RECLAMATION

Managing Water in the West

Climate Change Adaptation Strategies and Insights Sacramento-San Joaquin Basins Study

CWEMF Annual Meeting

April 13, 2016

U.S. Department of the Interior
Bureau of Reclamation

Session Presentations

- Climate Change Impact Study with CMIP5 and Comparison with CMIP3 – Jay Wang (DWR)
- Assessing Impacts of Climate and Socioeconomic Changes on Central Valley System Risk and Reliability – Brian Van Lienden, and Tapash Das (CH2M)
- Development of Water Management Actions and Portfolios to Address Central Valley System Risks – Armin Munévar (CH2M)
- Evaluation of Portfolio Performance and Trade-offs in Management of Future Central Valley System Risks – Michael Tansey (Reclamation)
- Next Steps for the Sacramento and San Joaquin Basins Study – Arlan Nickel (Reclamation)
- Discussion

Climate Change Impact Study with CMIP5 and Comparison with CMIP3

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Bay-Delta Office, Department of Water Resources, California

Previous CC Impact Study with CMIP3 in DWR

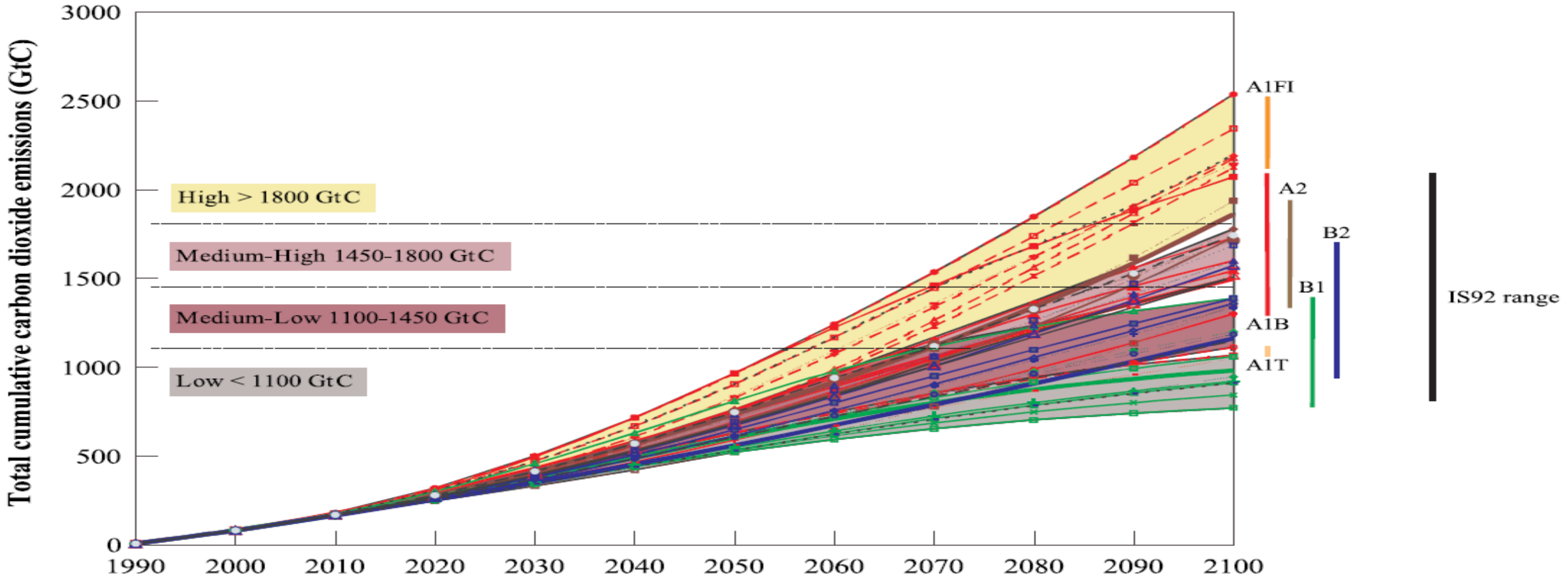
- 2006: "Progress on Incorporating Climate Change into Management of California's Water Resources"
- 2009: "Using future climate projections to support water resources decision making in California "
- BDCP: "APPENDIX 5A.2 CLIMATE CHANGE APPROACH AND IMPLICATIONS FOR AQUATIC SPECIES"

CMIP3 vs. CMIP5

– CMPI3:Coupled Model Intercomparison Project Stage 3, used for the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC)
– CMIP5: Coupled Model Intercomparison Project Stage 5, used for the Fifth Assessment Report (AR5) of IPCC

