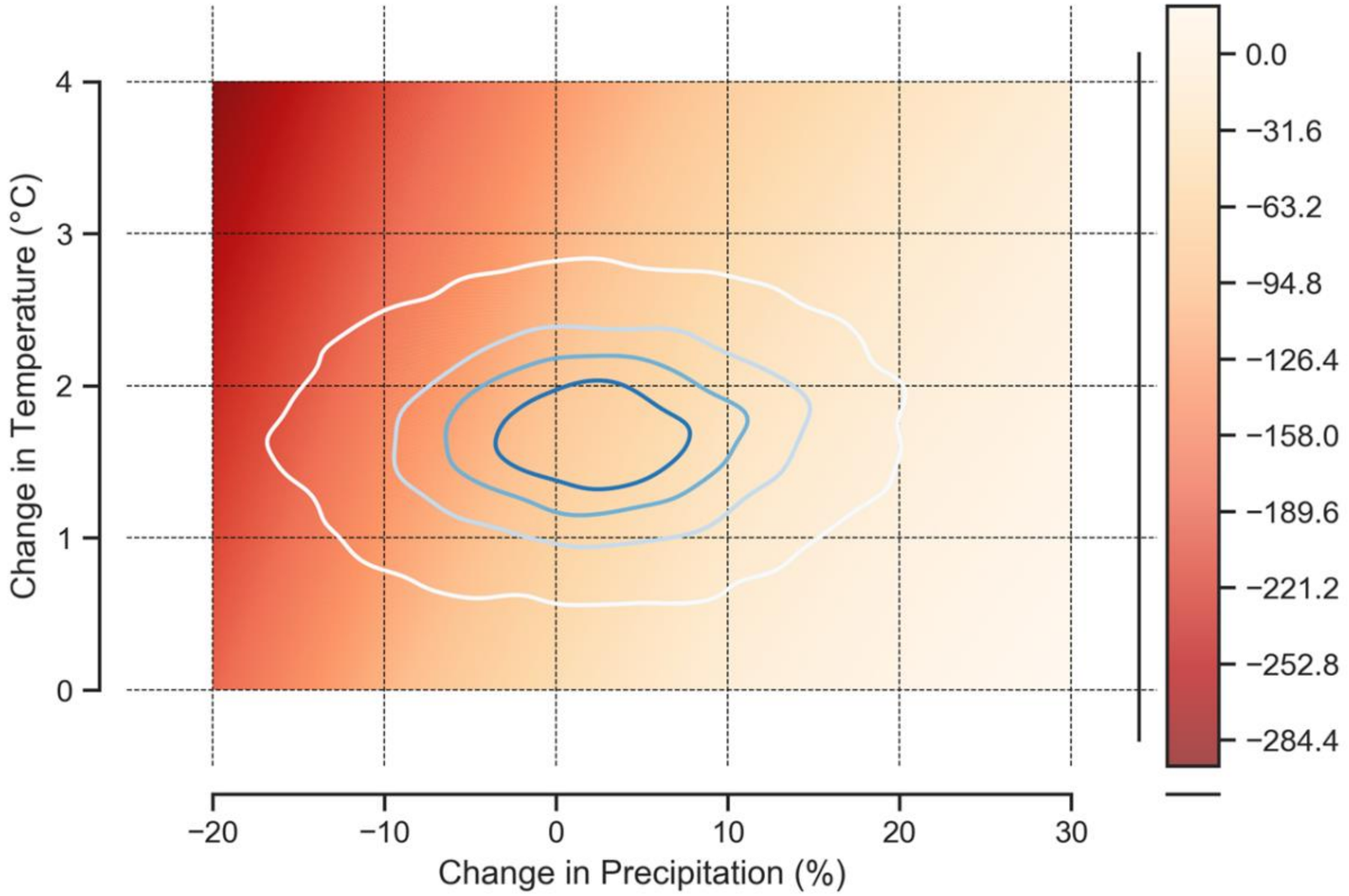
relevant and *credible* variables


Best
Worst
Performance at future planning horizon relative to baseline
Exceedance Probability
50
0
-50
-100
-150
-200
-250
-300
-350
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0, +30%
1, +30%
0, +20%
2, +30%
1, +20%
3, +30%
0, +10%
2, +20%
4, +30%
3, +20%
4, +20%
0, 0%
1, +10%
2, +10%
3, +10%
4, +10%
1, 0%
2, 0%
0, -10%
3, 0%
1, -10%
4, 0%
2, -10%
15%
36%
3, -10%
0, -20%
1, -20%
4, -10%
2, -20%
3, -20%
4, -20%
Accumulate GCM-informed
conditional probabilities



Likelihood of future performance worse than threshold

Some important system metric



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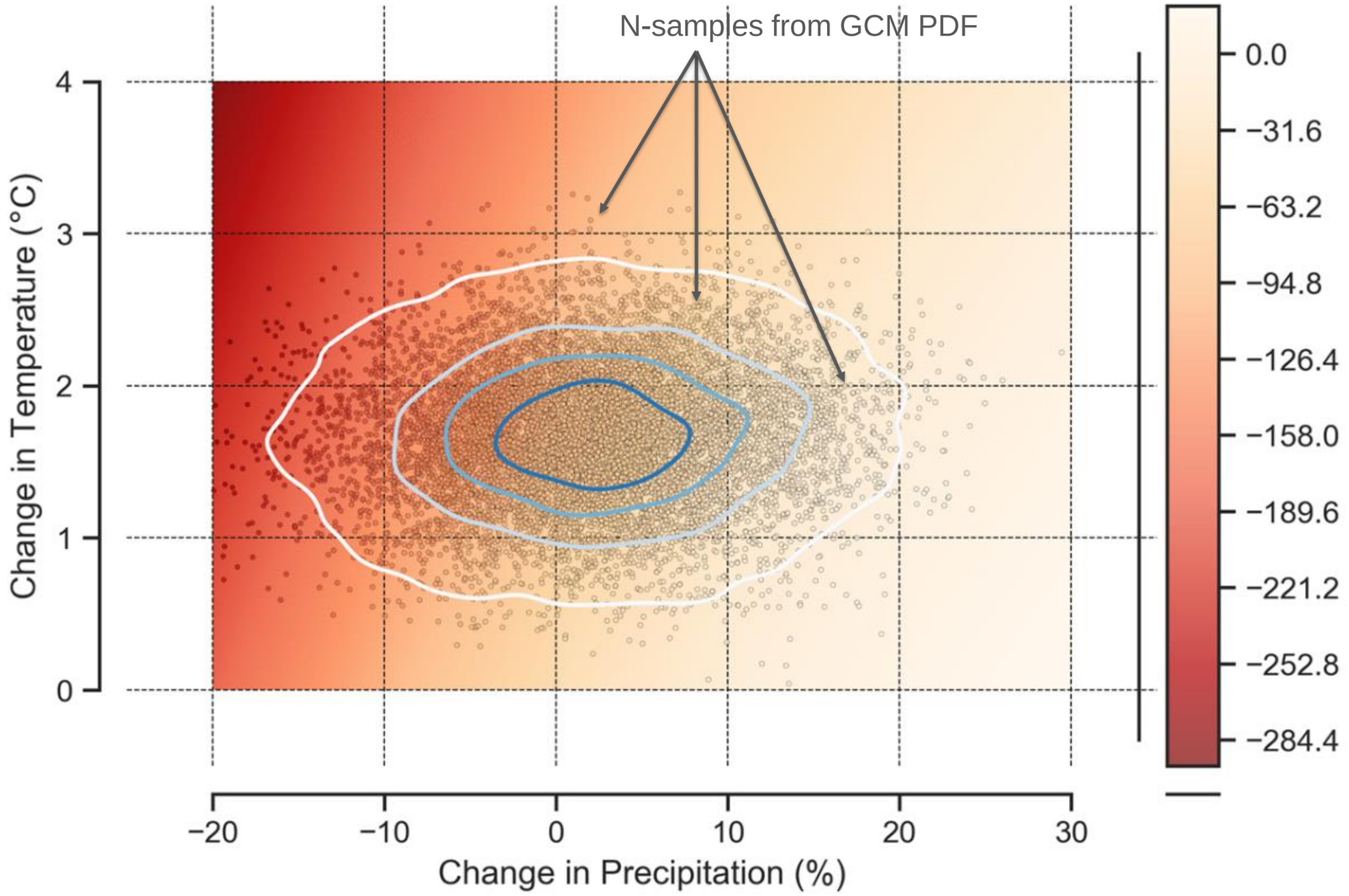
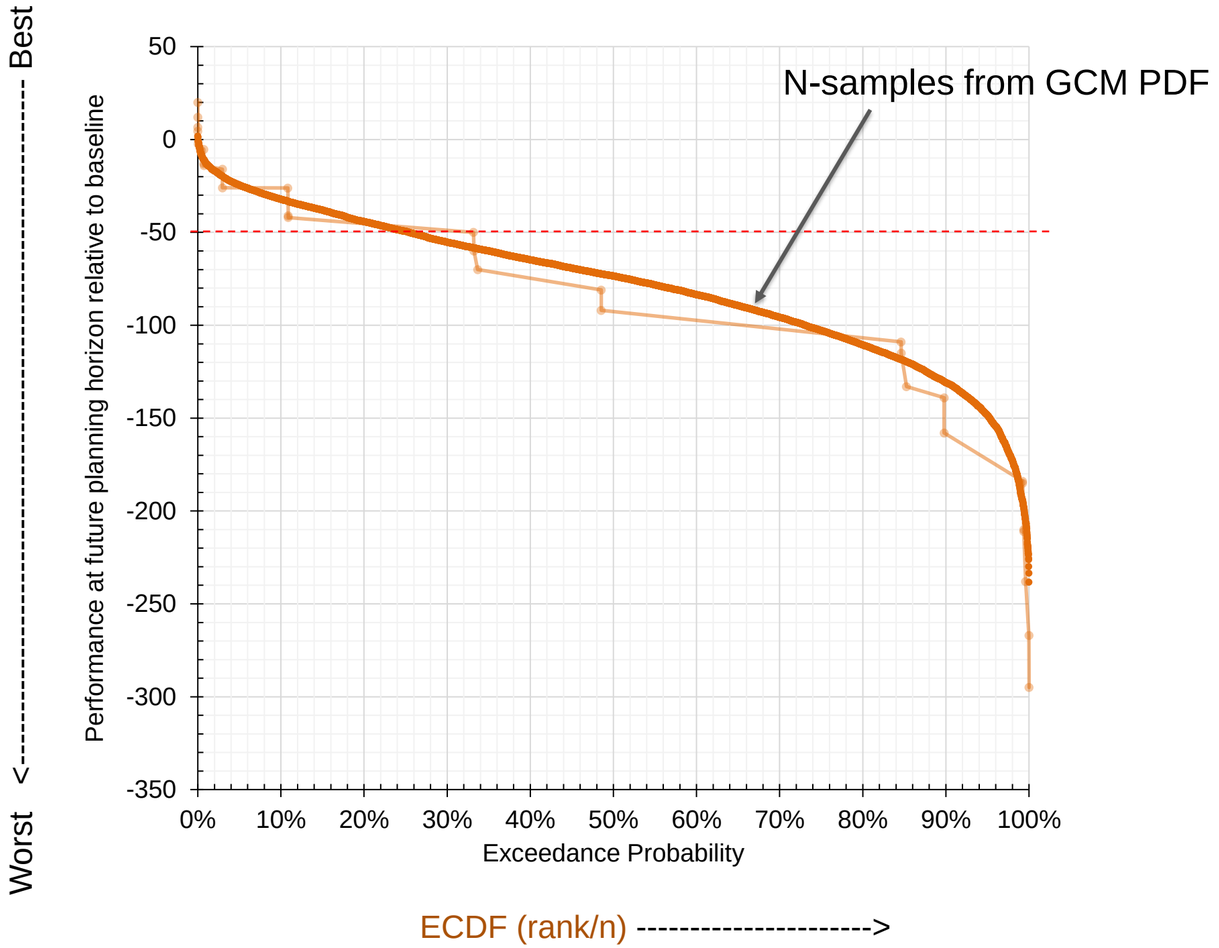
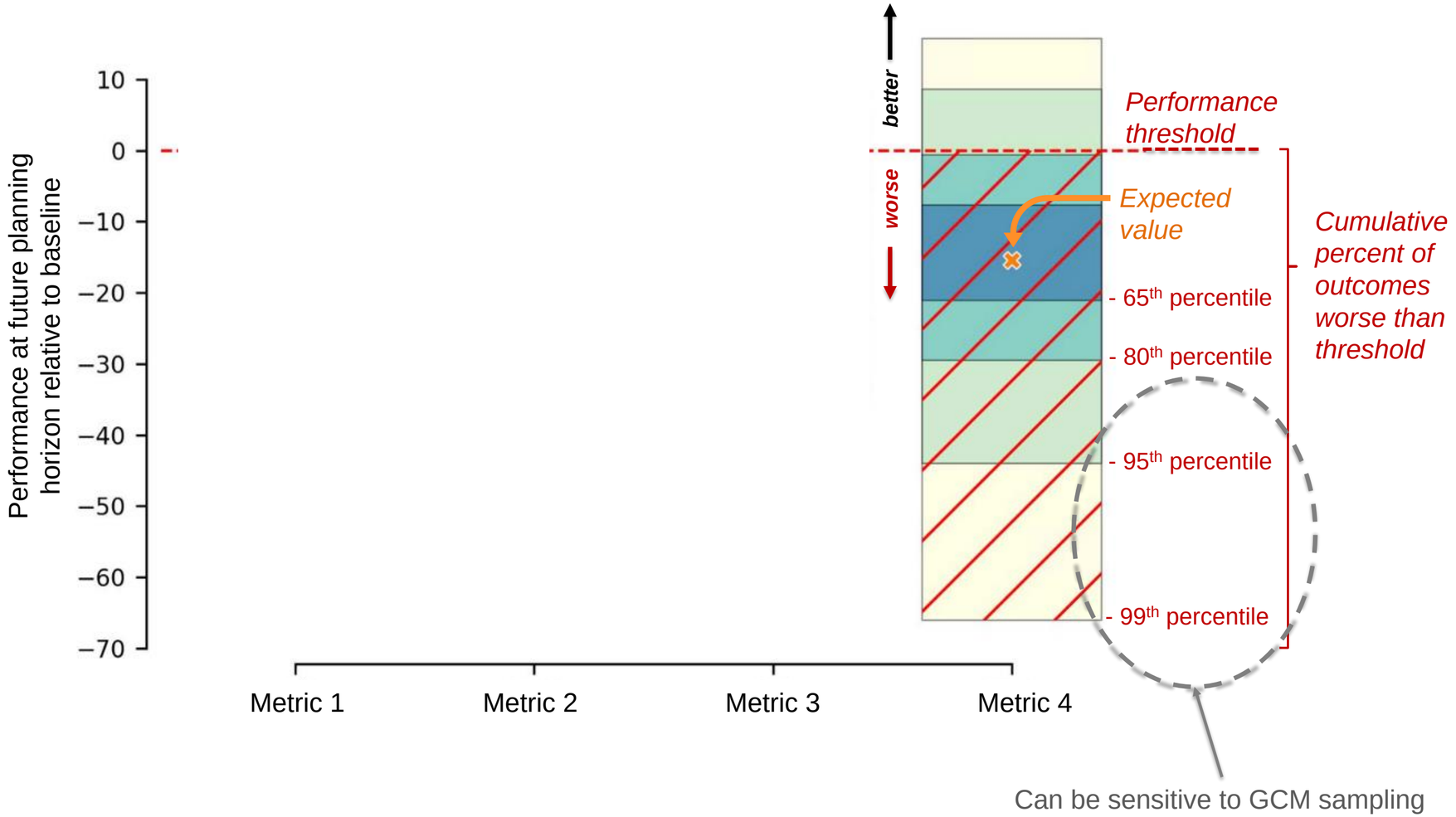



Best
<----------
Worst
Performance at future planning horizon relative to baseline
50
0
-50
-100
-150
-200
-250
-300
-350
N-samples from GCM PDF
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability
ECDF (rank/n) ---------->
CALIFORNIA WATER PLAN UPDATE 2023

Some important system metrics



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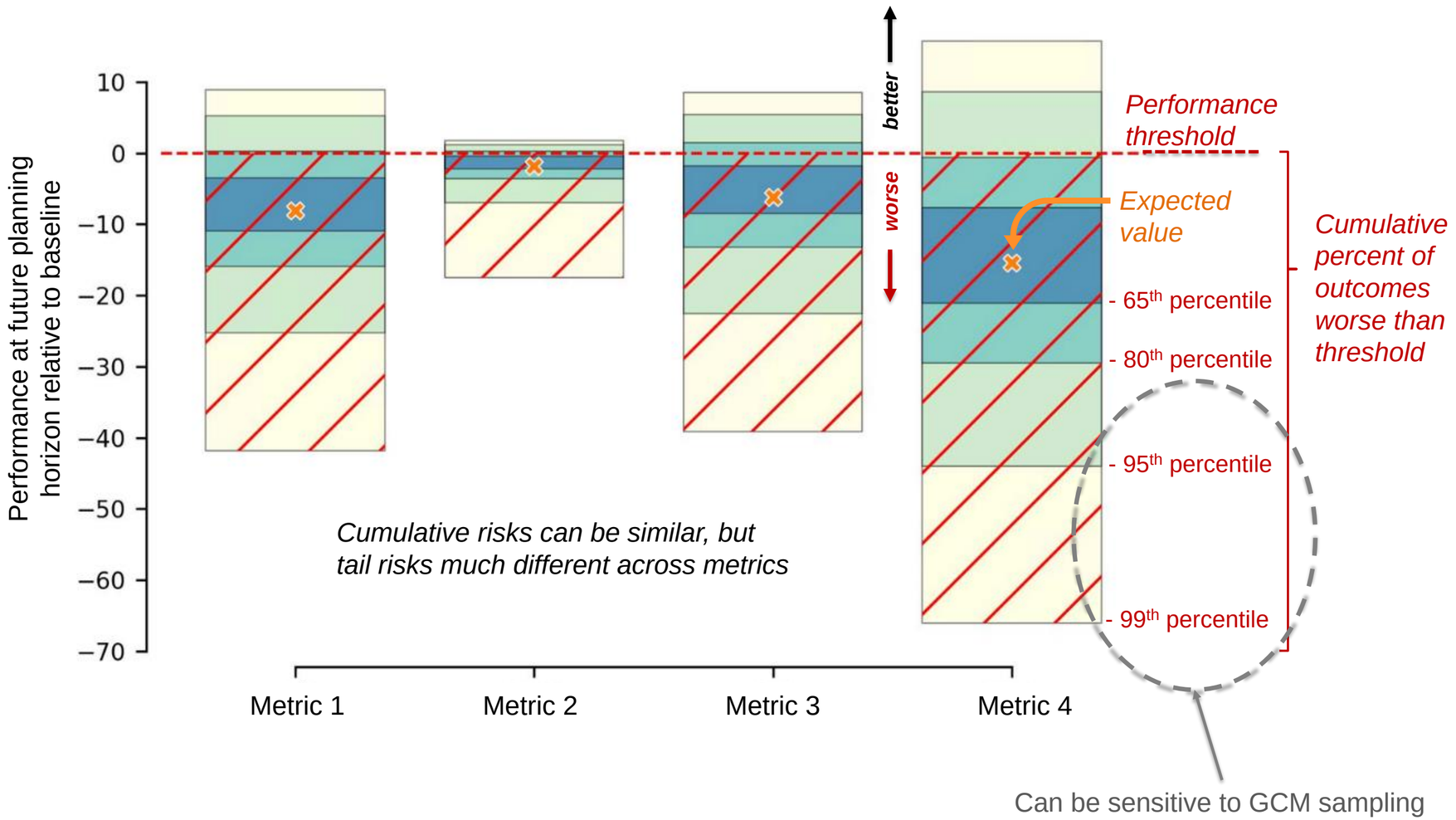
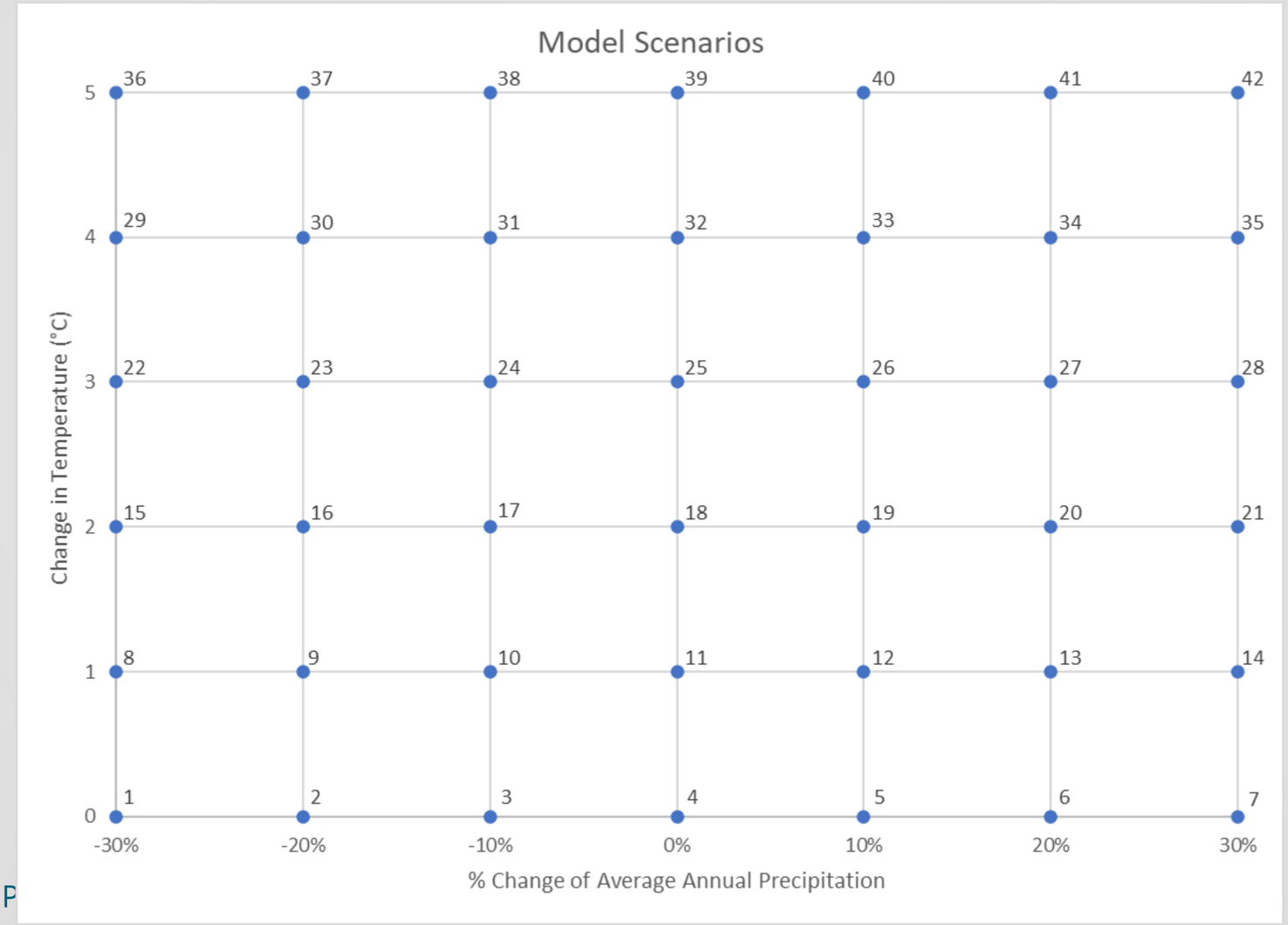
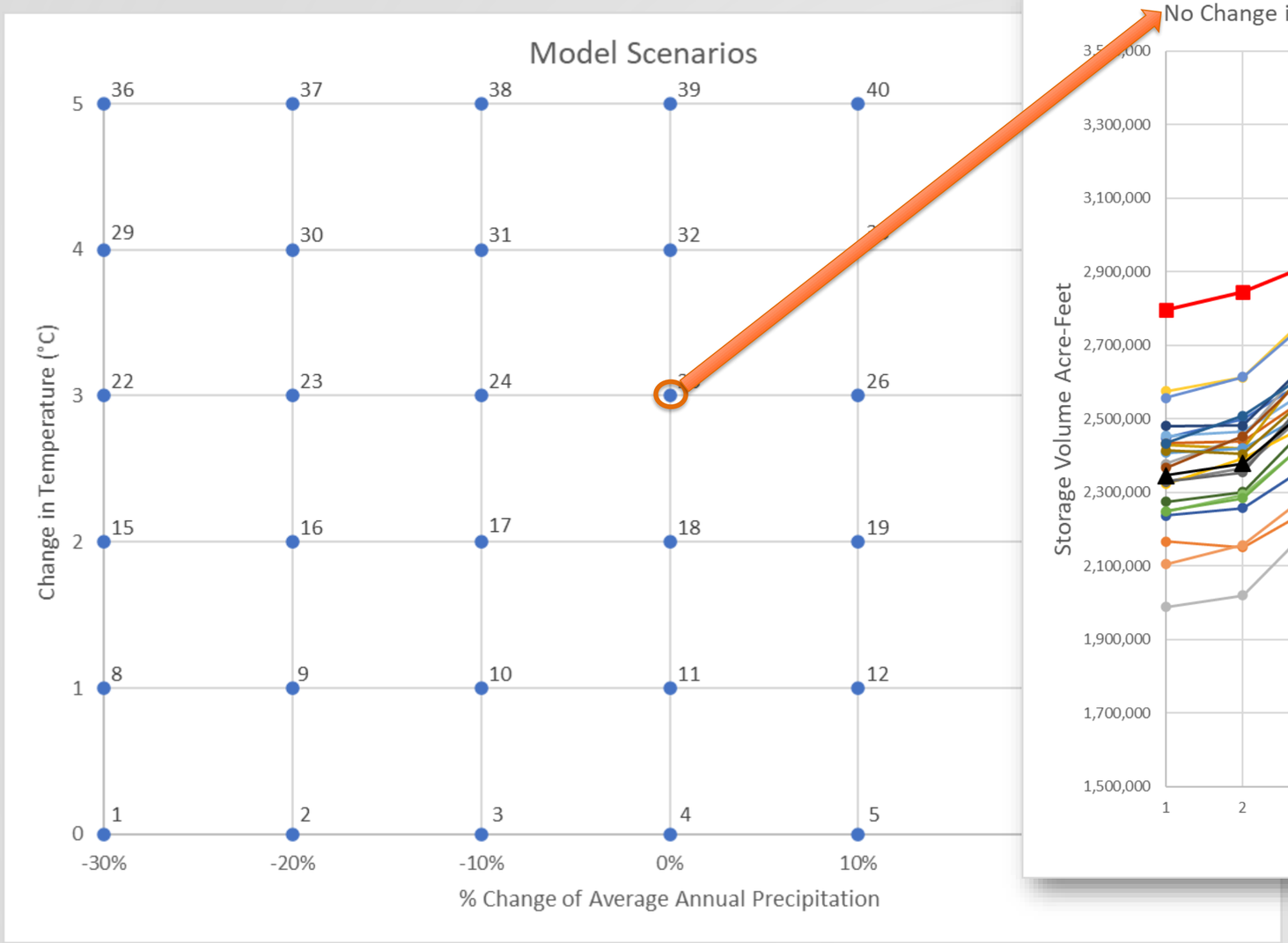


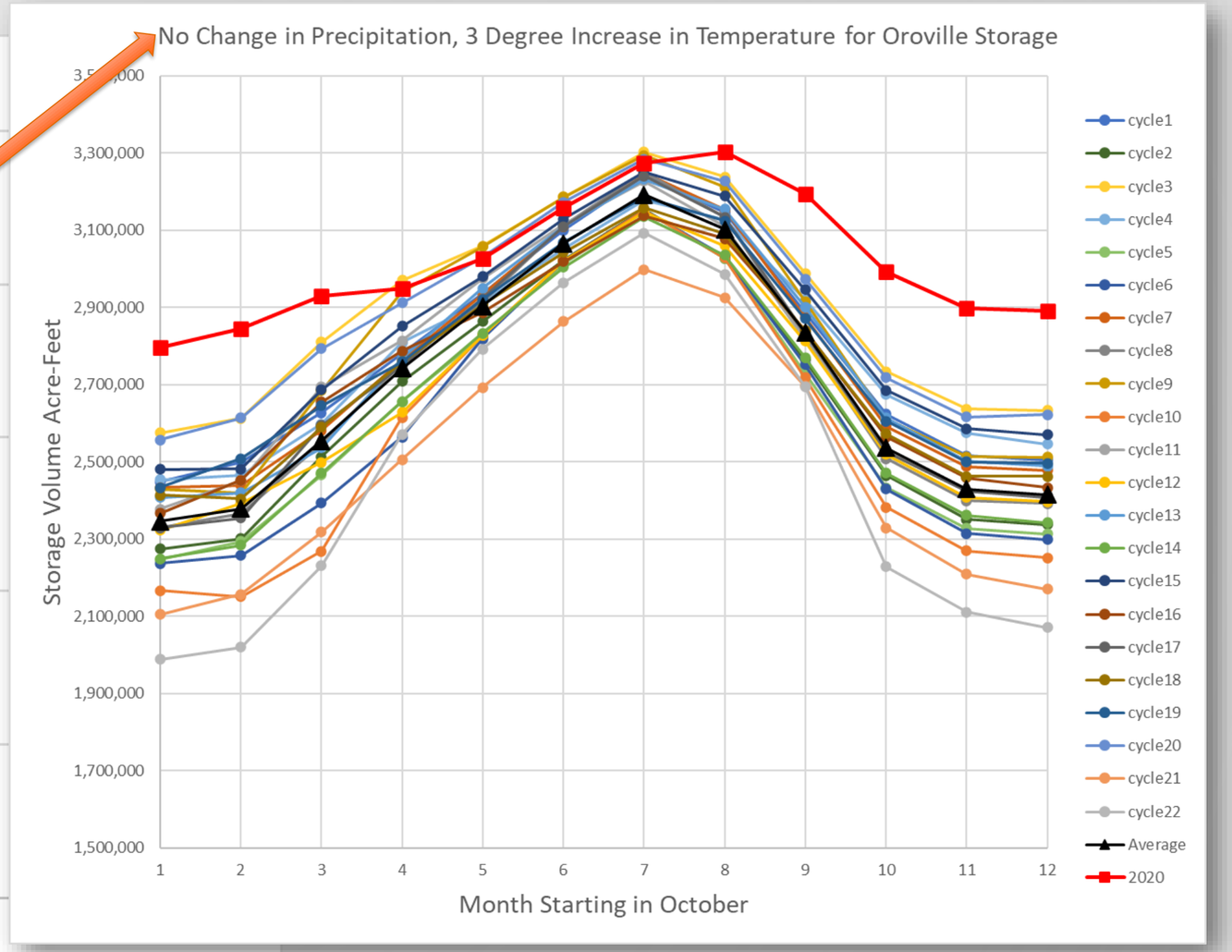
FUTURE SCENARIOS UPDATE 2023 RESULTS

Results will be based on 0 to 5°C change in temp. and -30% to +30% change in Precipitation



Metric 1 Surface Storage – Oroville





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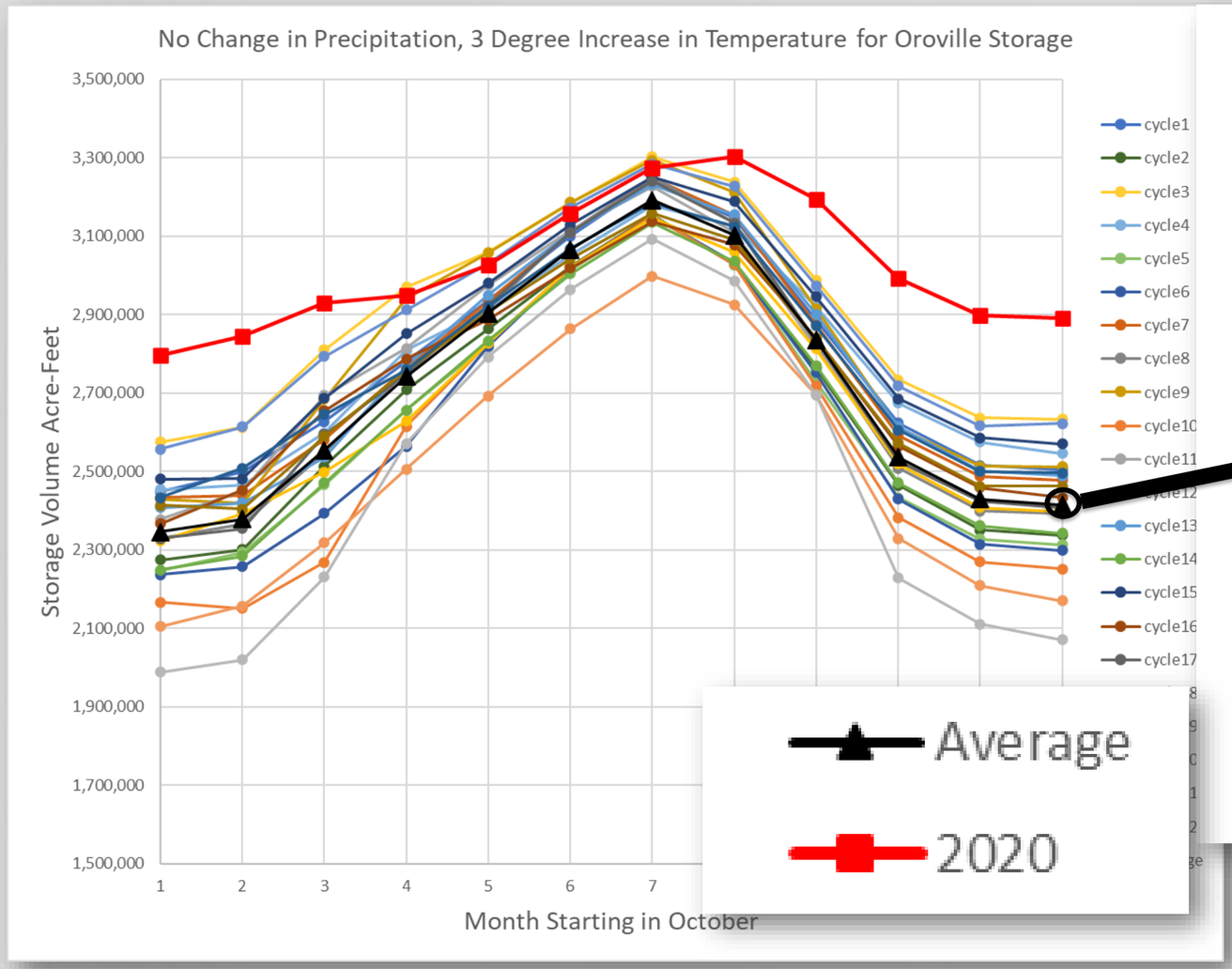

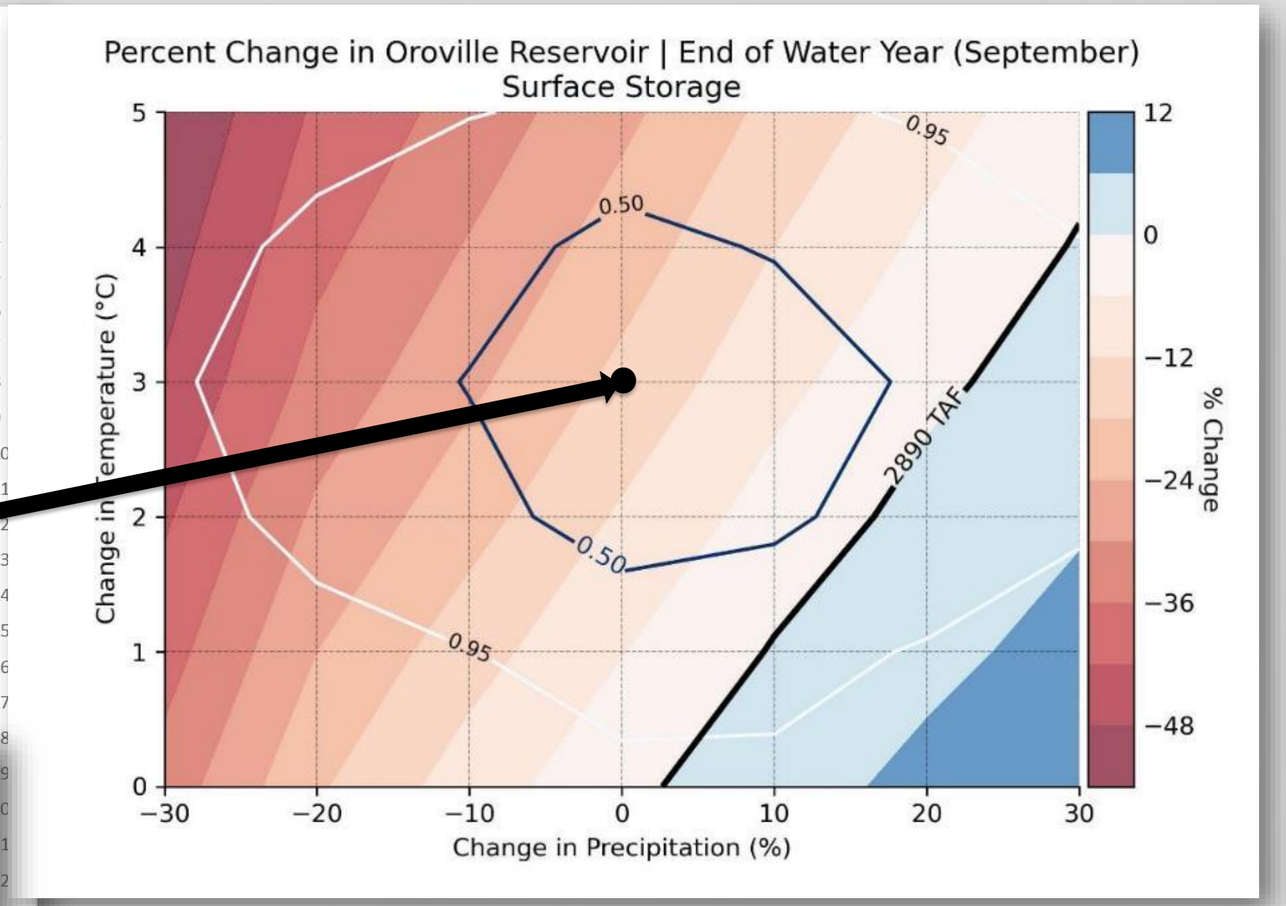

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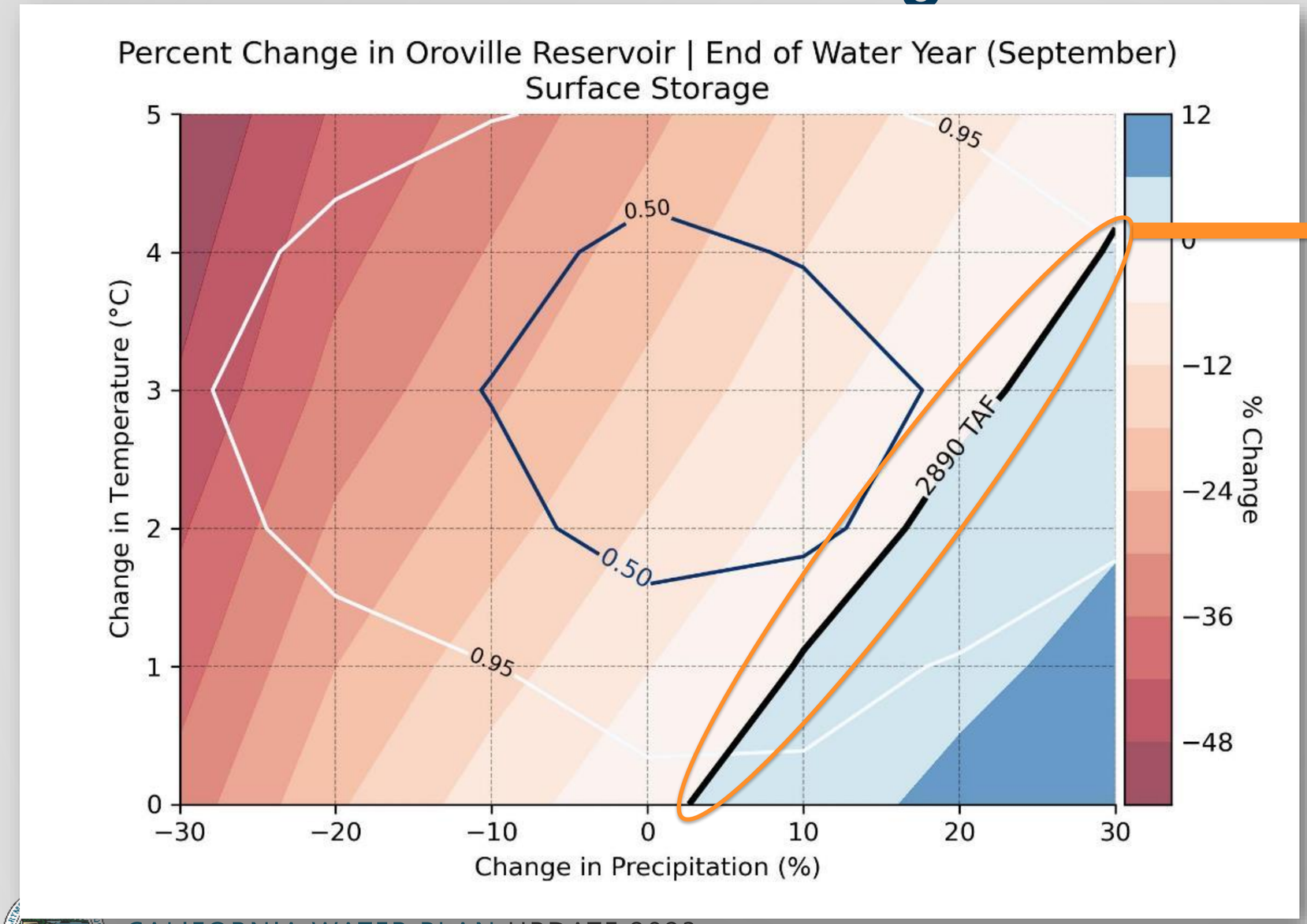
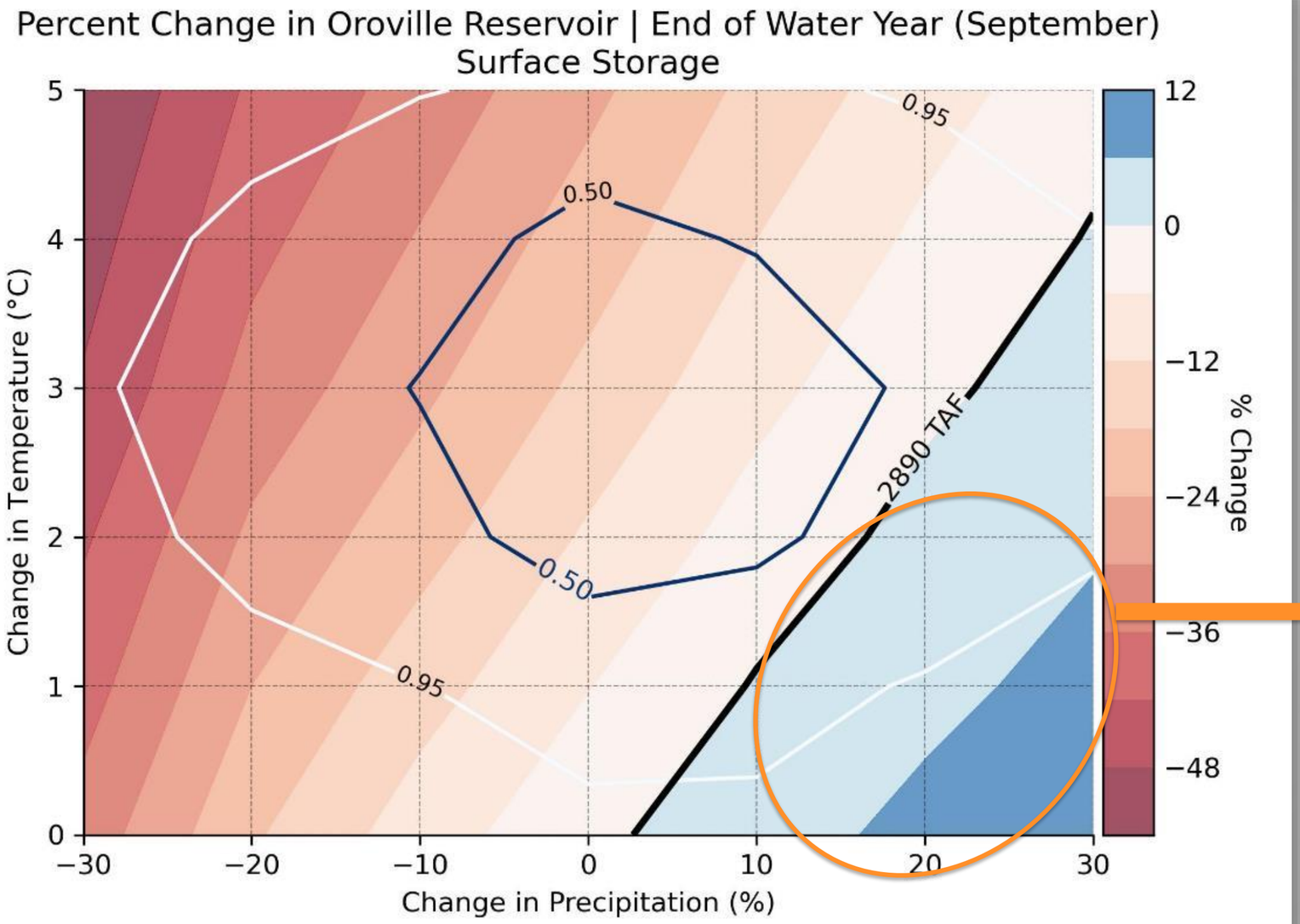


The black line represents a performance threshold, for this study it is a baseline performance.