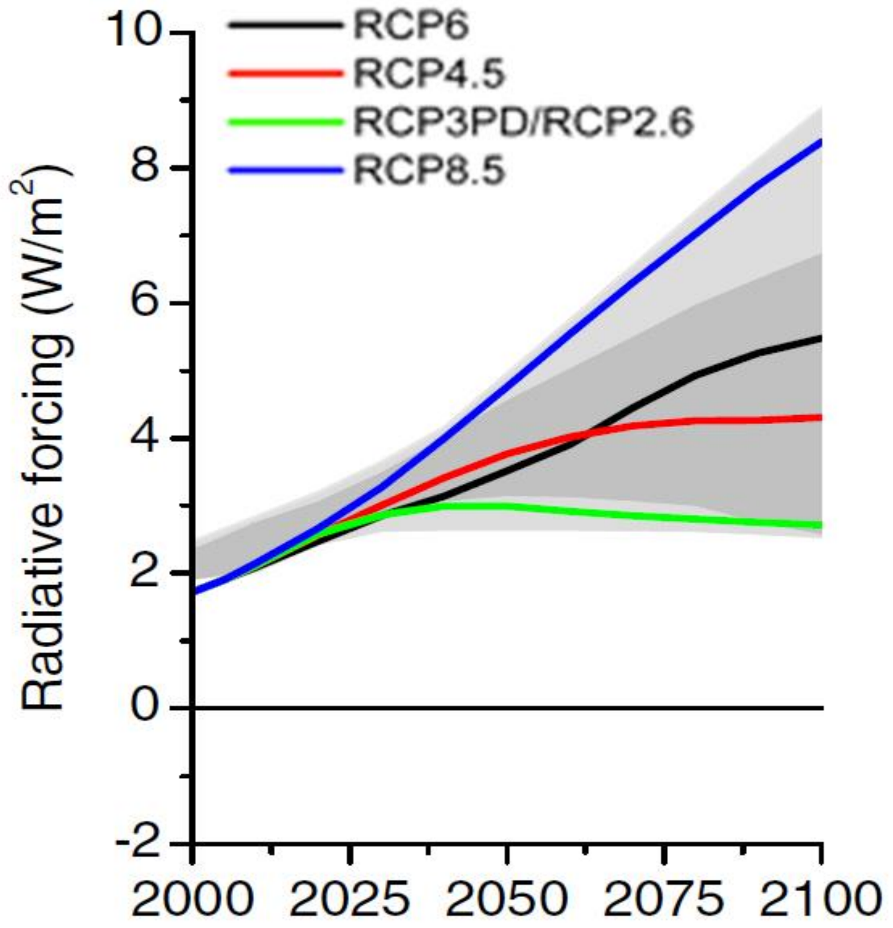
CMIP3 : AOGCMs and SRES

- 23 AOGCMs: Atmosphere-Ocean GCMs
- SRES: The Special Report on *Emissions Scenarios* (*SRES*)