Metric 1 Surface Storage – Oroville



Blue areas generally indicate improved system performance

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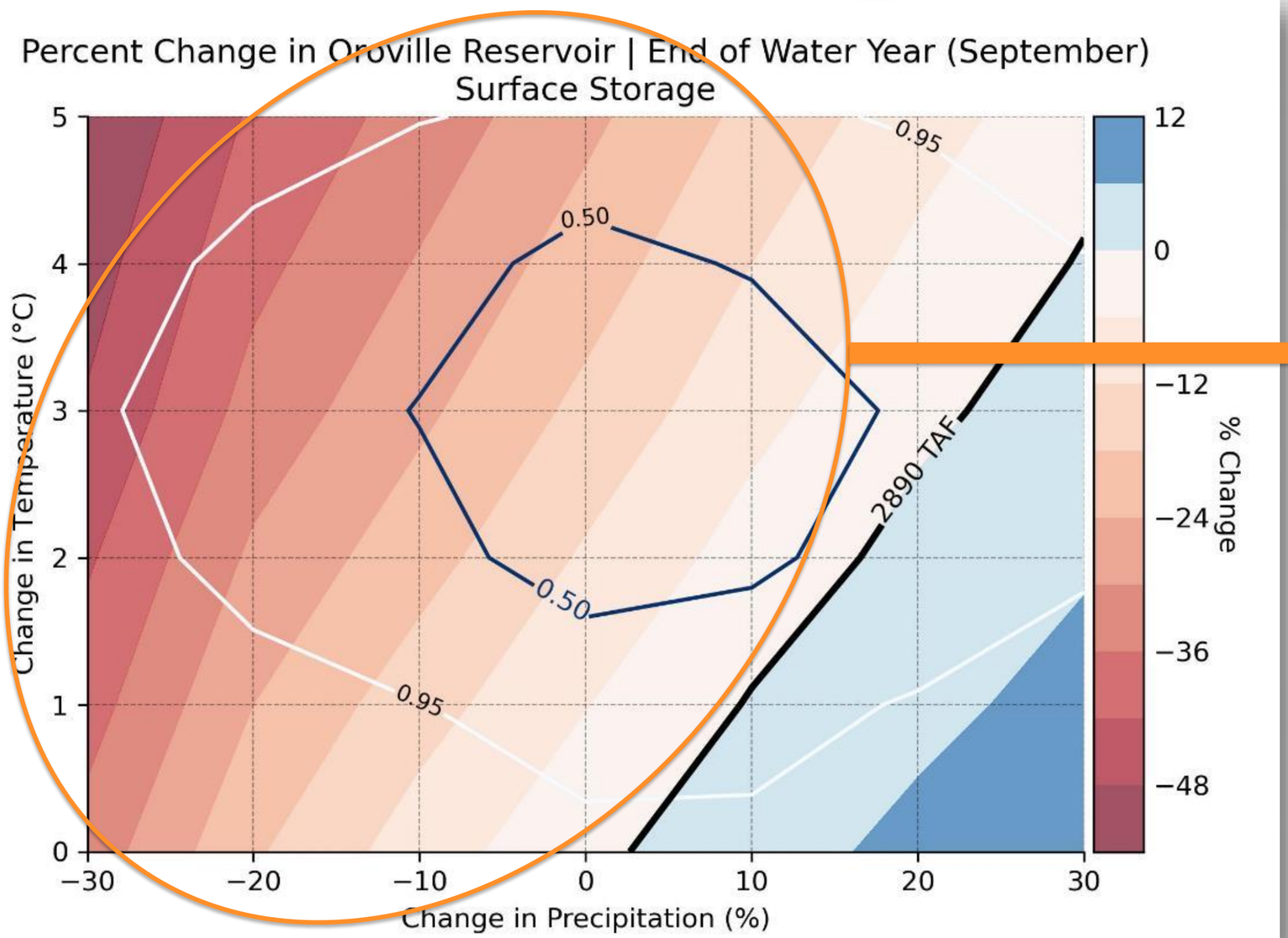
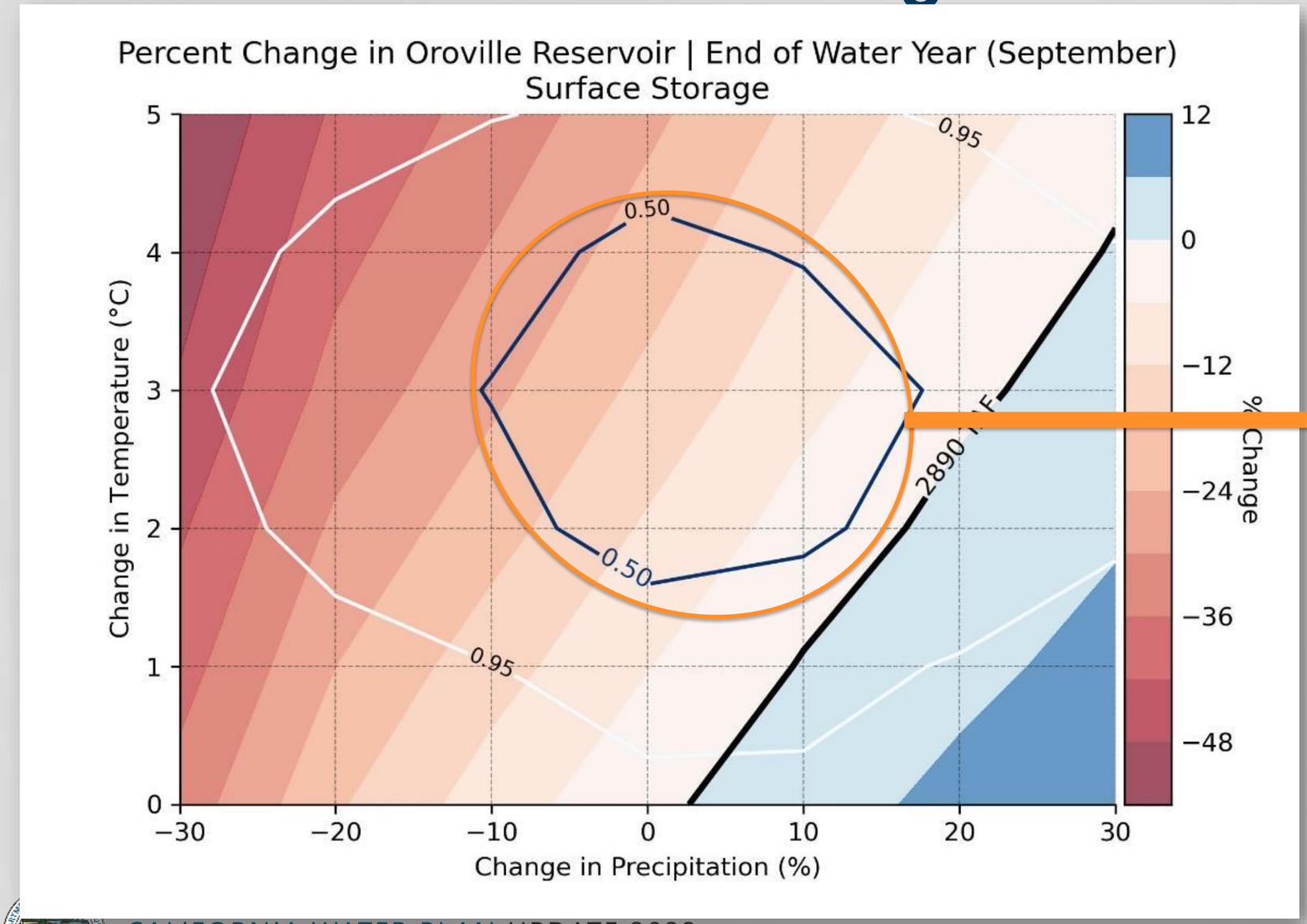


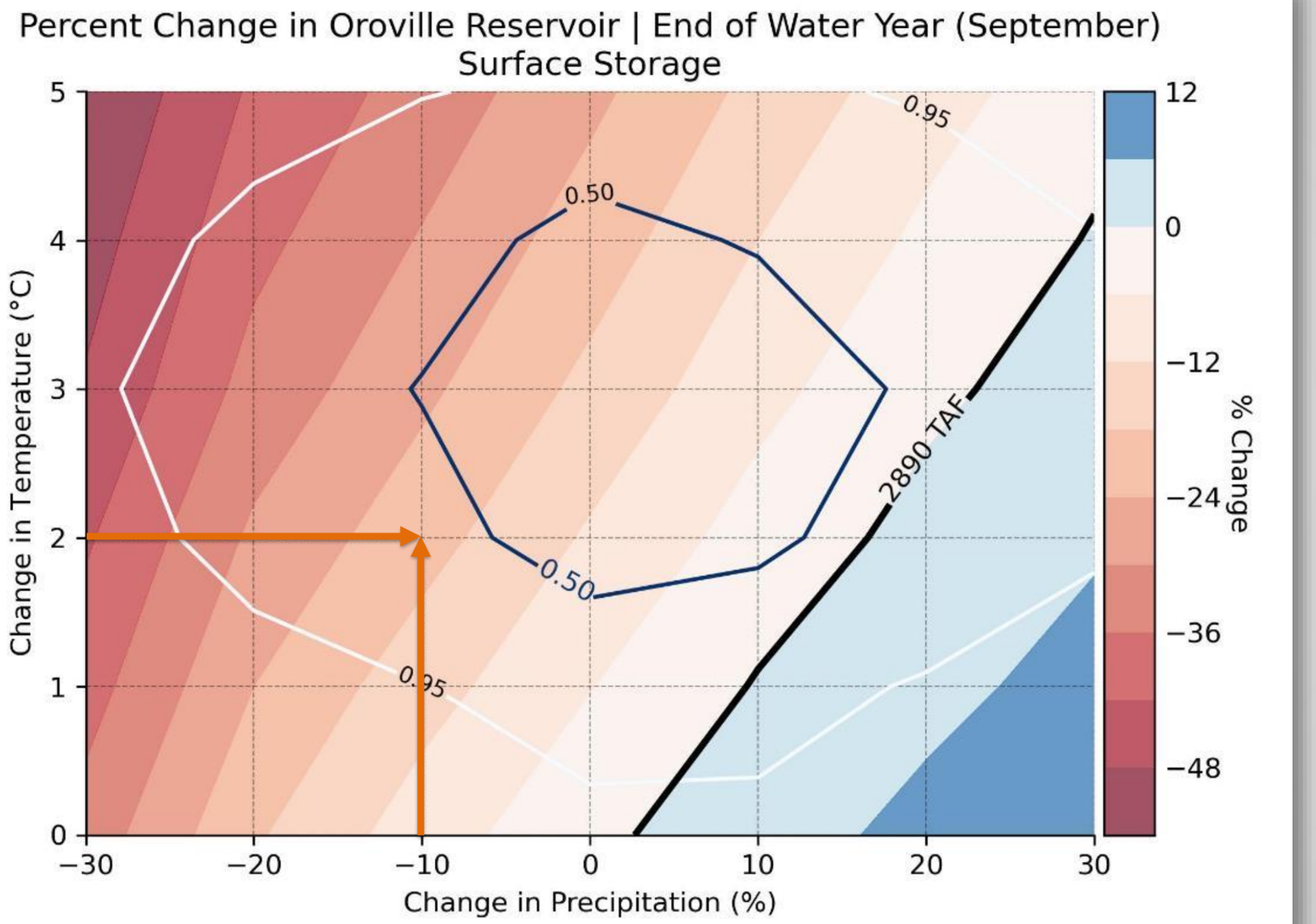
Red areas generally indicate areas of decreased performance.

Metric 1 Surface Storage – Oroville



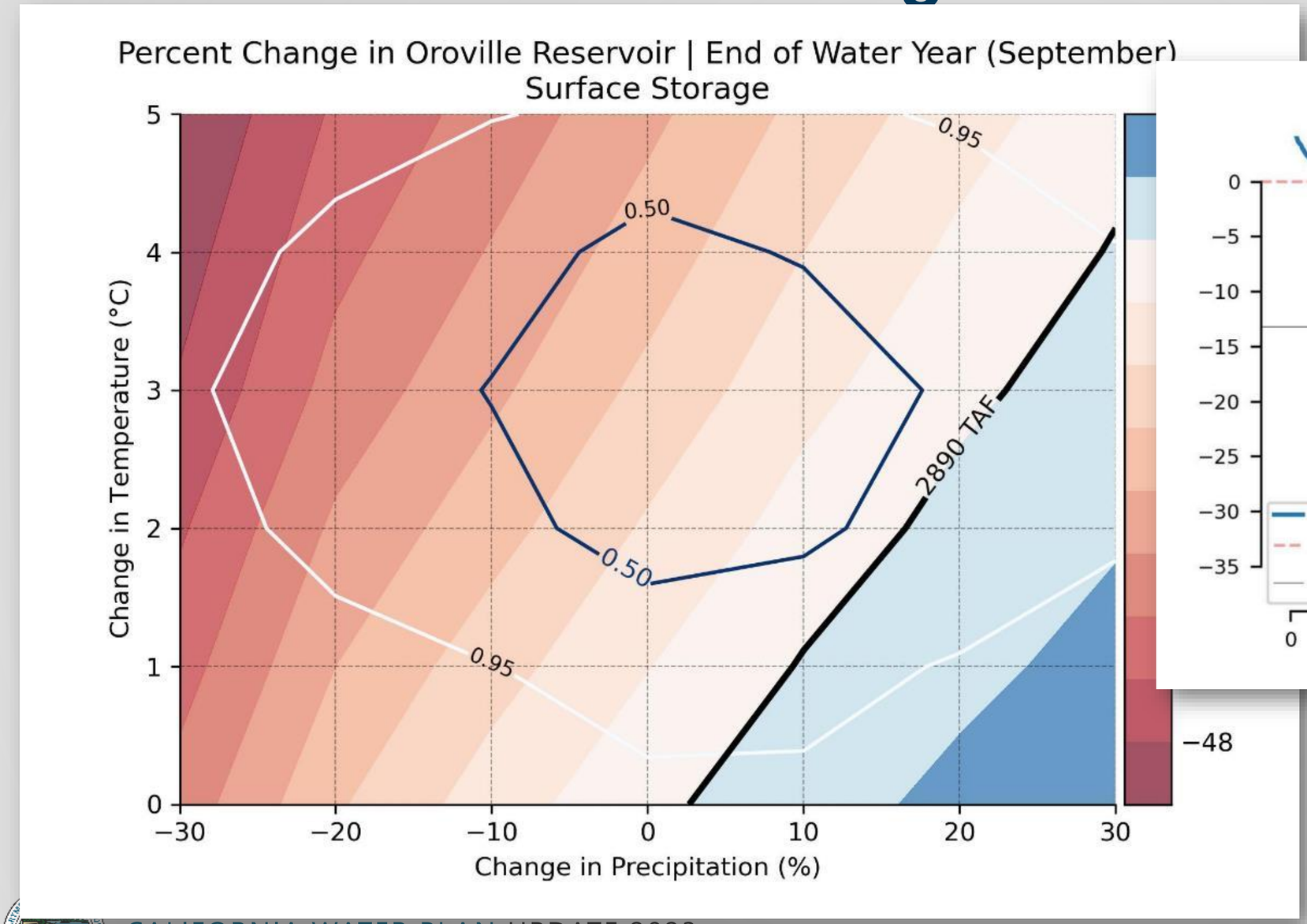
The contours represent the probability of occurrence based on GCM projections

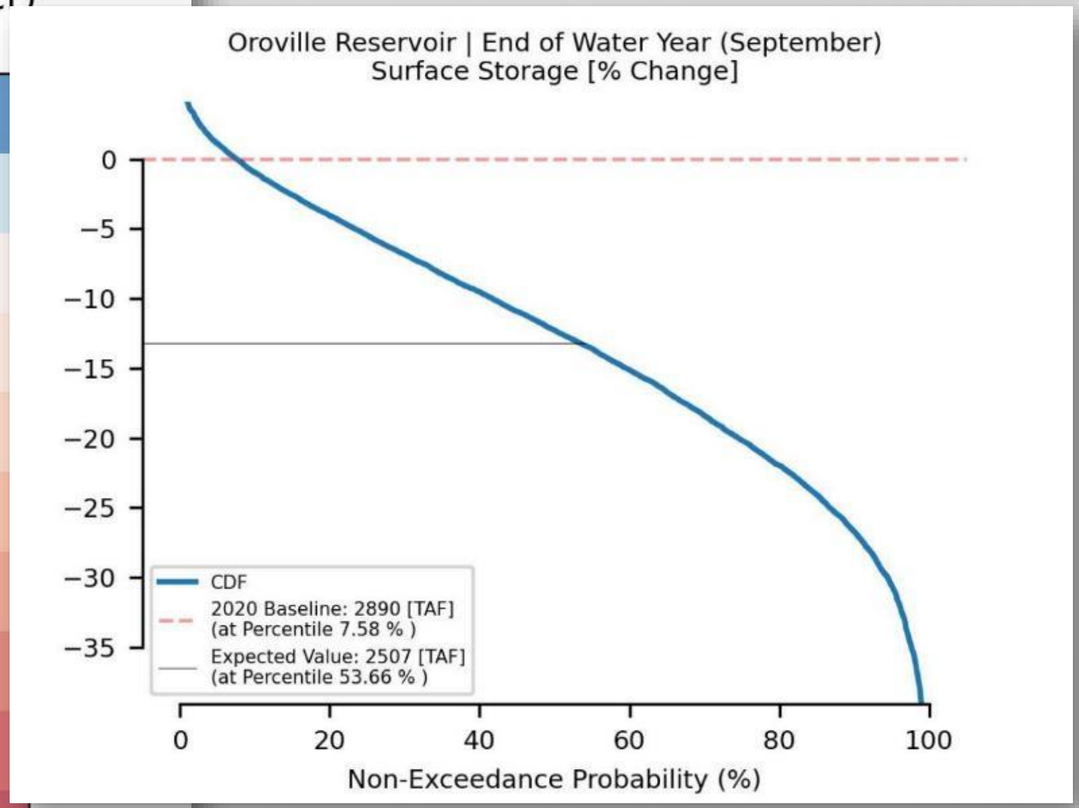
Metric 1 Surface Storage – Oroville



Response surfaces can be used to look at any combination of temperature and precipitation you are interested in regardless of probability of occurrence

Metric 1 Surface Storage – Oroville





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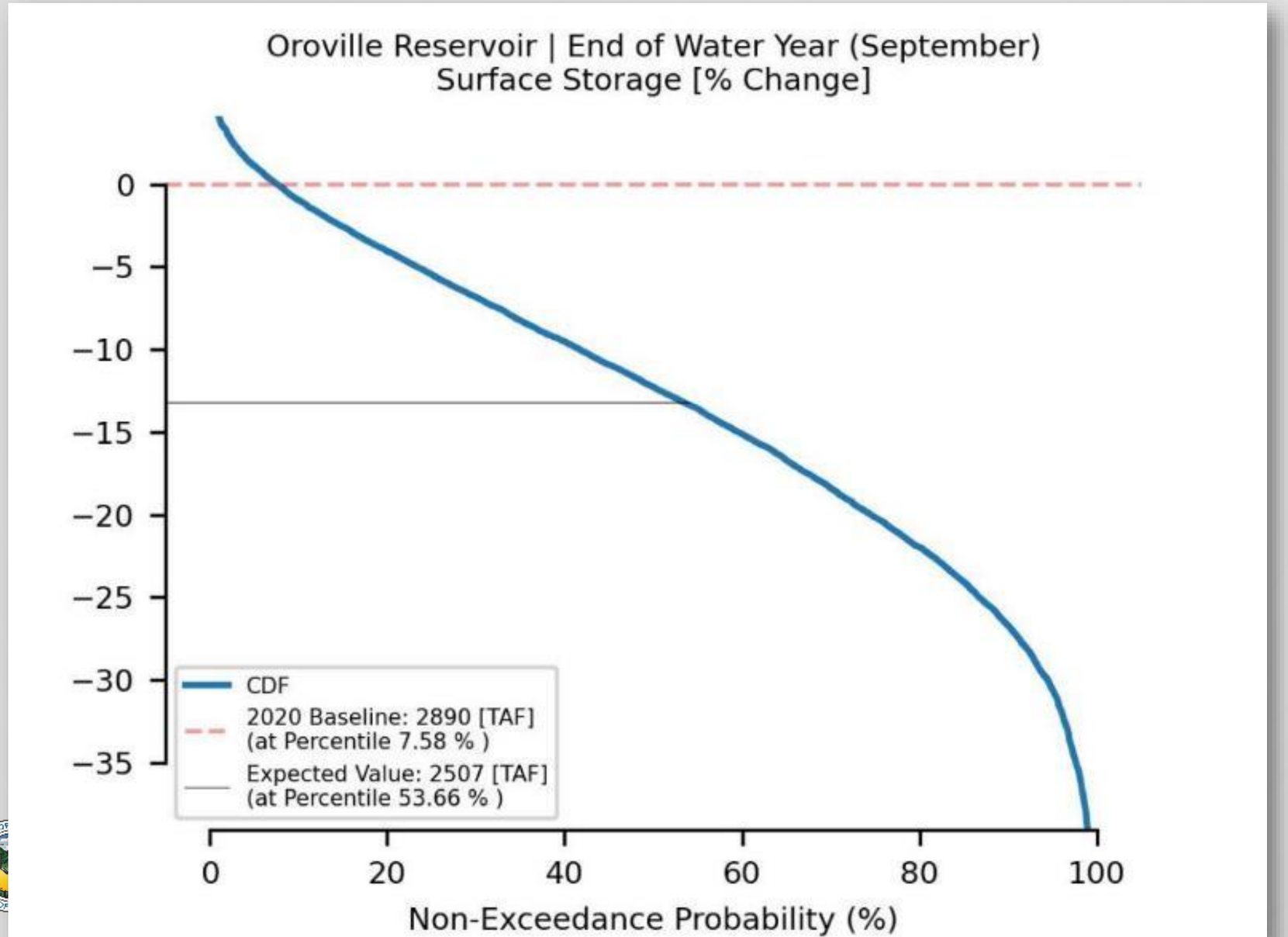
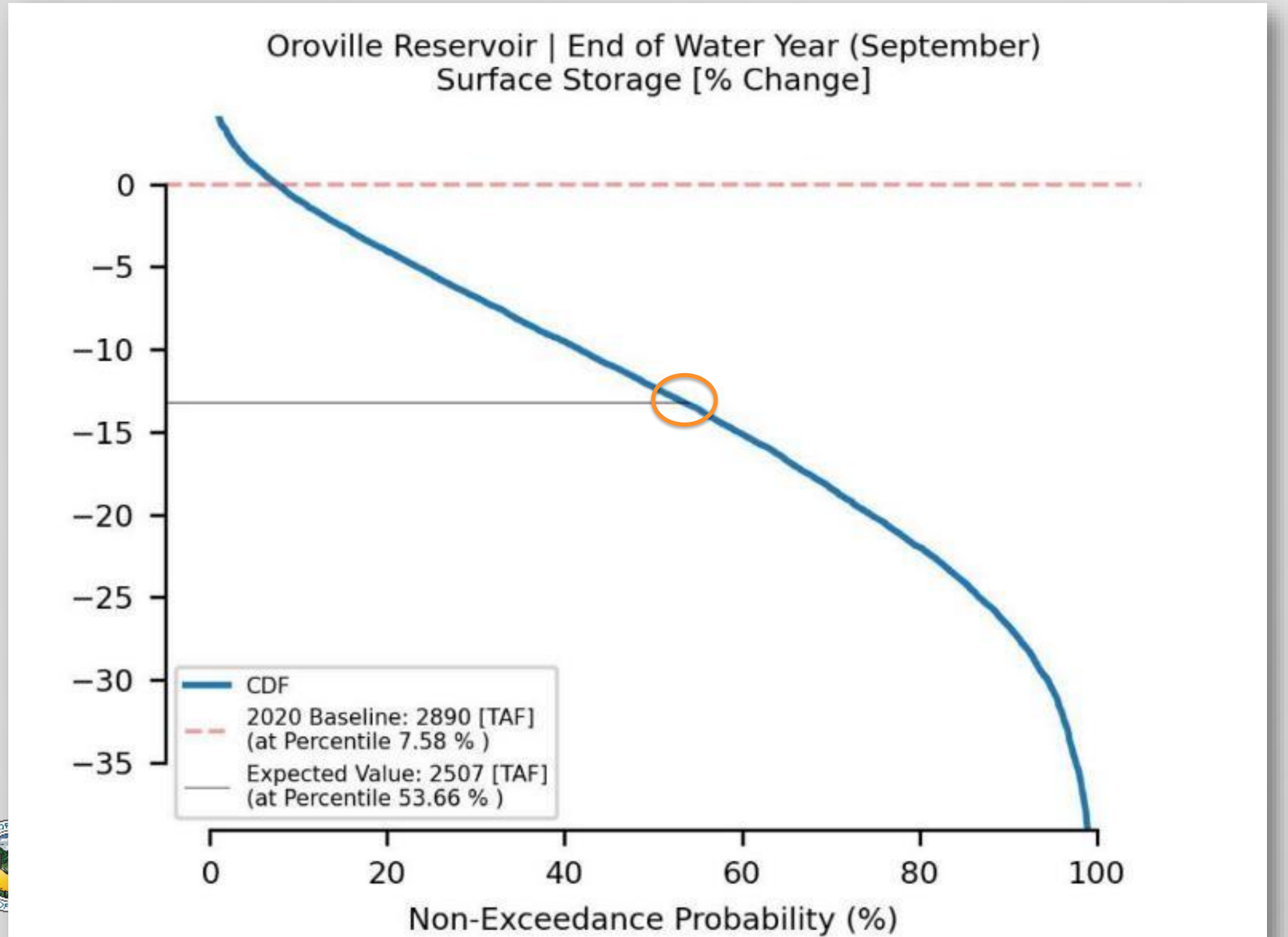


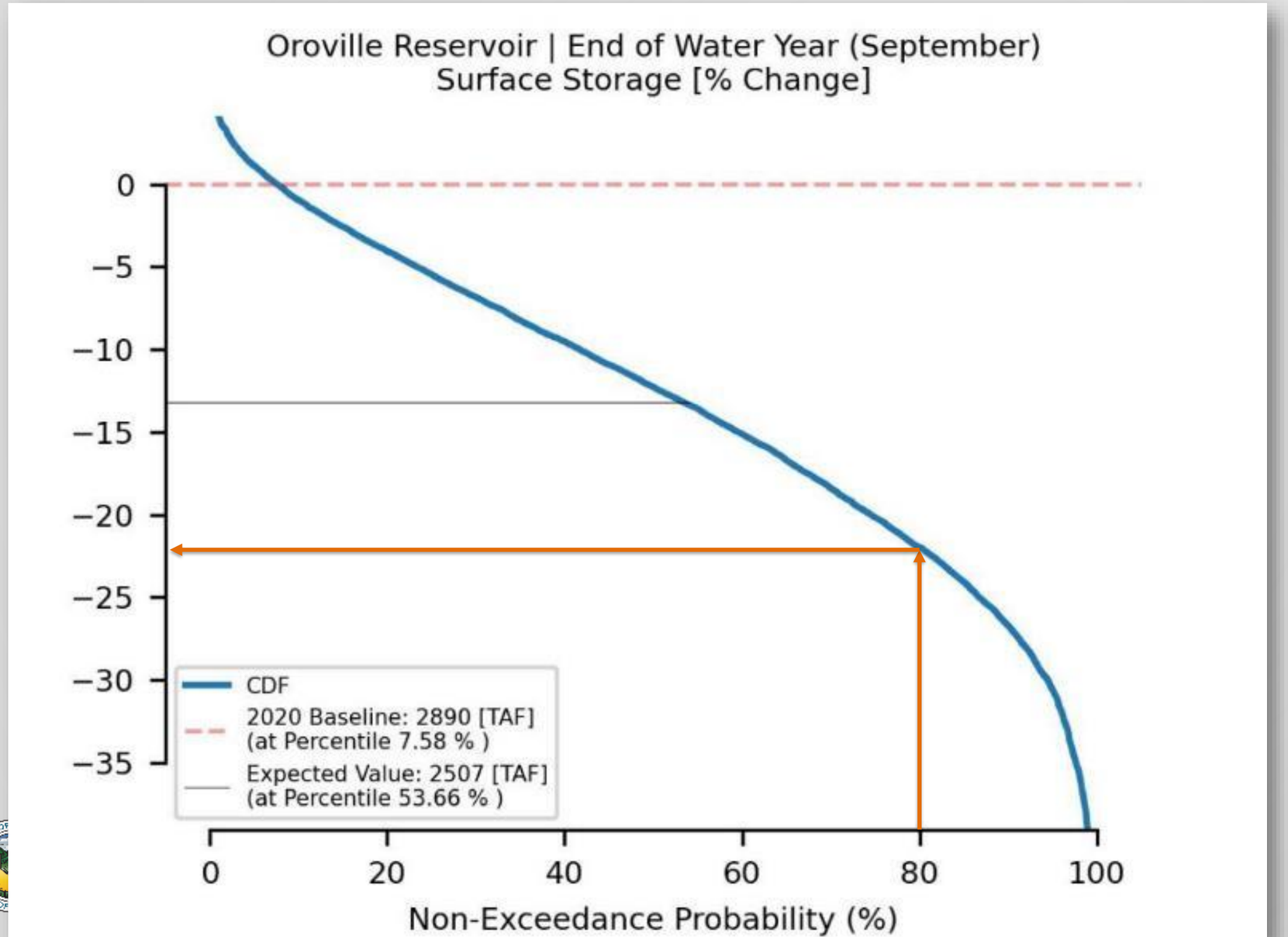
CDFs provide a probabilistic framework for the outcomes.