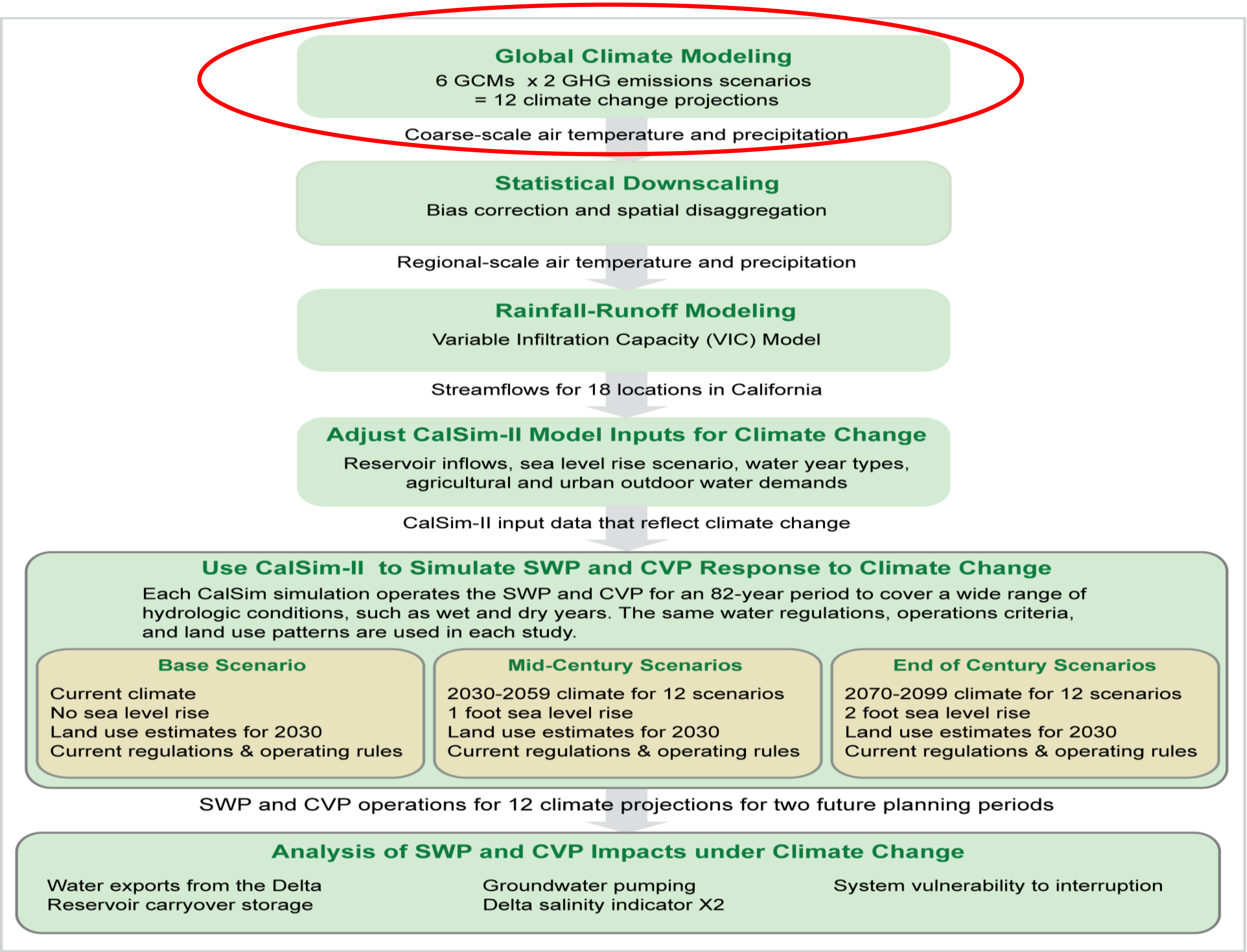


CMIP5: AOGCMs (or ESMs) and RCP

- 31 models
- Four RCPs (Representative Concentration Pathways): RCP 2.6, RCP4.5, RCP6.0 , and RCP 8.5
- High resolution and more complex physics !!!



Approach for Assessing Potential Impacts of Climate Change: *Select GCMs and Emission Scenarios*