Metric 1 Surface Storage – Oroville



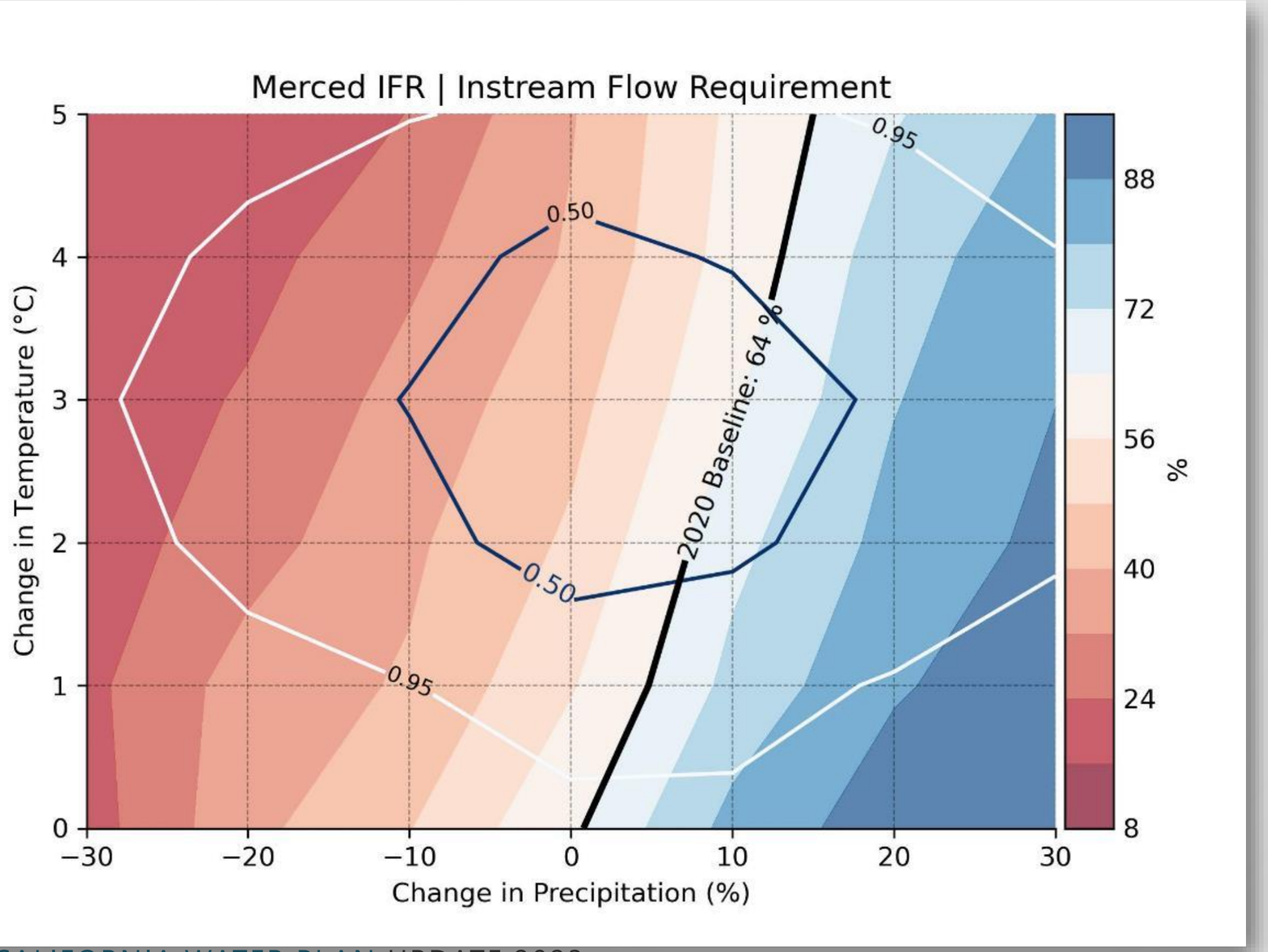
CDFs provide a probabilistic framework for the outcomes. These let you identify most likely conditions …

Metric 1 Surface Storage – Oroville



CDFs provide a probabilistic framework for the outcomes. These let you identify most likely conditions but they also let you set your own risk thresholds.

Metric 2 Environment – Merced River IFR



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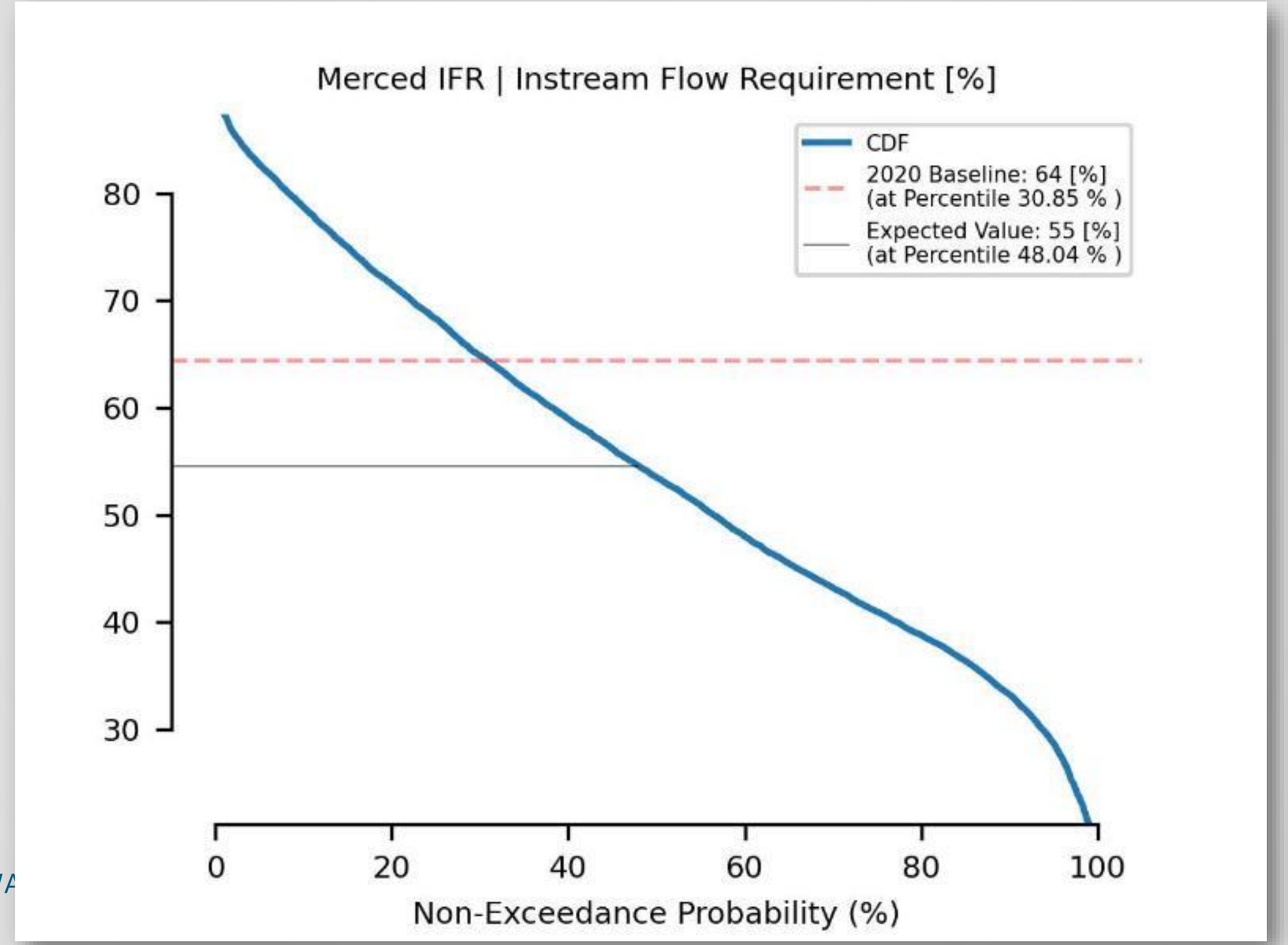
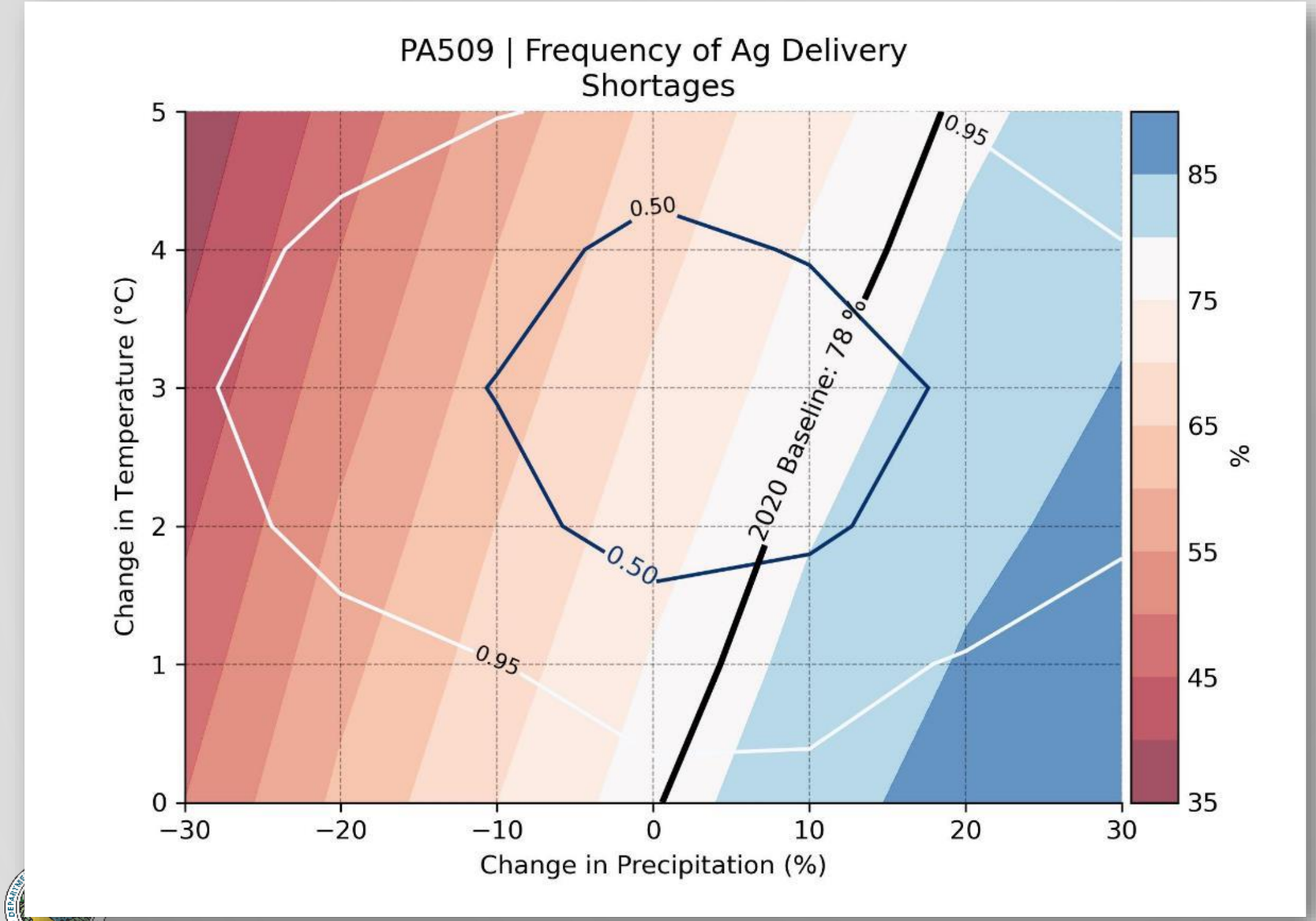
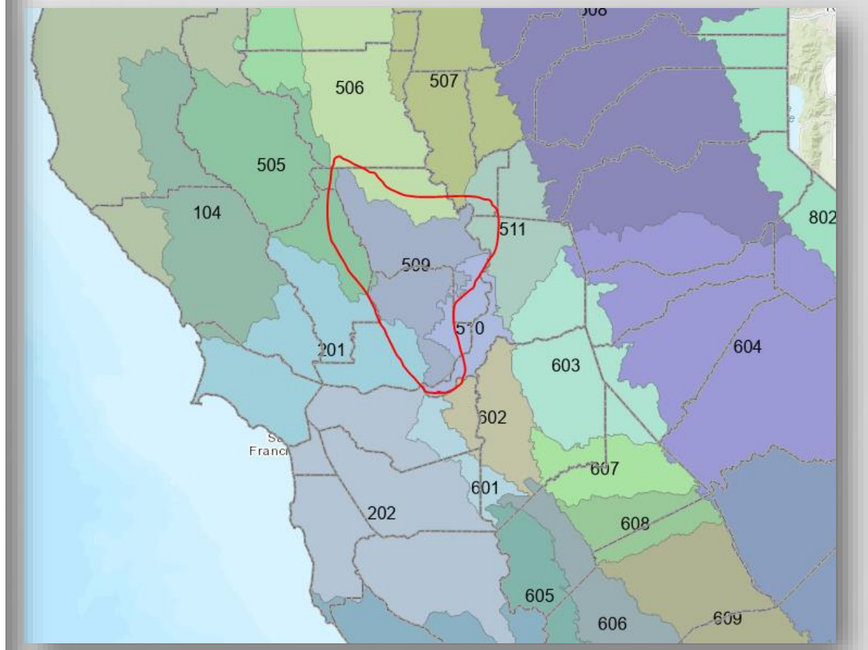


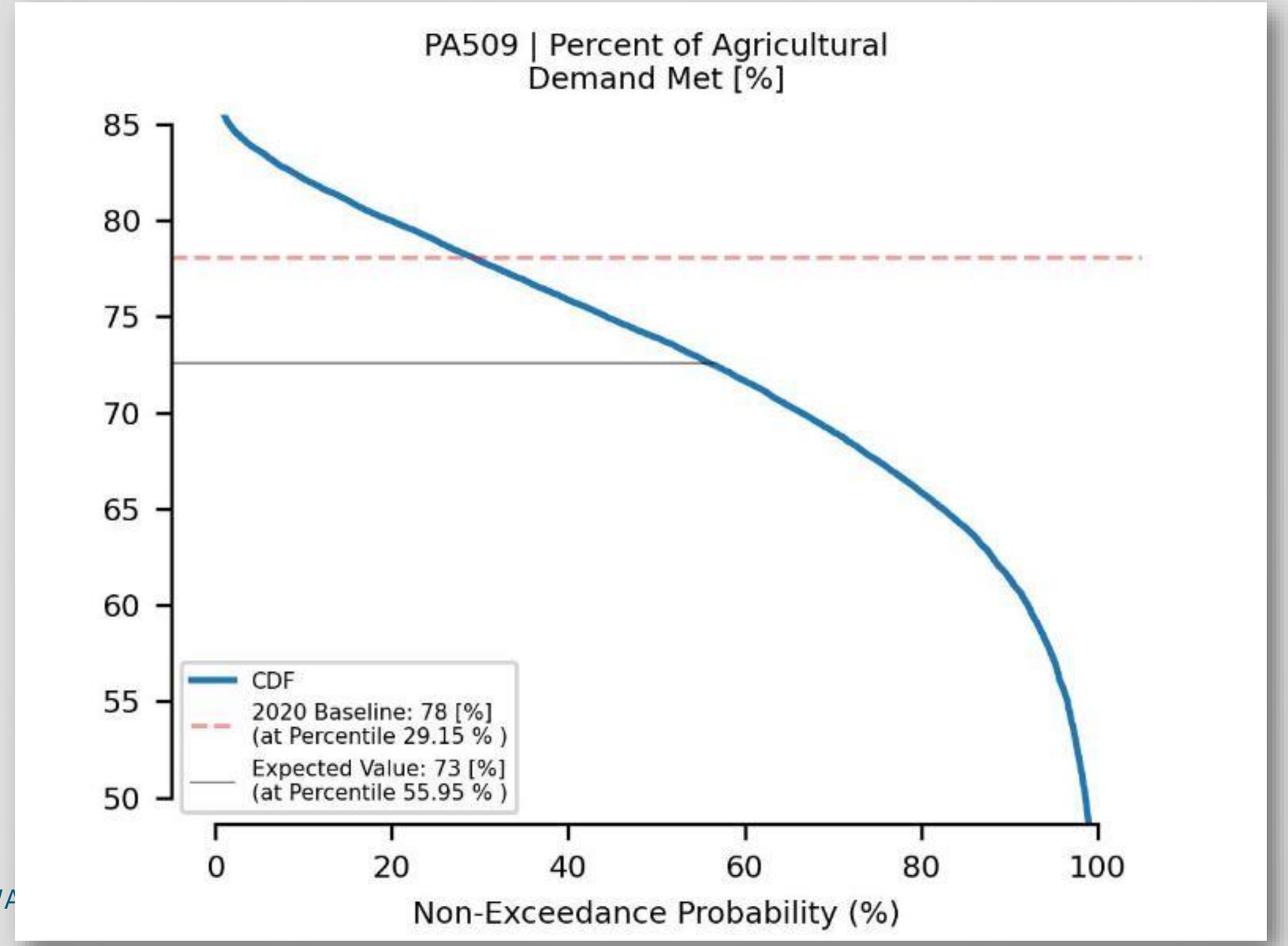
Metric 3 Agriculture – PA 509



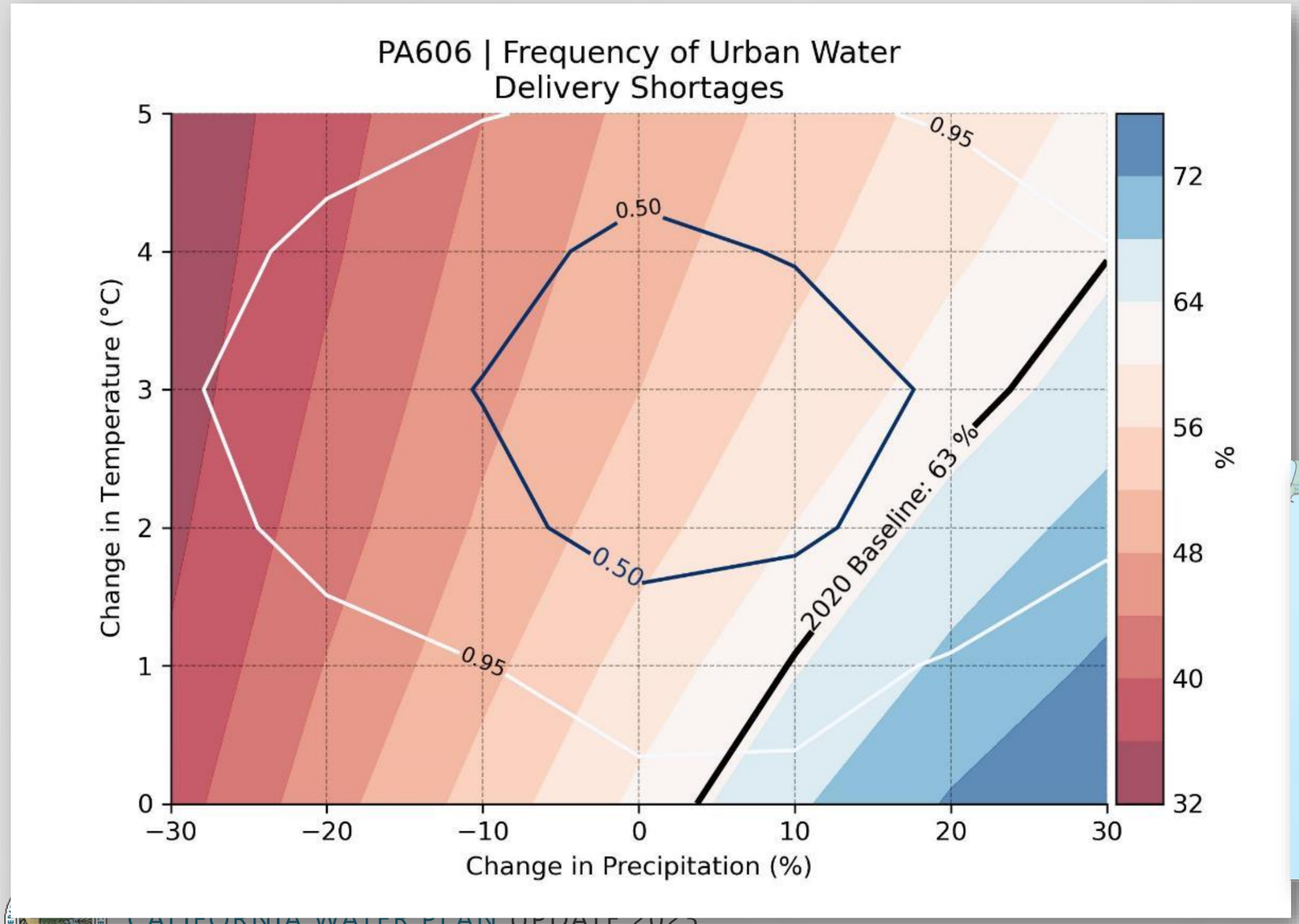
This area encompasses the west portion of C2VSIM Subregion 6 or Depletion Study Area (DSA) 65 and represents Woodland, Davis, Dixon, and Vacaville areas.



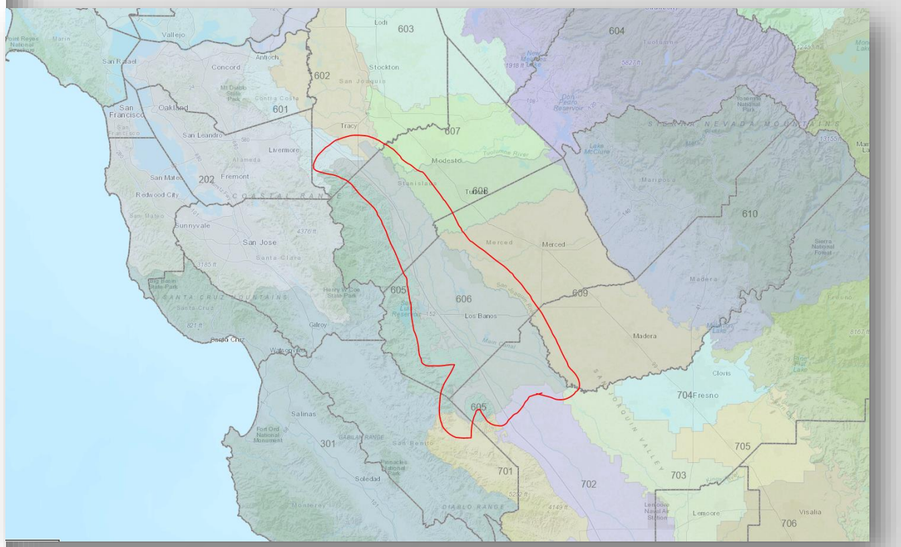
Metric 3 Agriculture – PA 509



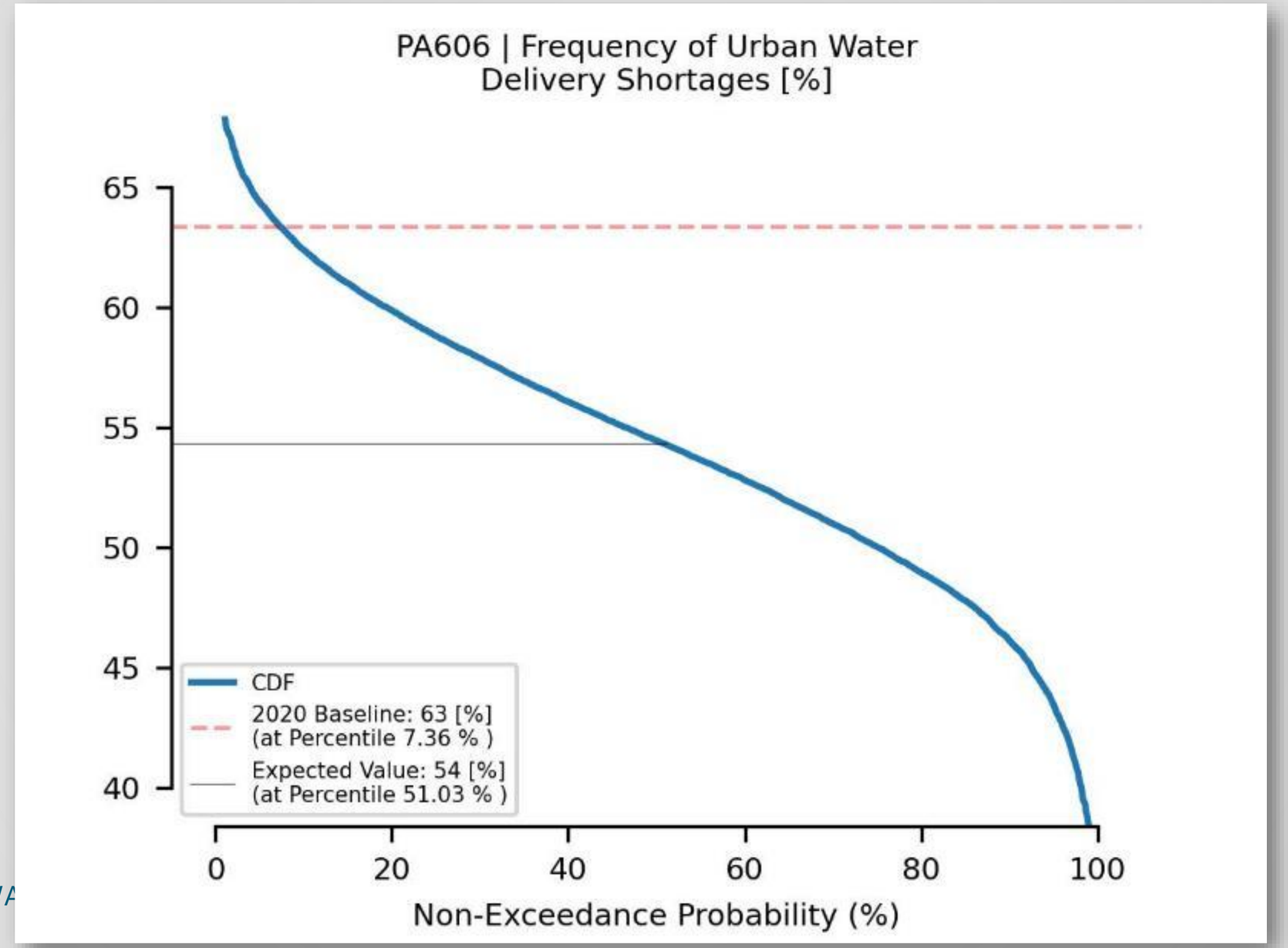
Metric 4 Urban – PA 606



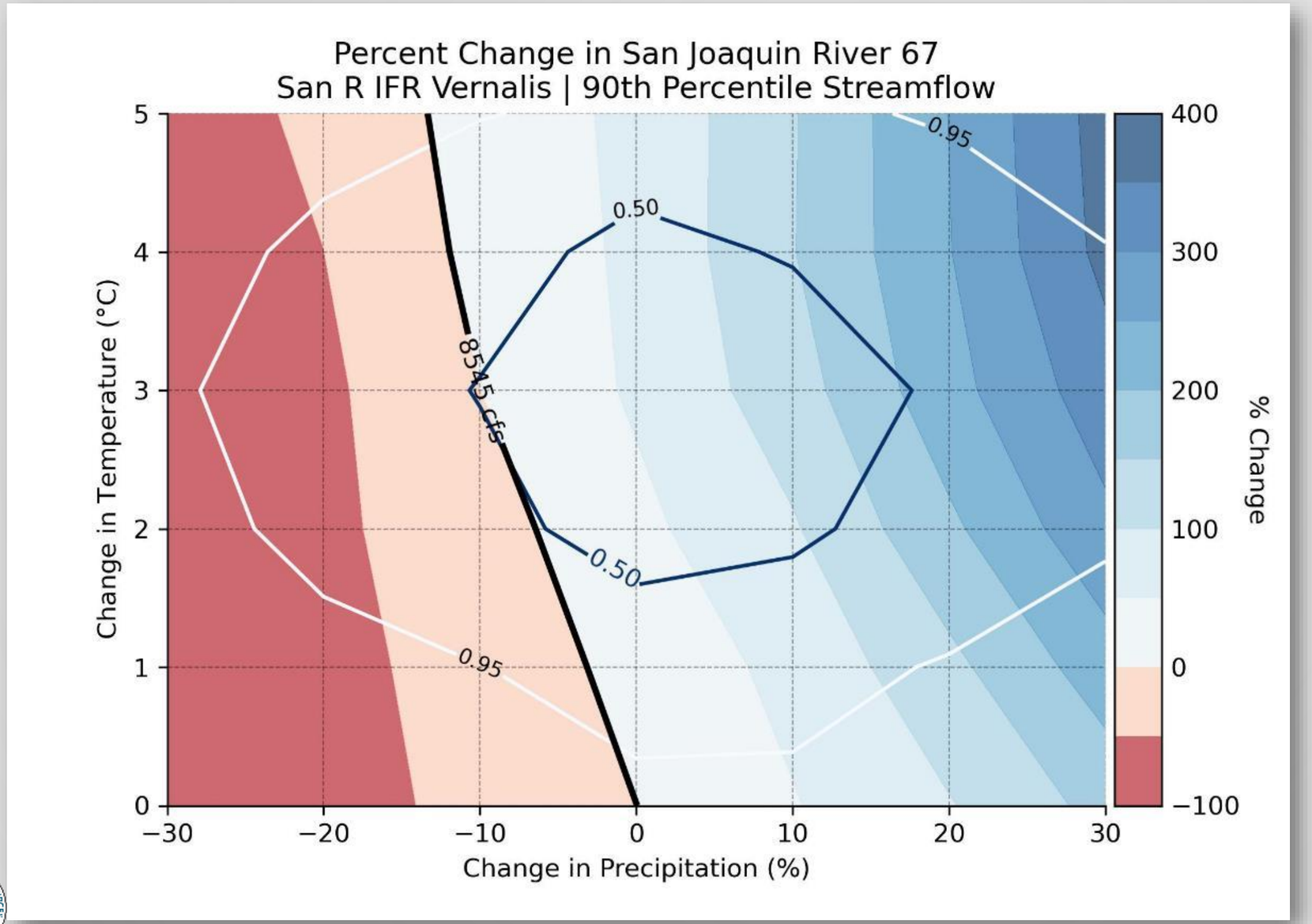
This area is the same as Subregion 10 of C2VSIM or Depletion Study Area (DSA) 49A and represents the Delta-Mendota Basin and includes Los Banos, Newman, Gustine, Patterson and Firebaugh.



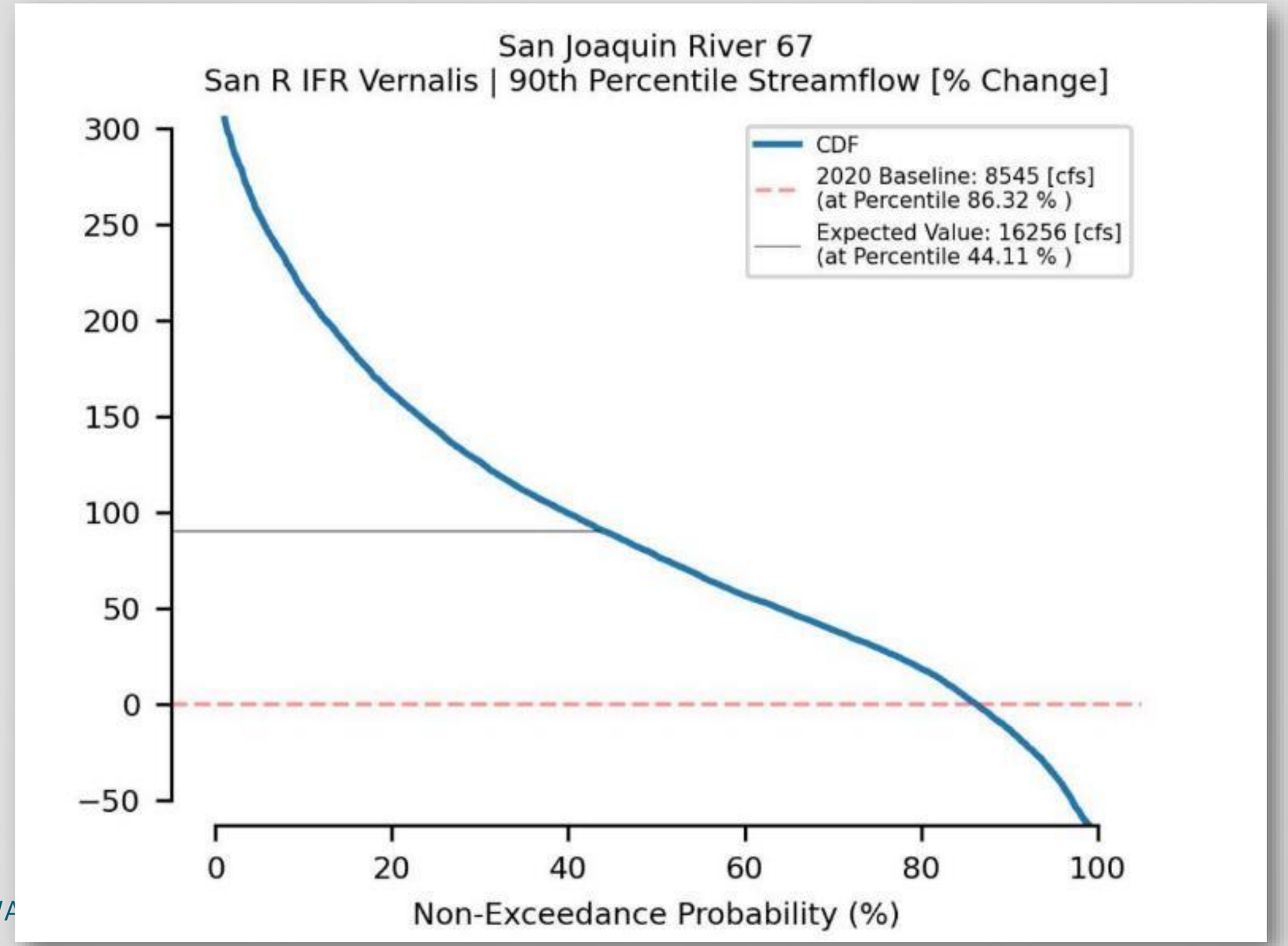
Metric 4 Urban – PA 606



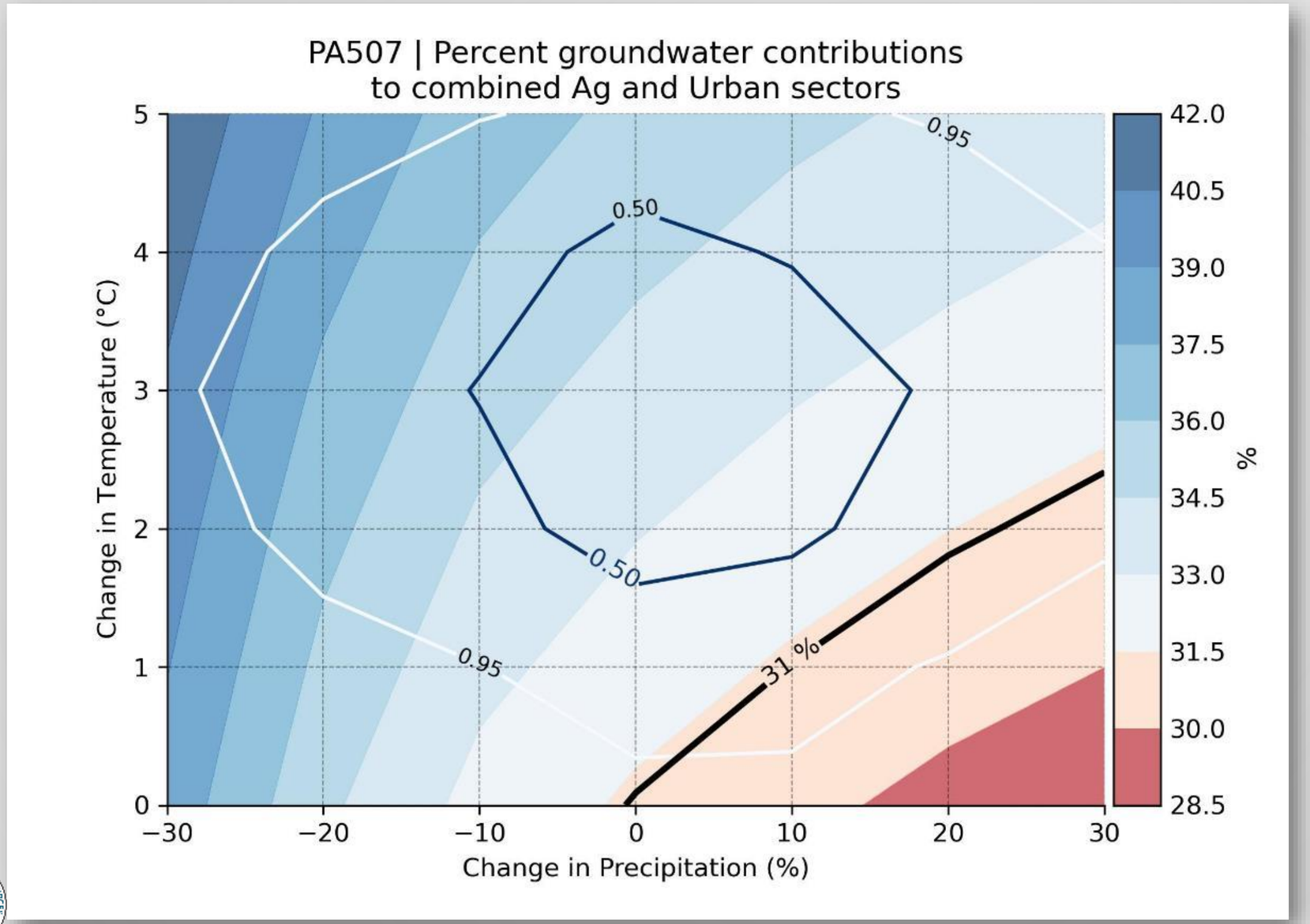
Metric 5 Flood Potential – Vernalis



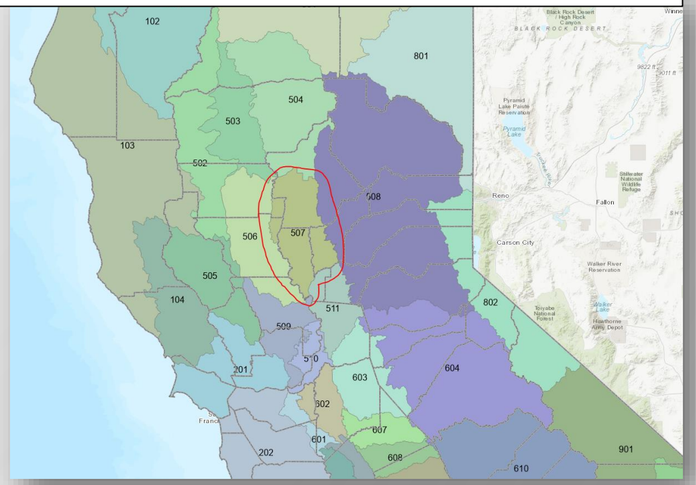
Metric 5 Flood Potential – Vernalis



Metric 6 GW System – PA 507



This area is the same as C2VSIM Subregion 5 or Depletion Study Area (DSA) 69 and represents Eastern Sacramento Basin Valley foothills near Sutter Buttes (North and South Yuba, East Butte and eastern parts of West Butte and Sutter



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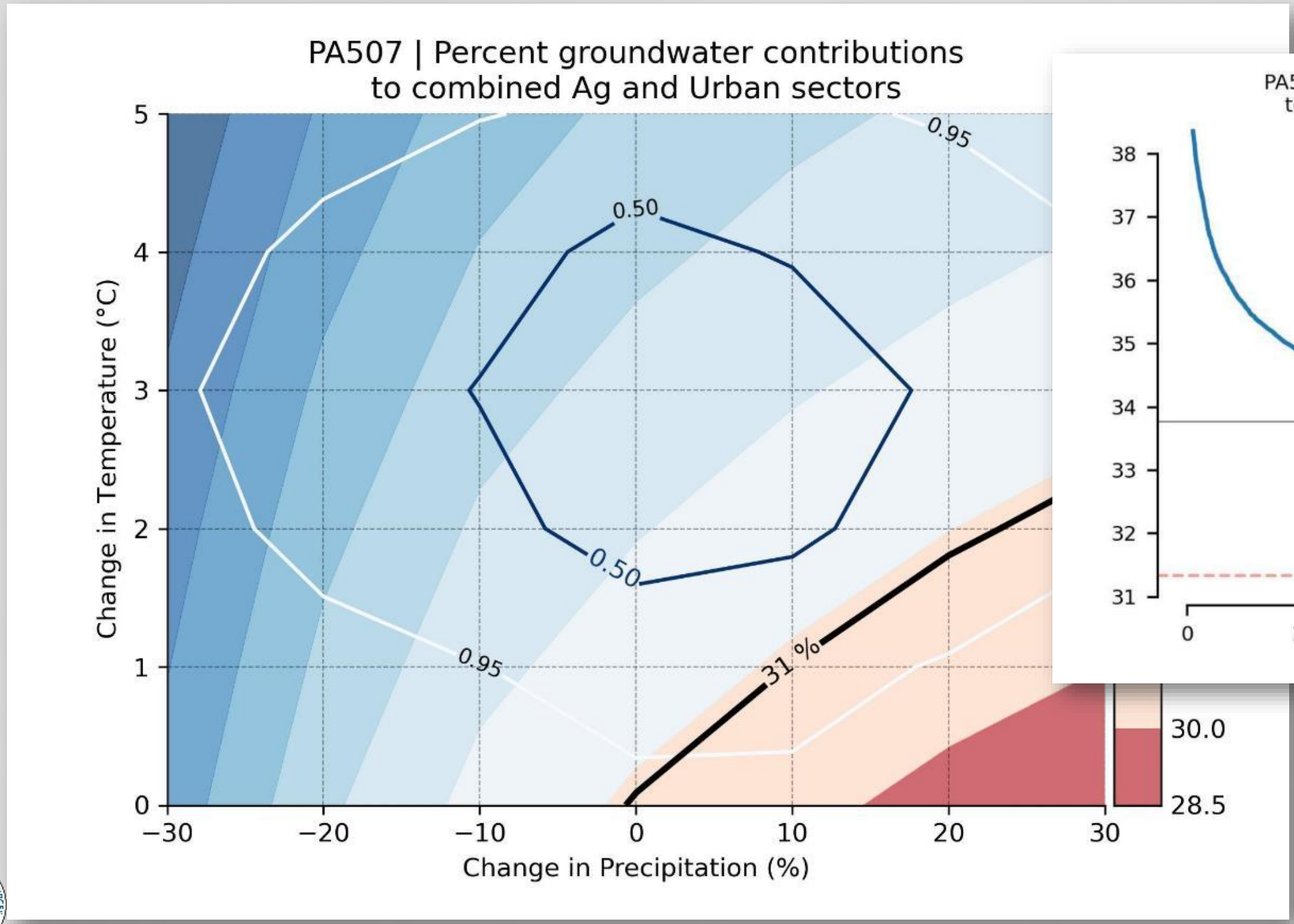
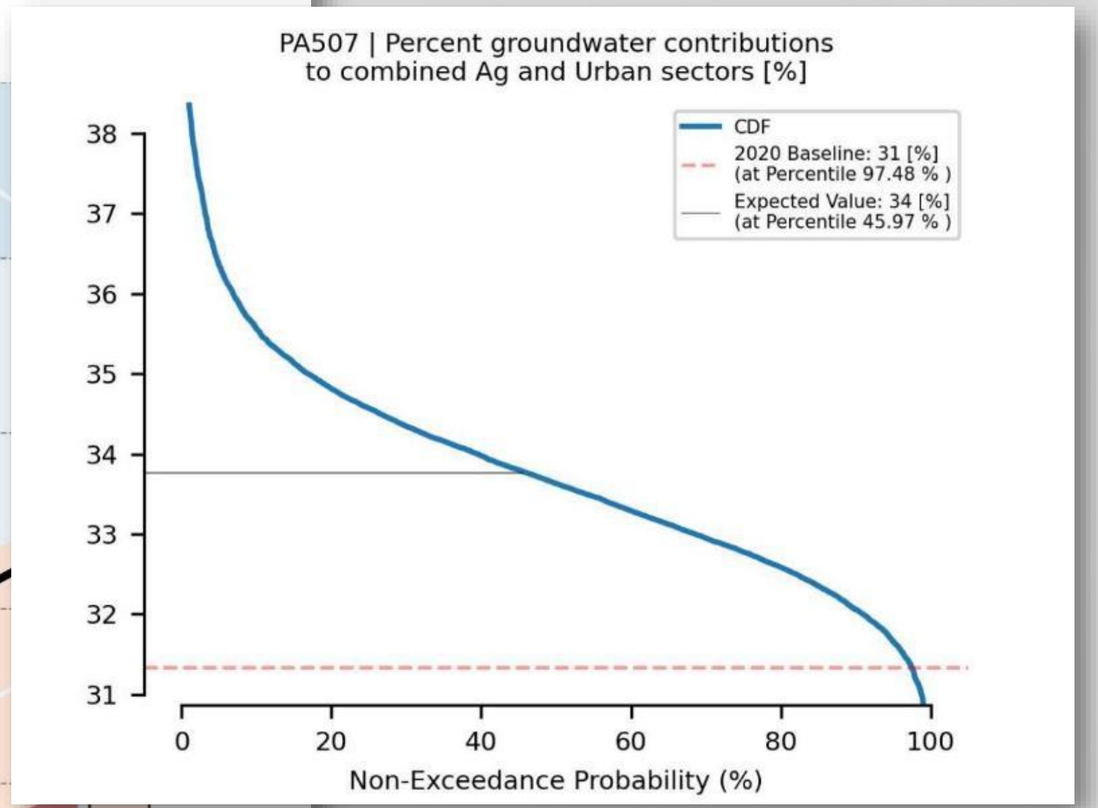
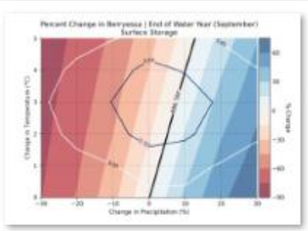
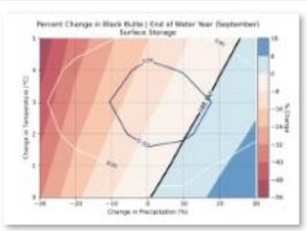
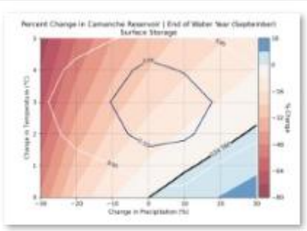


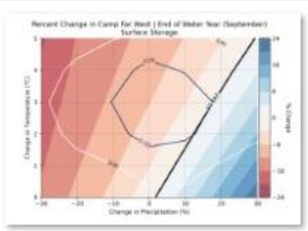


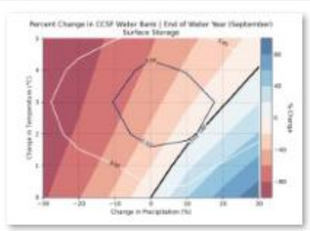
Metric 1 – All Response Surfaces

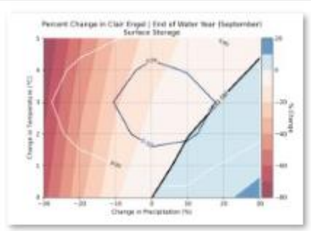

RS_Berryessa_rel_p

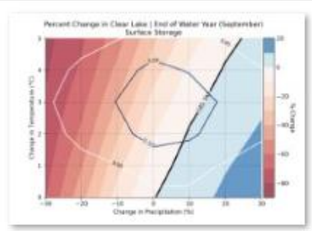

RS_Black Butte_rel_p

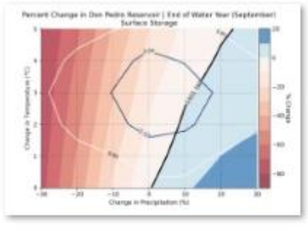

RS_Camanche Reservoir_rel_p

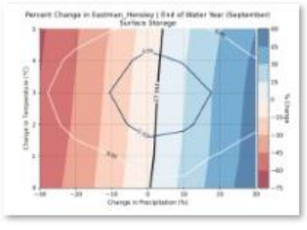

RS_Camp Far West_rel_p

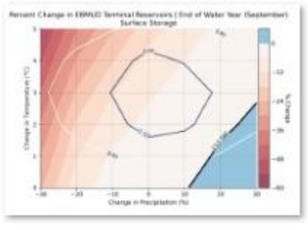

RS_CCSF Water Bank_rel_p

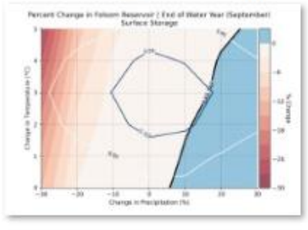

RS_Clair Engel_rel_p

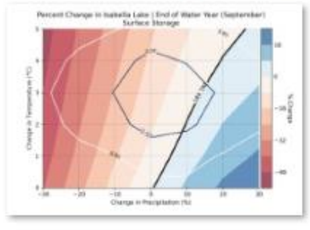

RS_Clear Lake_rel_p

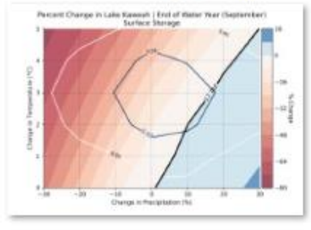

RS_Don Pedro Reservoir_rel_p

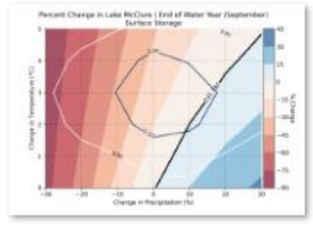

RS_Eastman_Hensley_rel_p

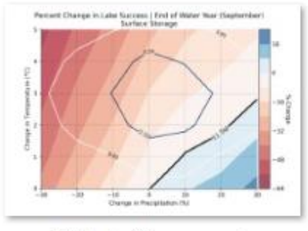

RS_EBMUD Terminal Reservoirs_rel_p

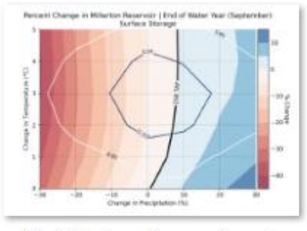

RS_Folsom Reservoir_rel_p

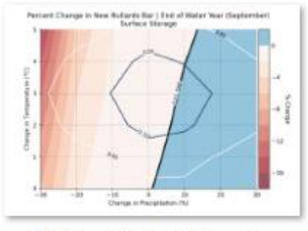

RS_Isabella Lake_rel_p

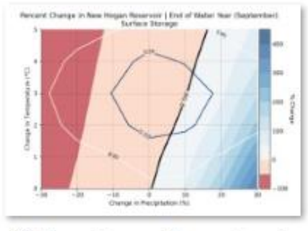

RS_Lake Kaweah_rel_p

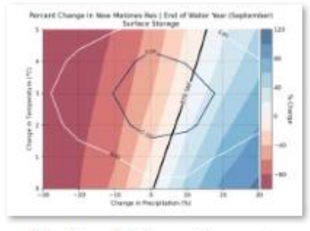

RS_Lake McClure_rel_p

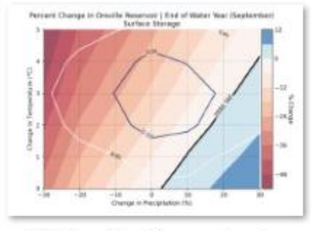

RS_Lake Success_rel_p

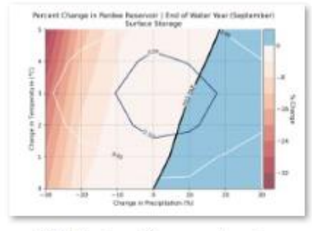

RS_Millerton Reservoir_rel_p

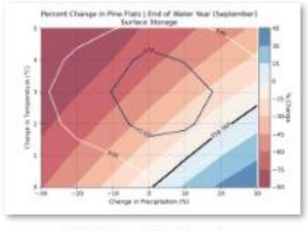

RS_New Bullards Bar_rel_p

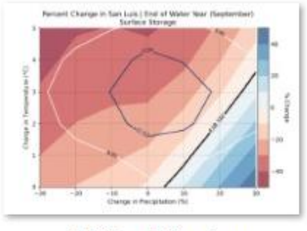

RS_New Hogan Reservoir_rel_p

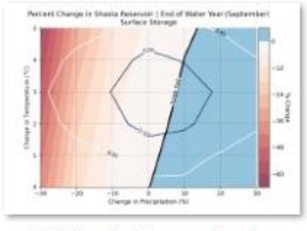

RS_New Melones Res_rel_p


RS_Oroville Reservoir_rel_p


RS_Pardee Reservoir_rel_p

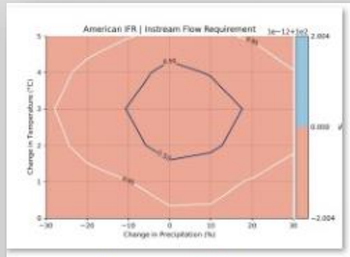

RS_Pine Flats_rel_p


RS_San Luis_rel_p

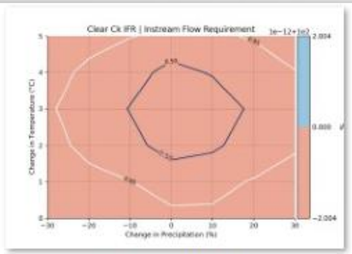

RS_Shasta Reservoir_rel_p


RS_Tulloch_rel_p

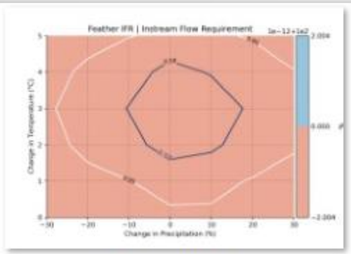
Metric 2 – All Response Surfaces



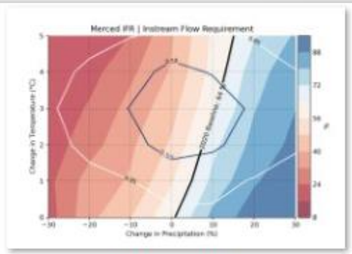
RS_American IFR_abs



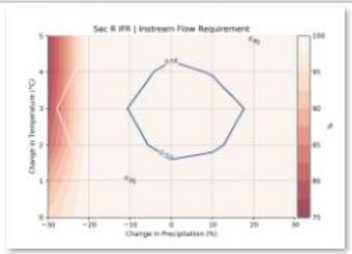
RS_Clear Ck IFR_abs



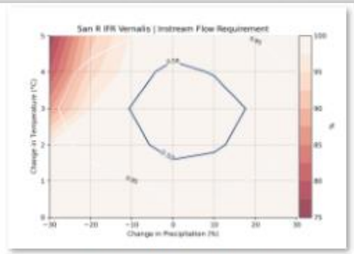
RS_Feather IFR_abs



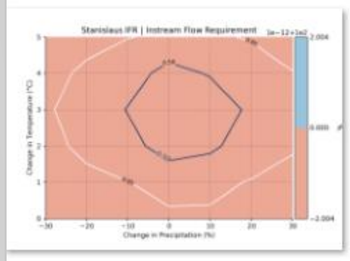
RS_Merced IFR_abs



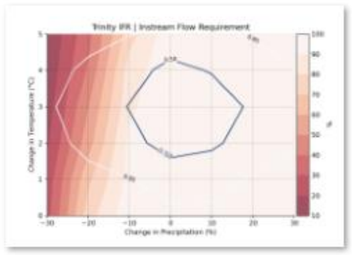
RS_Sac R IFR_abs



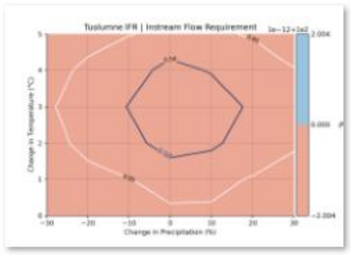
RS_San R IFR Vernalis_abs



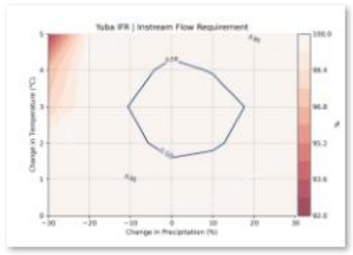
RS_Stanislaus IFR_abs



RS_Trinity IFR_abs

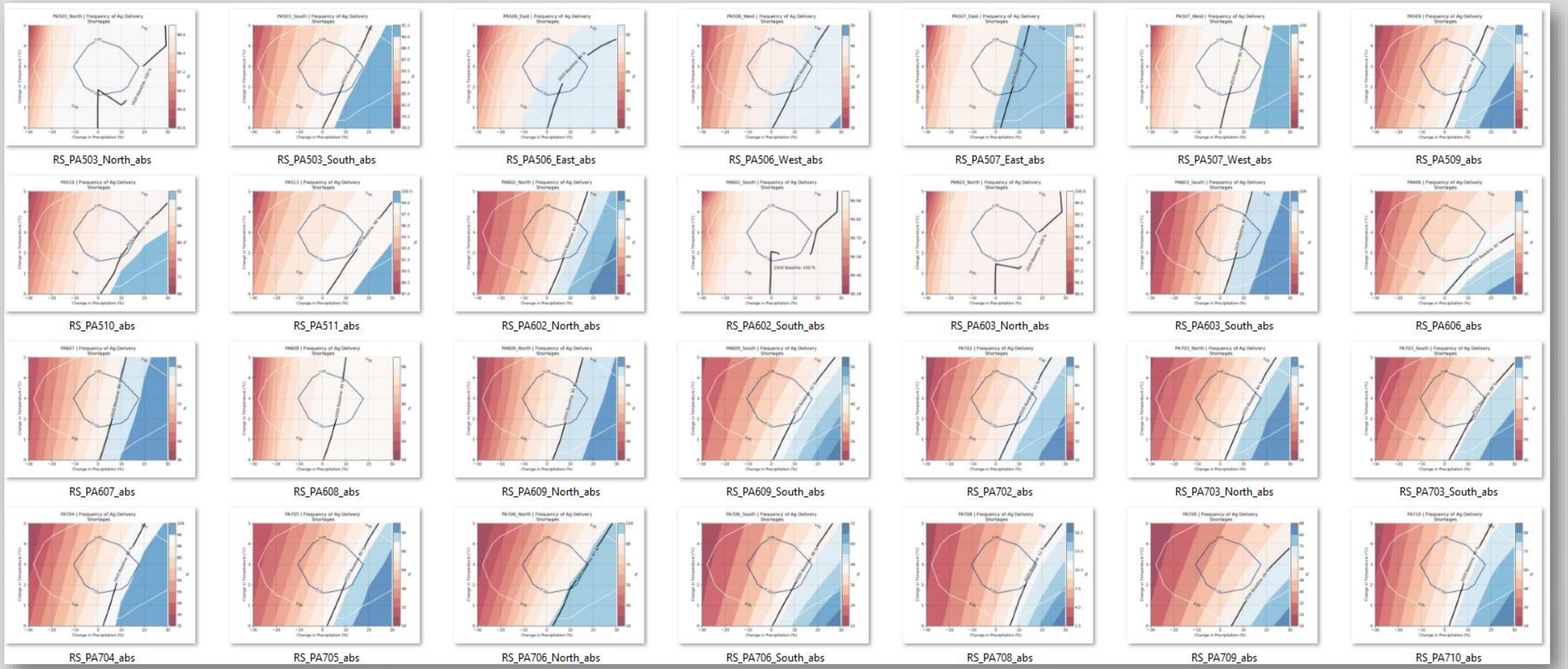


RS_Tuolumne IFR_abs

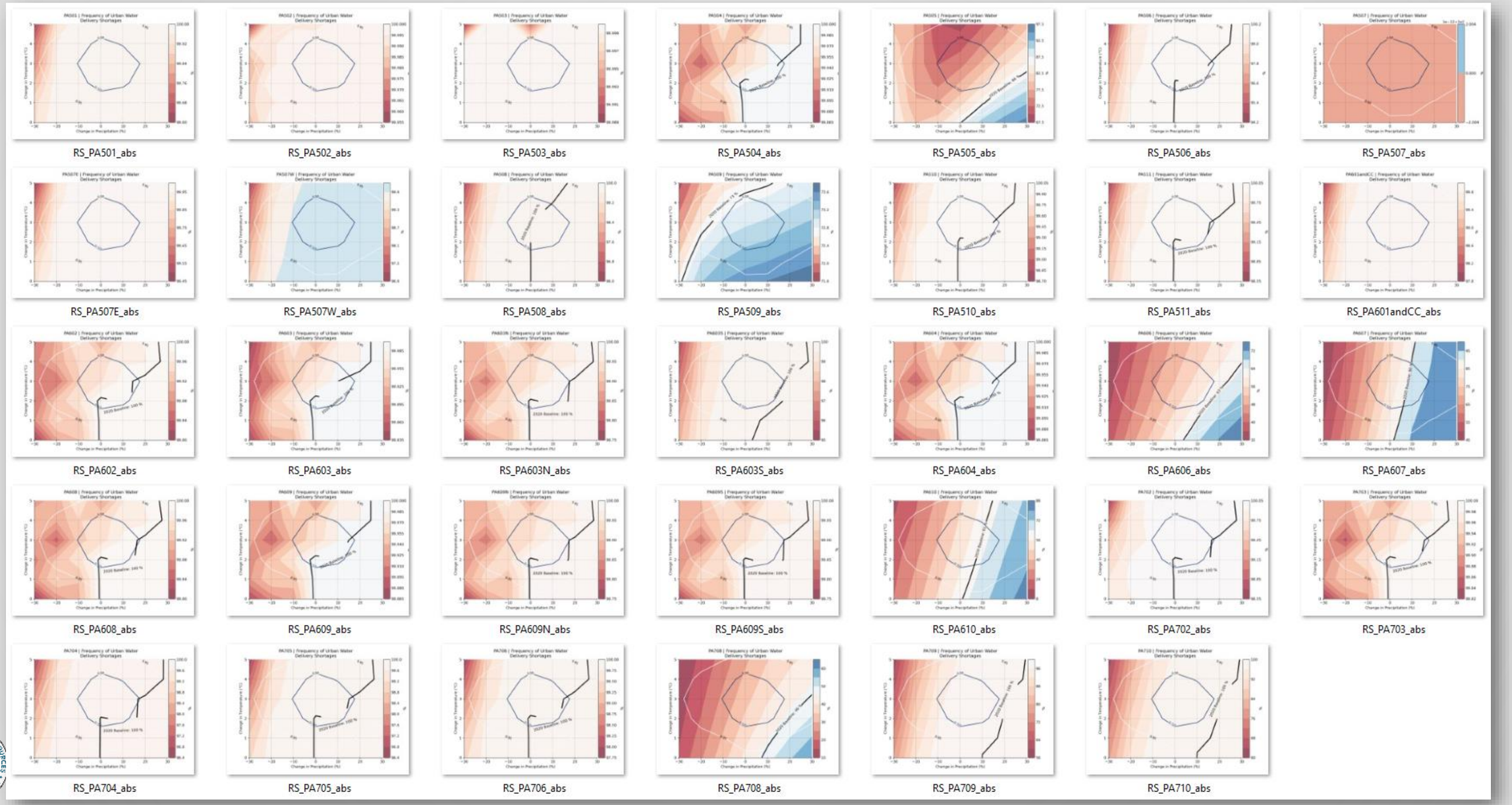


RS_Yuba IFR_abs

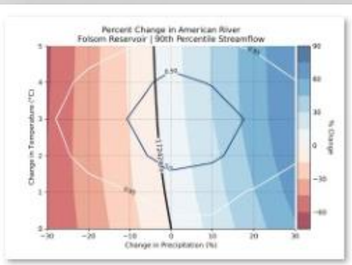
Metric 3 – All Response Surfaces



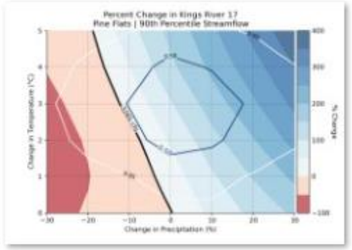
Metric 4 – All Response Surfaces

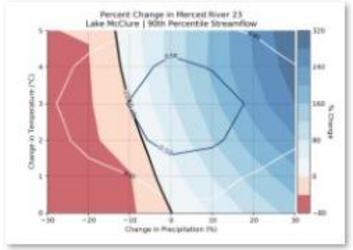


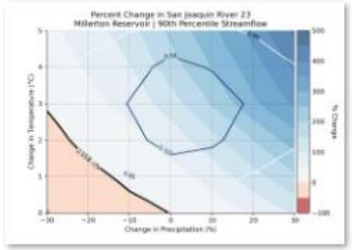
Metric 5 – All Response Surfaces

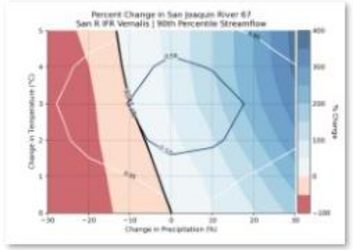

RS_AR-FR_rel_p

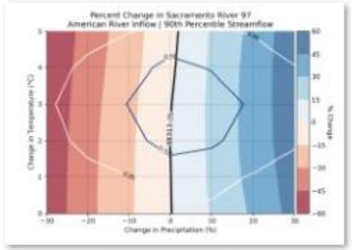

RS_FR-OR_rel_p

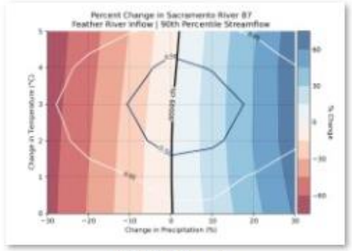

RS_KR-PF_rel_p

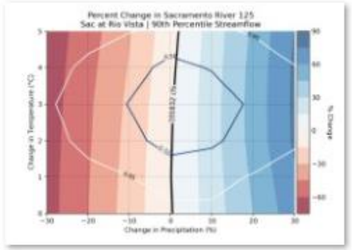

RS_MR-LM_rel_p

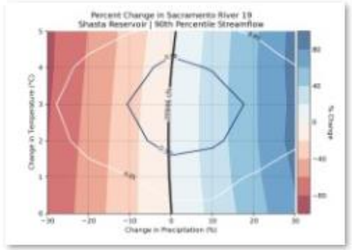

RS_SJR-MR_rel_p


RS_SJR-Ver_rel_p

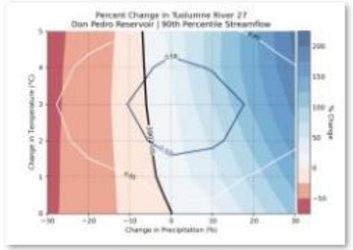

RS_SR-ARin_rel_p


RS_SR-FRin_rel_p


RS_SR-RV_rel_p


RS_SR-ShR_rel_p


RS_St-NM_rel_p


RS_TL-NDP_rel_p


RS_Y-NBB_rel_p

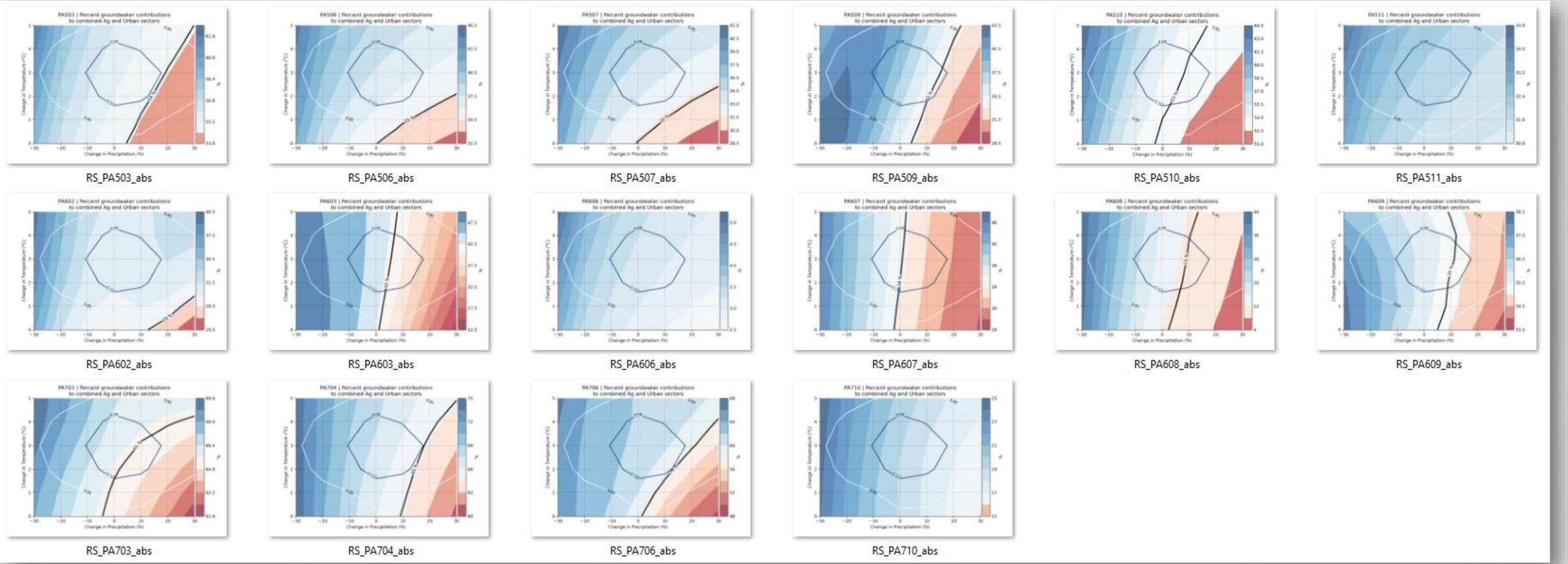
Control Points

Sacramento HR
1. Folsom Reservoir Outflow
2. Oroville Reservoir Outflow
3. Shasta Reservoir Outflow
4. Confluence of Feather and Sacramento River
5. Confluence of American and Sacramento River
6. Sacramento River at Rio Vista
7. New Bullards Bar Outflow

San Joaquin HR
1. Lake McClure Outflow
2. Millerton Reservoir Outflow
3. San Joaquin River at Vernalis
4. New Melones Reservoir Outflow
5. Den Pedro Reservoir Outflow

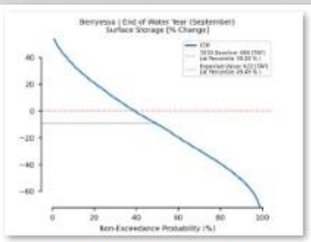
Tulare Lake HR
1. Kings River at Pine Flats

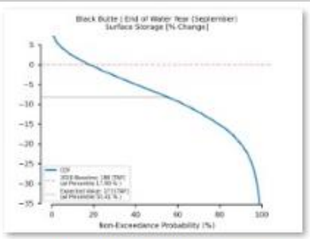
Metric 6 – All Response Surfaces

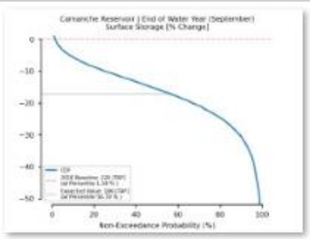


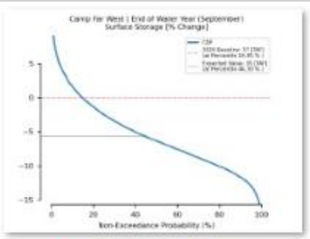
Note: Not all PAs had access to GW which is why not all PAs are shown

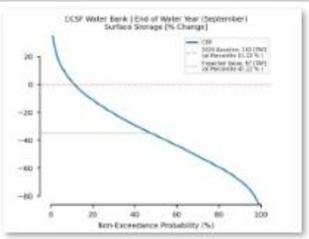
Metric 1 – All CDFs

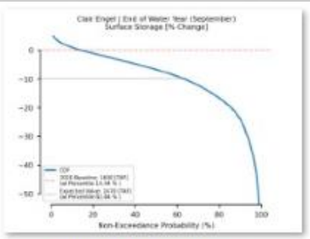

CDF_Berryessa_rel_p

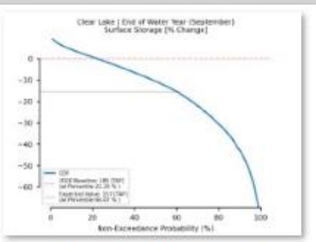

CDF_Black Butte_rel_p

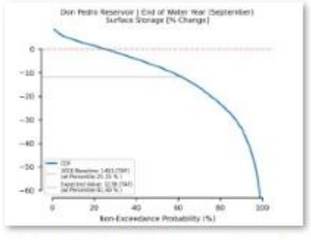

CDF_Camanche Reservoir_rel_p

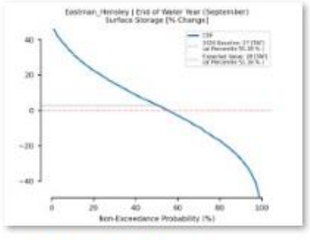

CDF_Camp Far West_rel_p

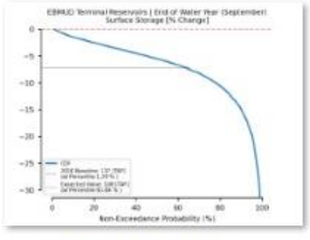

CDF_CCSF Water Bank_rel_p

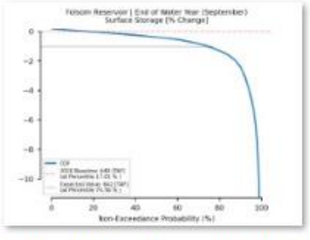

CDF_Clair Engel_rel_p

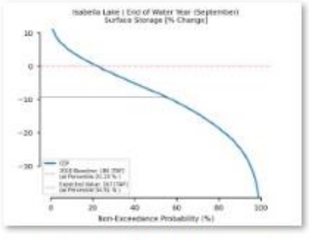

CDF_Clear Lake_rel_p

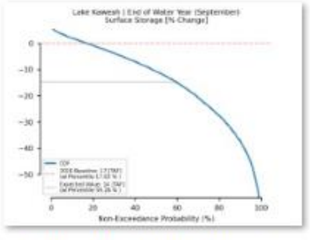

CDF_Don Pedro Reservoir_rel_p

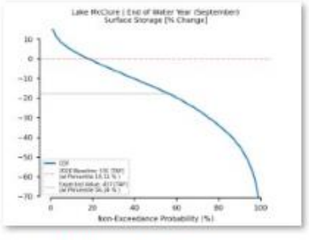

CDF_Eastman_Hensley_rel_p

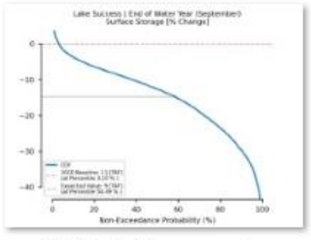

CDF_EBMUD Terminal Reservoirs_rel_p

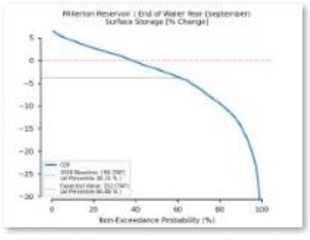

CDF_Folsom Reservoir_rel_p

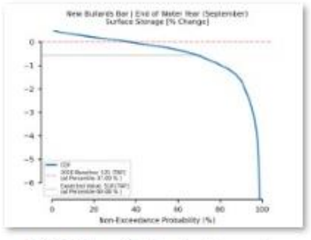

CDF_Isabella Lake_rel_p

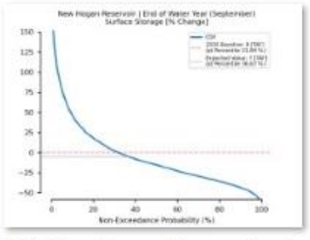

CDF_Lake Kaweah_rel_p

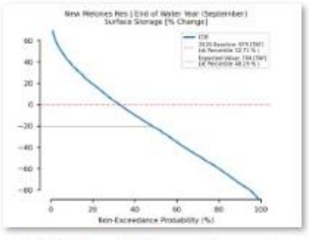

CDF_Lake McClure_rel_p

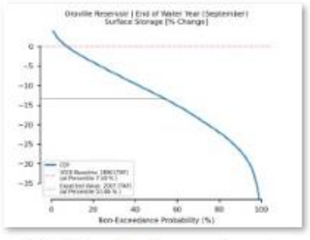

CDF_Lake Success_rel_p

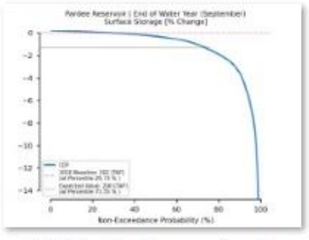

CDF_Millerton Reservoir_rel_p

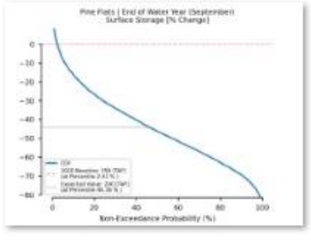

CDF_New Bullards Bar_rel_p

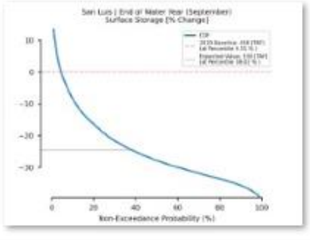

CDF_New Hogan Reservoir_rel_p

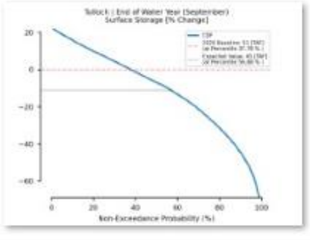

CDF_New Melones Res_rel_p


CDF_Oroville Reservoir_rel_p

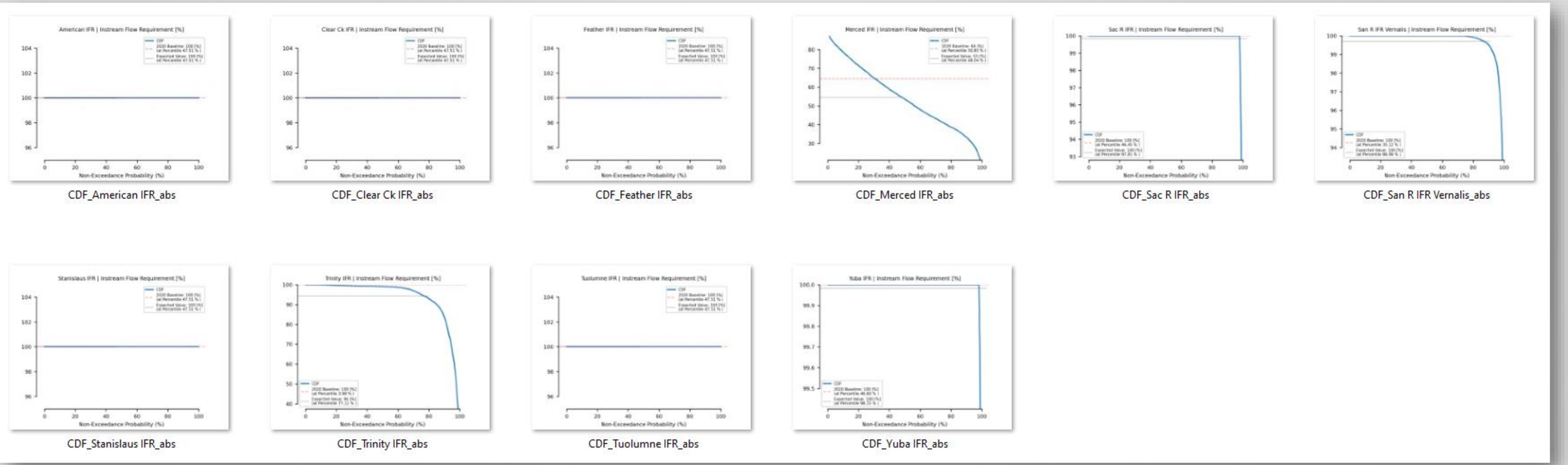

CDF_Pardee Reservoir_rel_p







Metric 2 – All CDFs



CDF_American IFR_abs

CDF_Clear Ck IFR_abs

CDF_Feather IFR_abs

CDF_Merced IFR_abs

CDF_Sac R IFR_abs

CDF_San R IFR Vernalis_abs

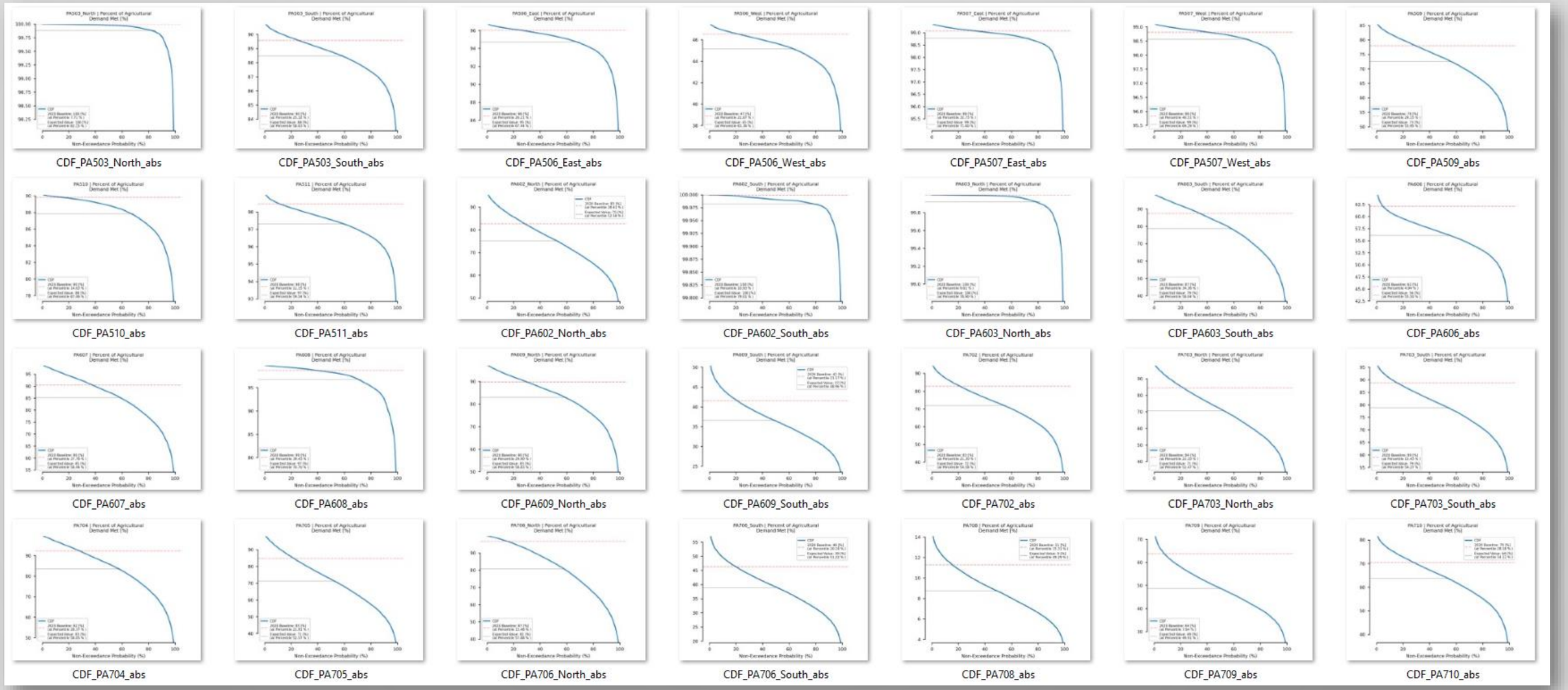
CDF_Stanislaus IFR_abs

CDF_Trinity IFR_abs

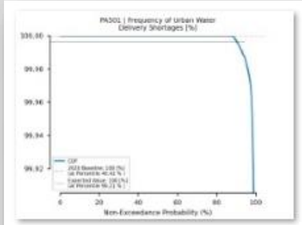
CDF_Tuolumne IFR_abs

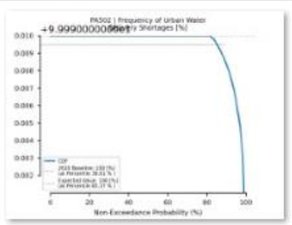
CDF_Yuba IFR_abs

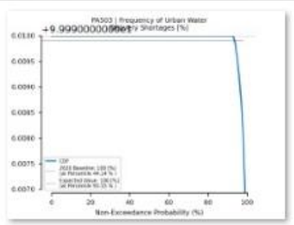
Metric 3 – All CDFs

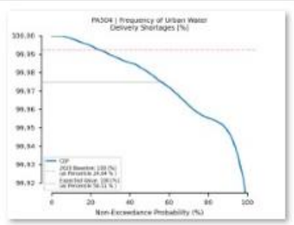


Metric 4 – All CDFs


CDF_PA501_abs


CDF_PA502_abs


CDF_PA503_abs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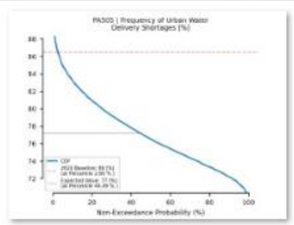
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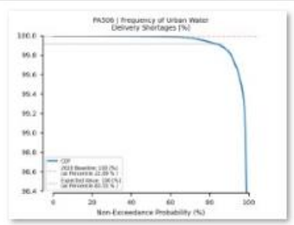
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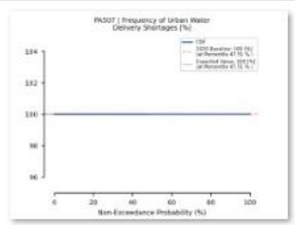
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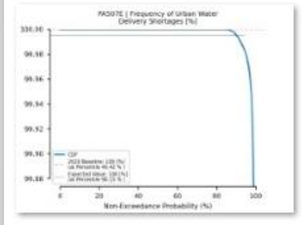
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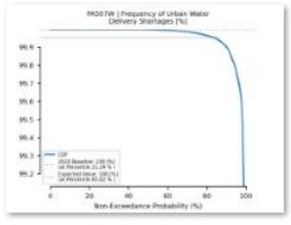
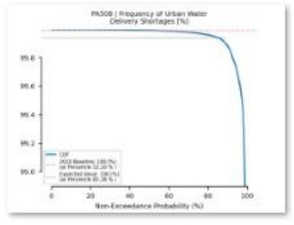

CDF_PA507W_abs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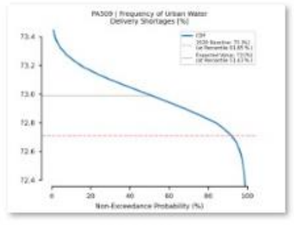
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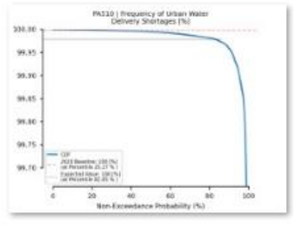
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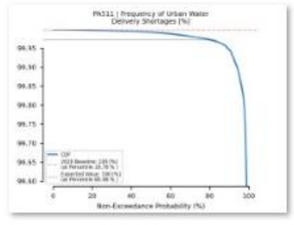
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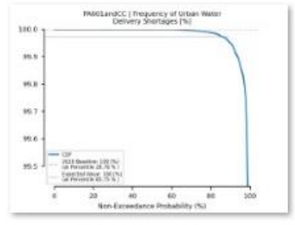
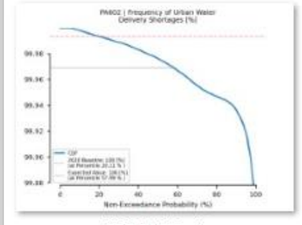

CDF_PA601andCC_abs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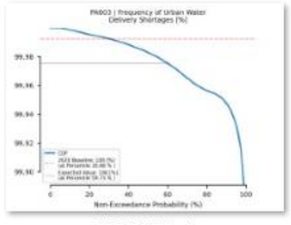
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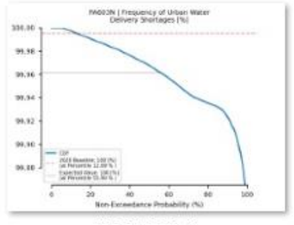
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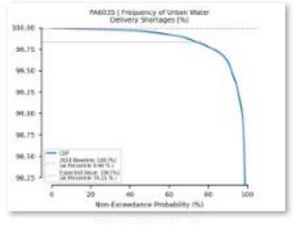
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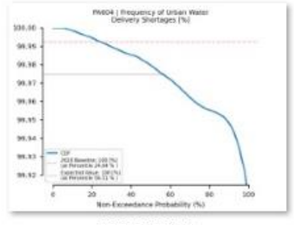
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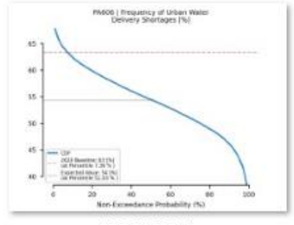
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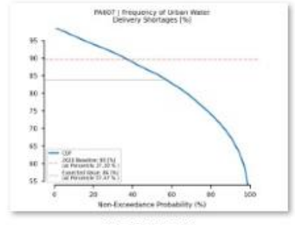
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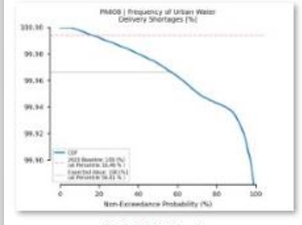
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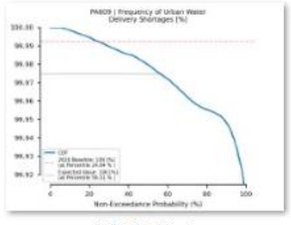
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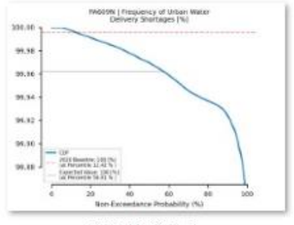
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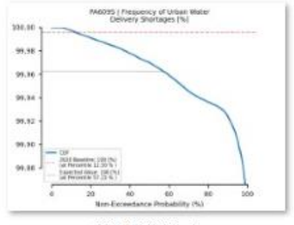
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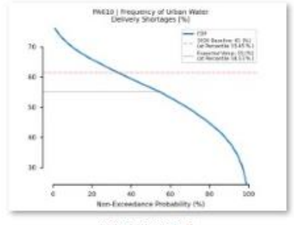
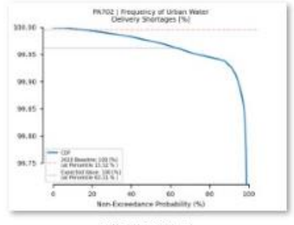

CDF_PA610_abs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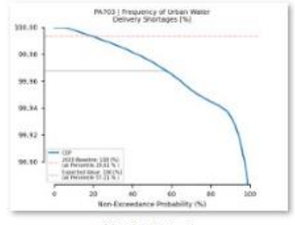
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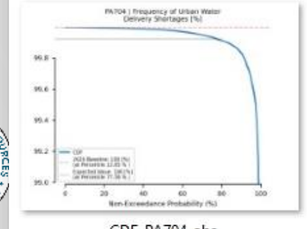
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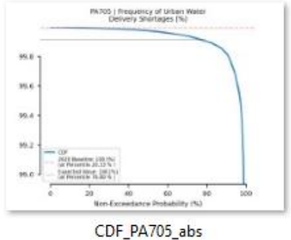
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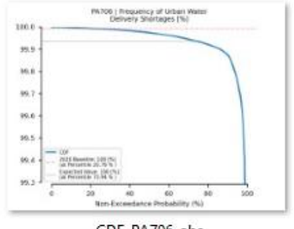
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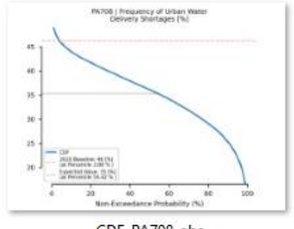
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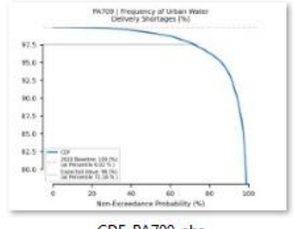
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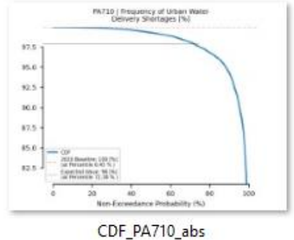
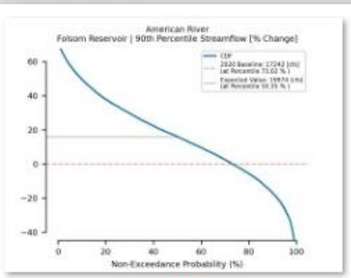
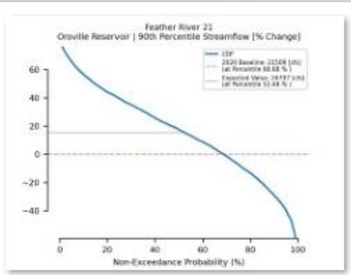

CDF_PA710_abs

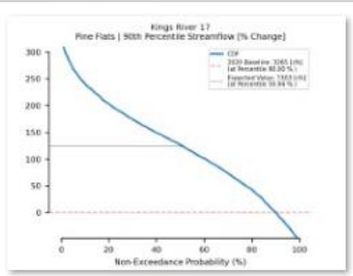
Metric 5 – All CDFs



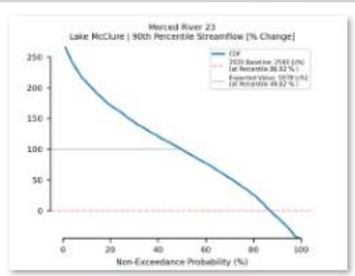
CDF_AR-FR_rel_p



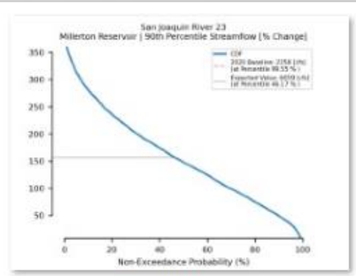
CDF_FR-OR_rel_p



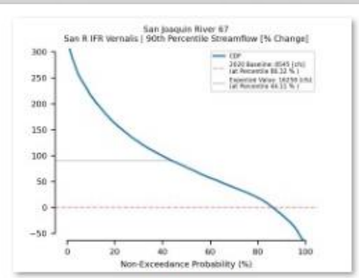
CDF_KR-PF_rel_p



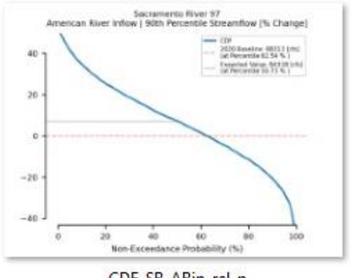
CDF_MR-LM_rel_p



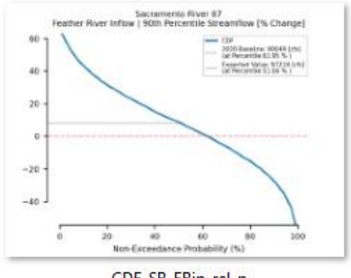
CDF_SJR-MR_rel_p



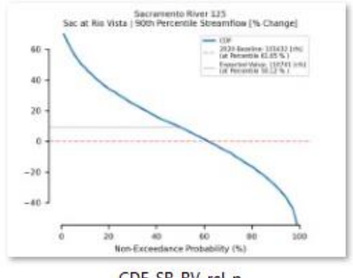
CDF_SJR-Ver_rel_p



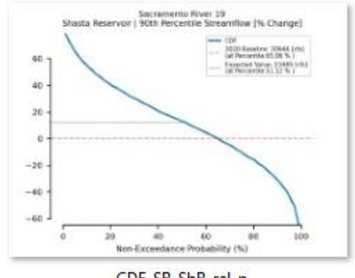
CDF_SR-ARin_rel_p



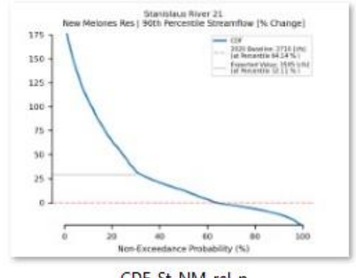
CDF_SR-FRin_rel_p



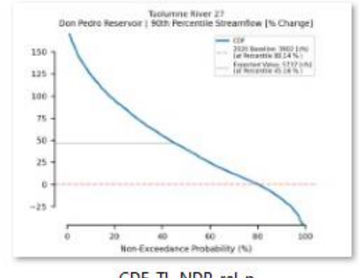
CDF_SR-RV_rel_p



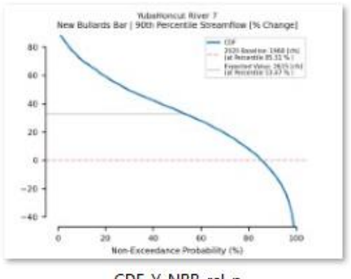
CDF_SR-ShR_rel_p



CDF_St-NM_rel_p

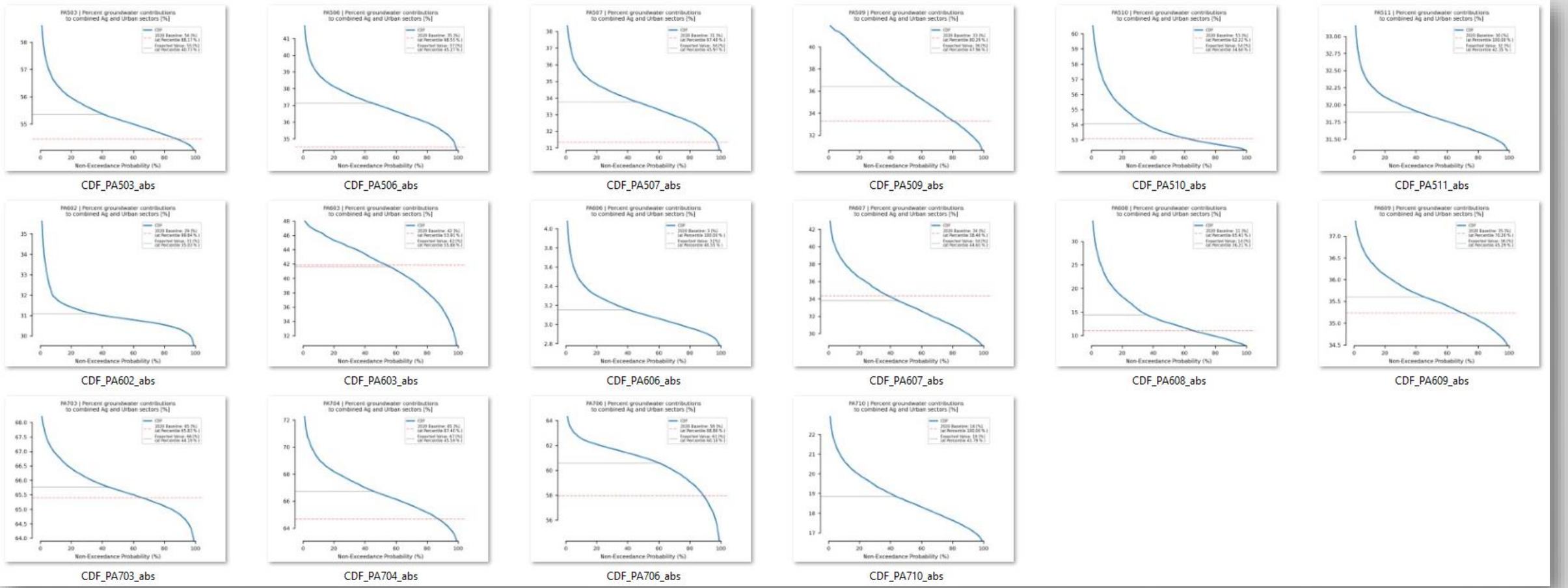


CDF_TL-NDP_rel_p



CDF_Y-NBB_rel_p

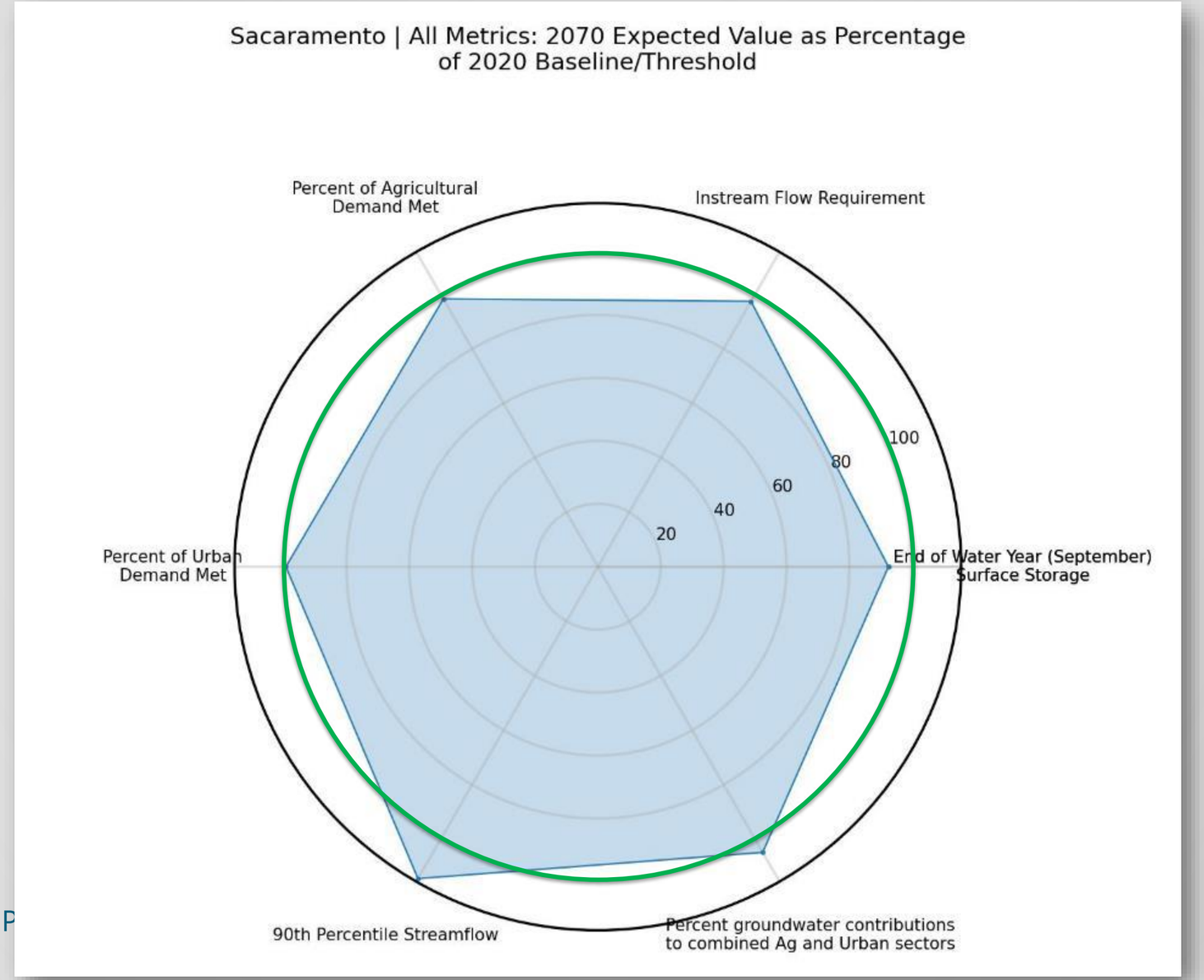
Metric 6 – All CDFs



Note: Not all PAs had access to GW which is why not all PAs are shown

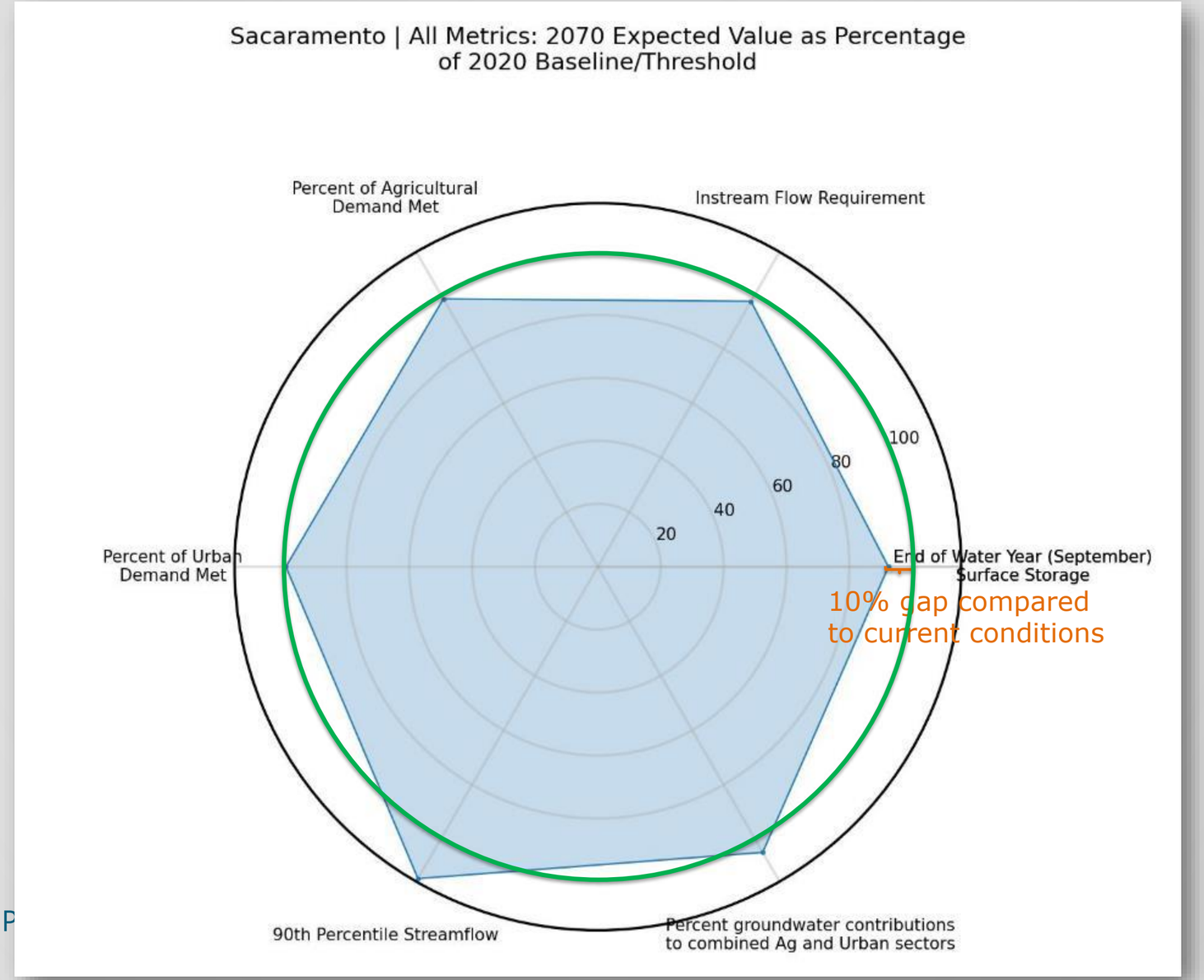
Sac River HR spider plot

- 2020 Conditions
- 2070 Conditions as compared to 2020



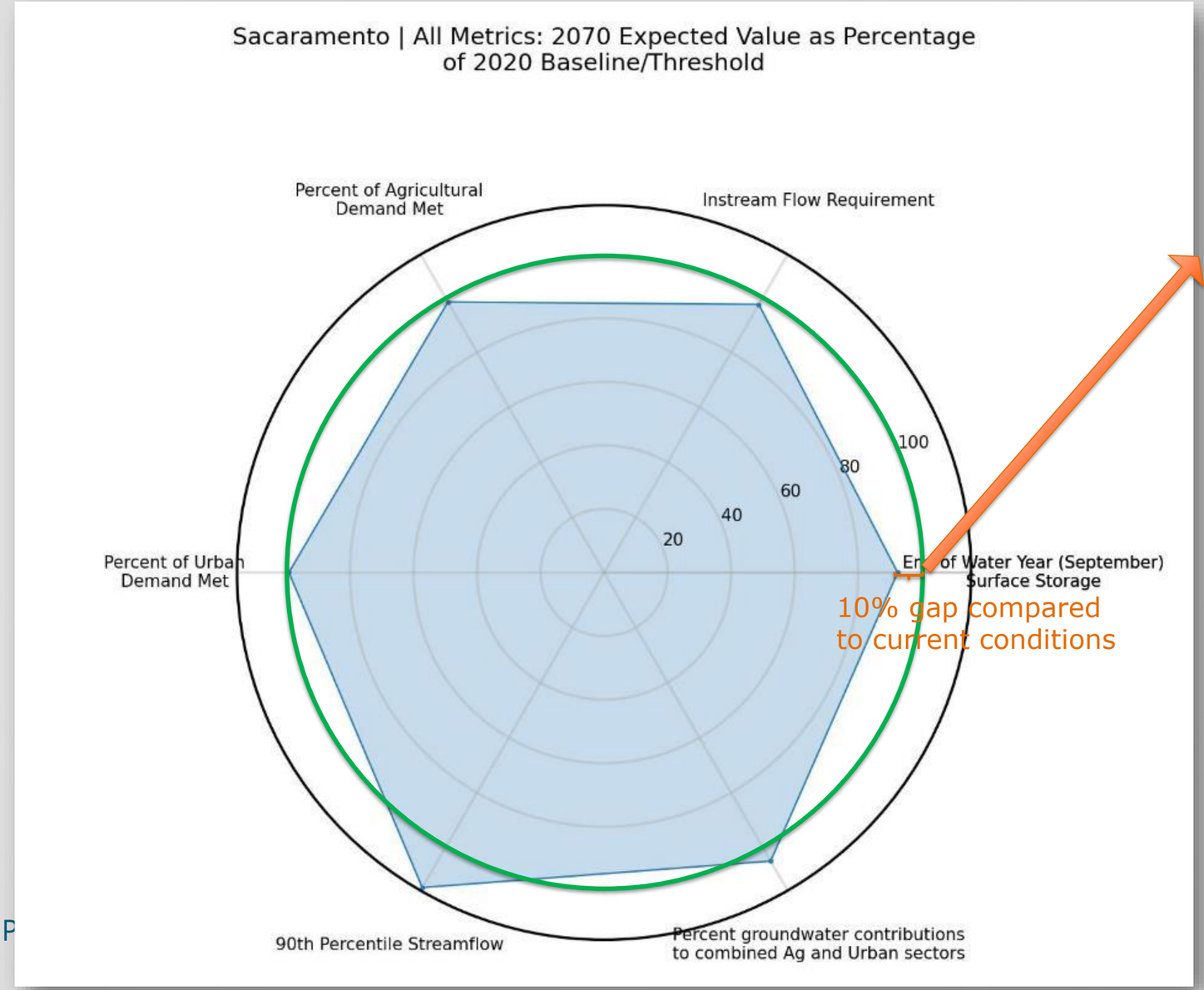
Sac River HR spider plot

- 2020 Conditions
- 2070 Conditions as compared to 2020



Sac River HR spider plot

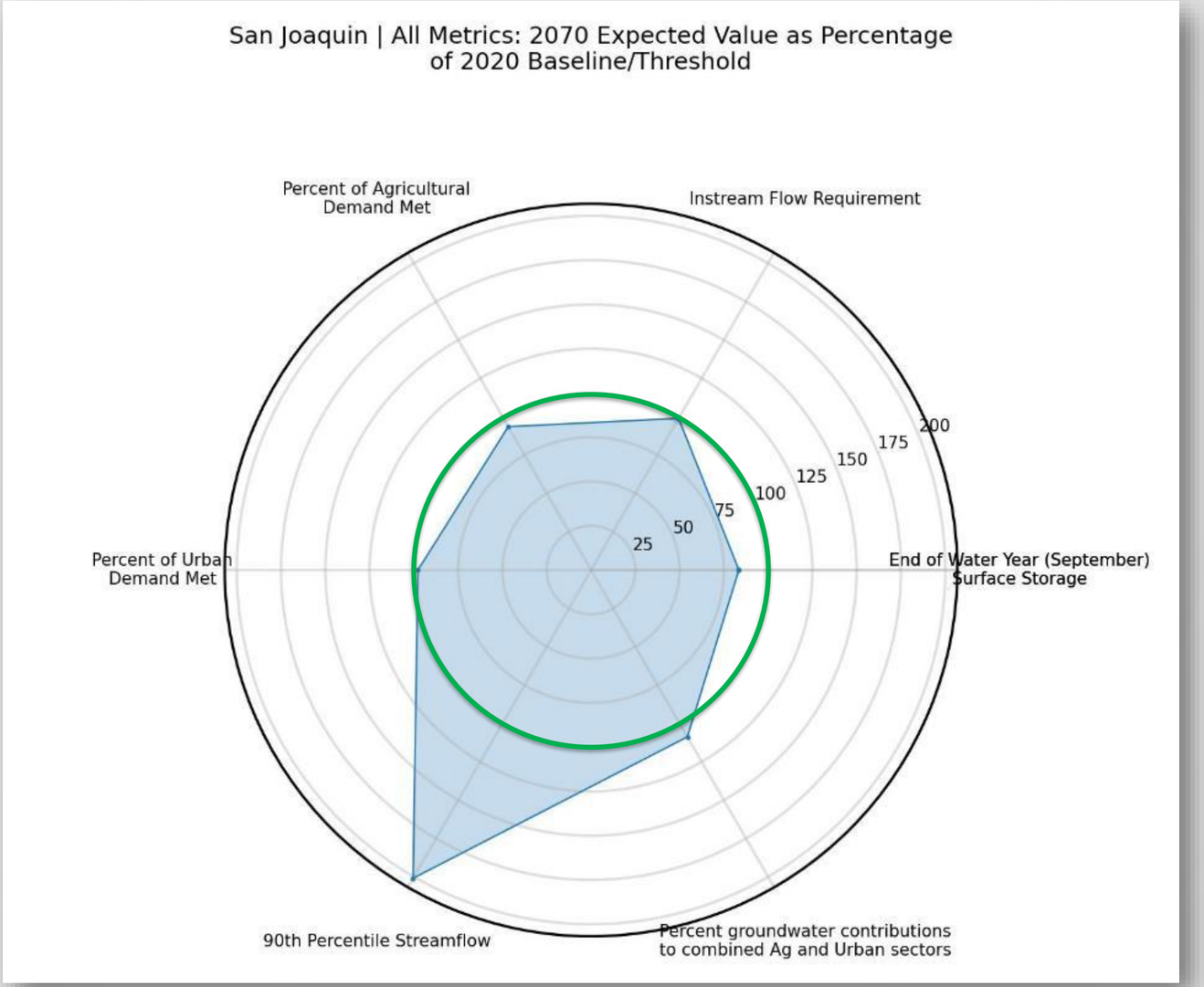
- 2020 Conditions
- 2070 Conditions as compared to 2020



In most likely 2070 conditions, the Sacramento River Hydrologic Region will only have 90% of the water in storage compared to current average conditions.

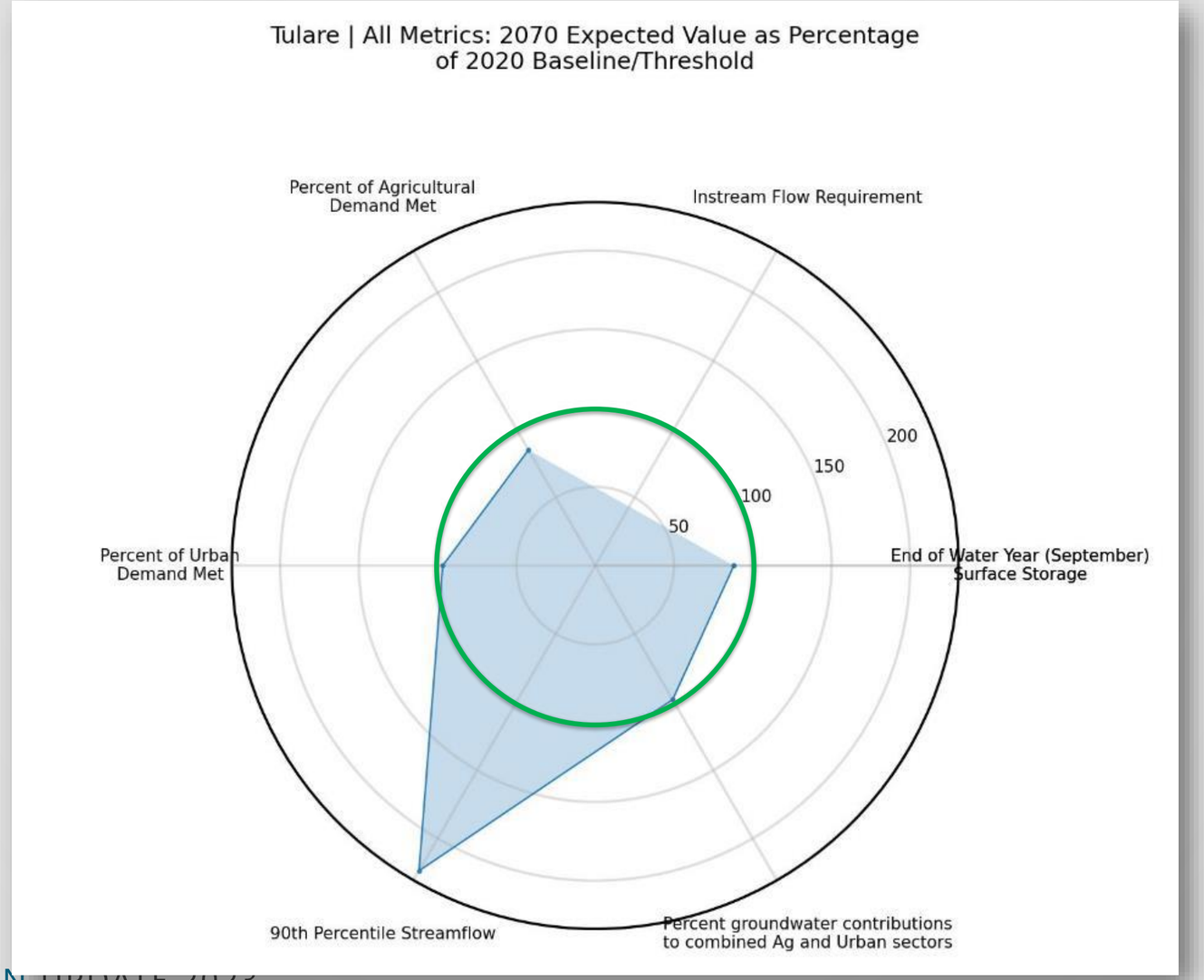
San Joaquin River HR spider plot

- 2020 Conditions
- 2070 Conditions as compared to 2020

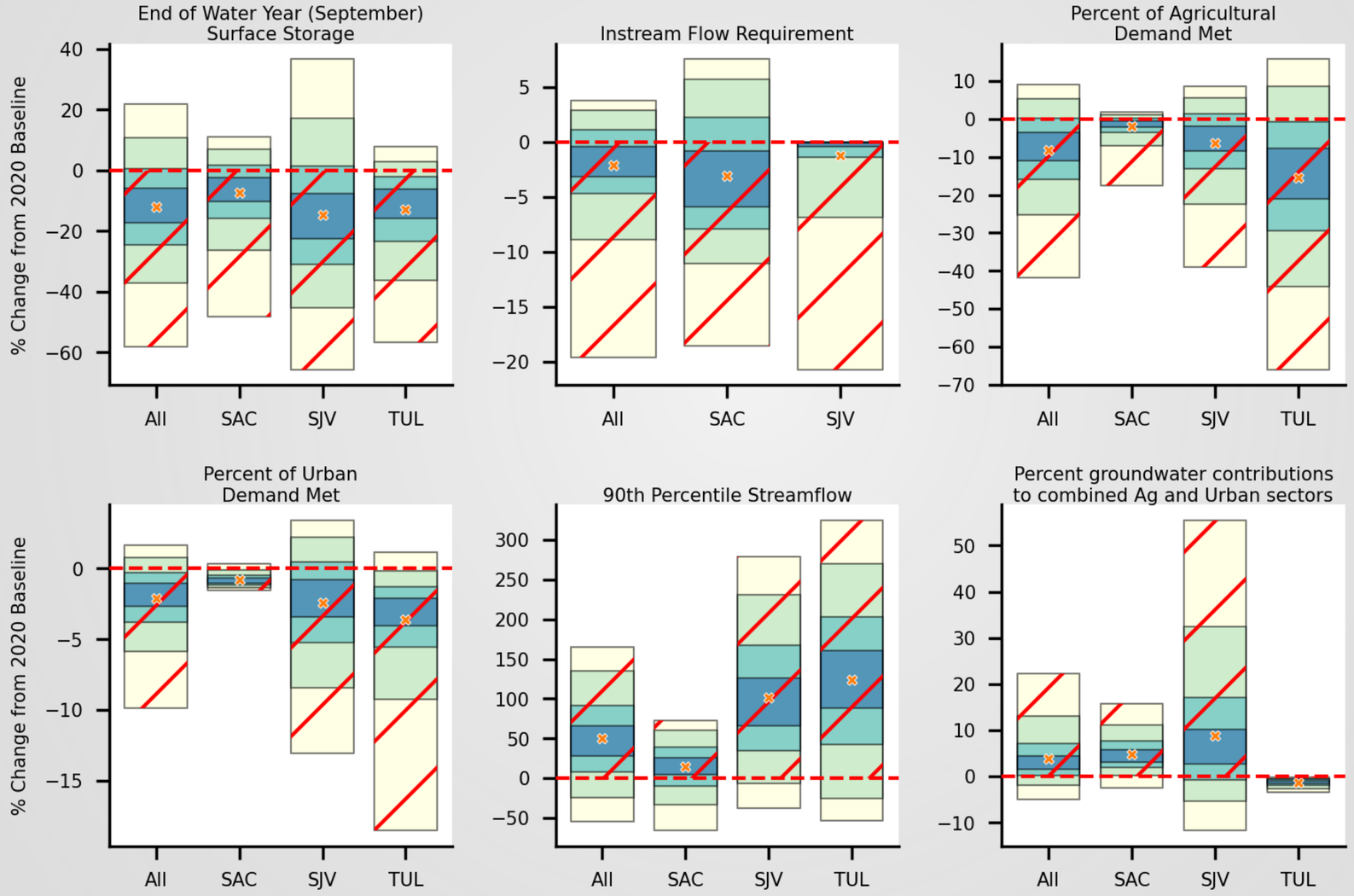


Tulare Lake HR spider plot

- 2020 Conditions
- 2070 Conditions as compared to 2020



Exploring Ways to Convey Uncertainty



Future Scenarios Update 2028

- Improved model representation
- Improved metrics
  - Are these metrics informative or are there improved metrics that could be used?
- Increased spatial coverage
  - Which regions of California would you be most interested in seeing this analysis extended to?
- Inclusion of adaptation strategies to mitigate future vulnerabilities
  - What adaptation strategies would you be most interested in seeing for Update 2028?