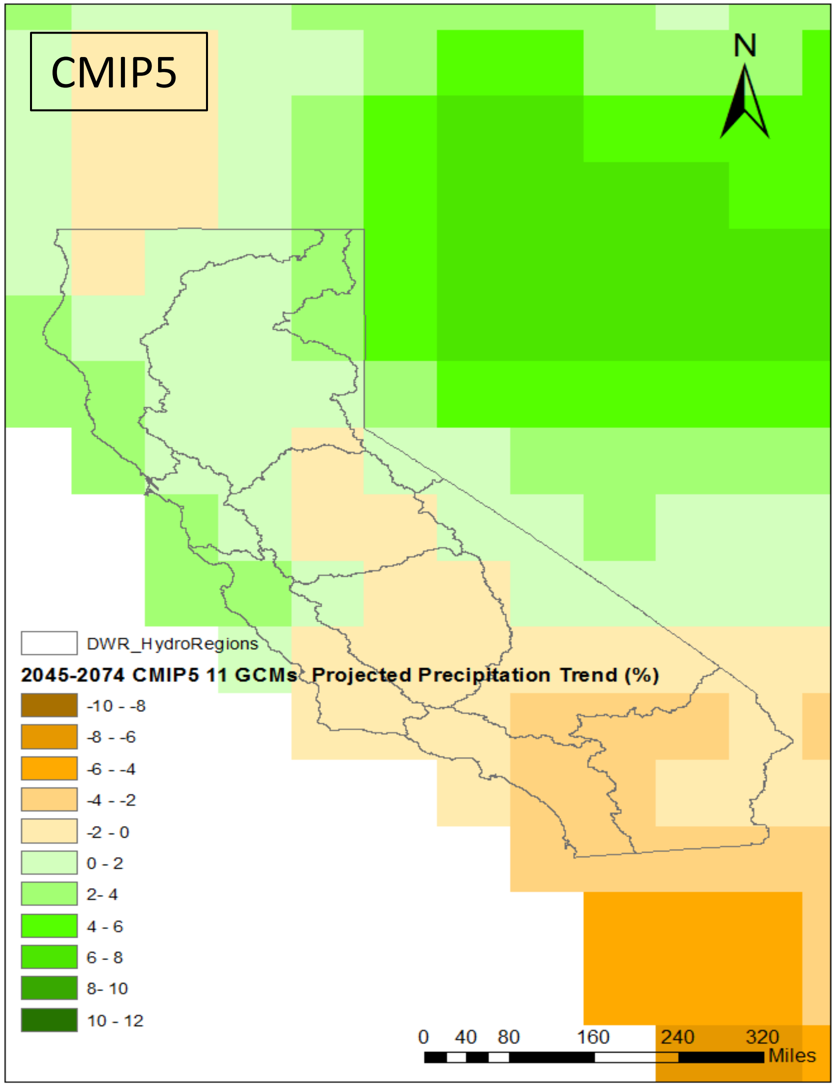


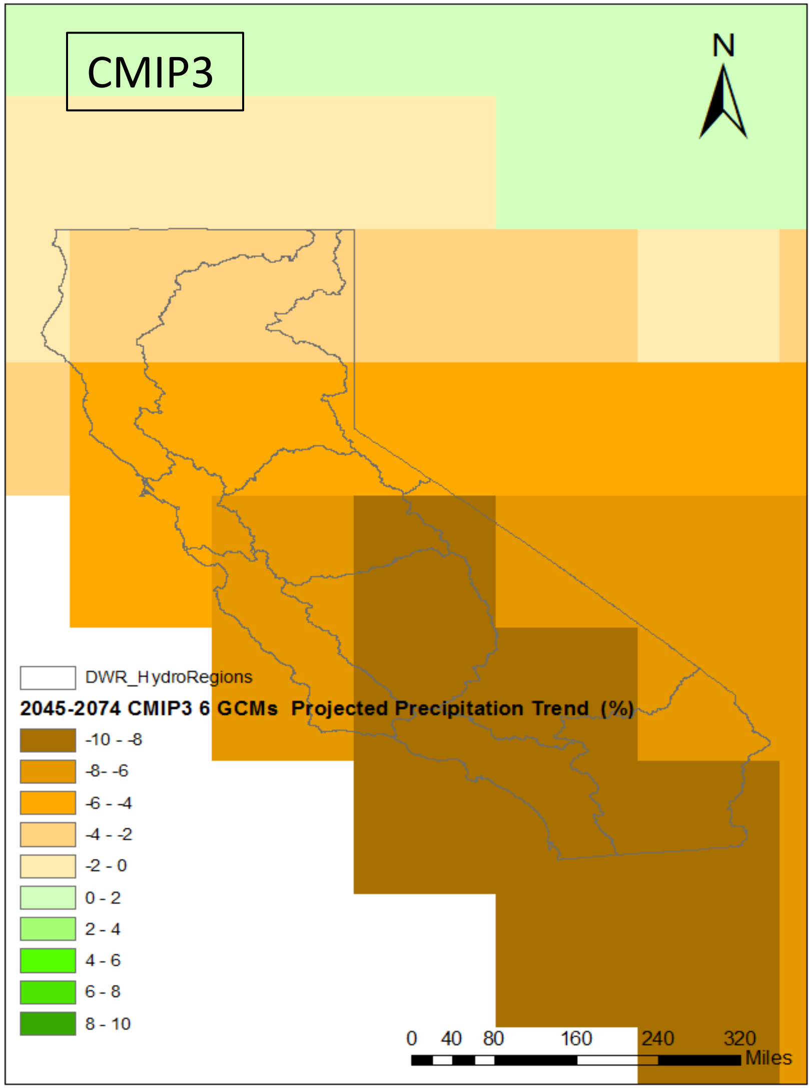
Selection of GCM Projections from CMIP3 and CMIP5

Selection of CMIP5 GCM Projections					
Model	**Institution**	**Ensemble Run**	**RCP**		**Subtotal**
ACCESS 1.0	Centre for Australian Weather and Climate Research	1	rcp45	rcp85	2
CMCC-CMS	Euro-Mediterranean Center of Italy	1	rcp45	rcp85	2
CESM1-BGC	NCAR (USA)	1	rcp45	rcp85	2
CCSM4	NCAR (USA)	5	rcp45	rcp85	10
CNRM-CM5	National Centre for Meteorological Research of France	1	rcp45	rcp85	2
MIROC5	Center for Climate System Research of Japan	1	rcp45	rcp85	2
GFDL-CM3	GFDL (USA)	1	rcp45	rcp85	2
GFDL-ESM2M	GFDL (USA)	1	rcp45	rcp85	2
HadGEM2-ES	Hadley Centre of UK	4	rcp45	rcp85	8
HadGEM2-CC	Hadley Centre of UK	1	rcp45	rcp85	2
CANESM2	Canadian Centre for Climate Modelling and Analysis	5	rcp45	rcp85	10
				Total Projections	44

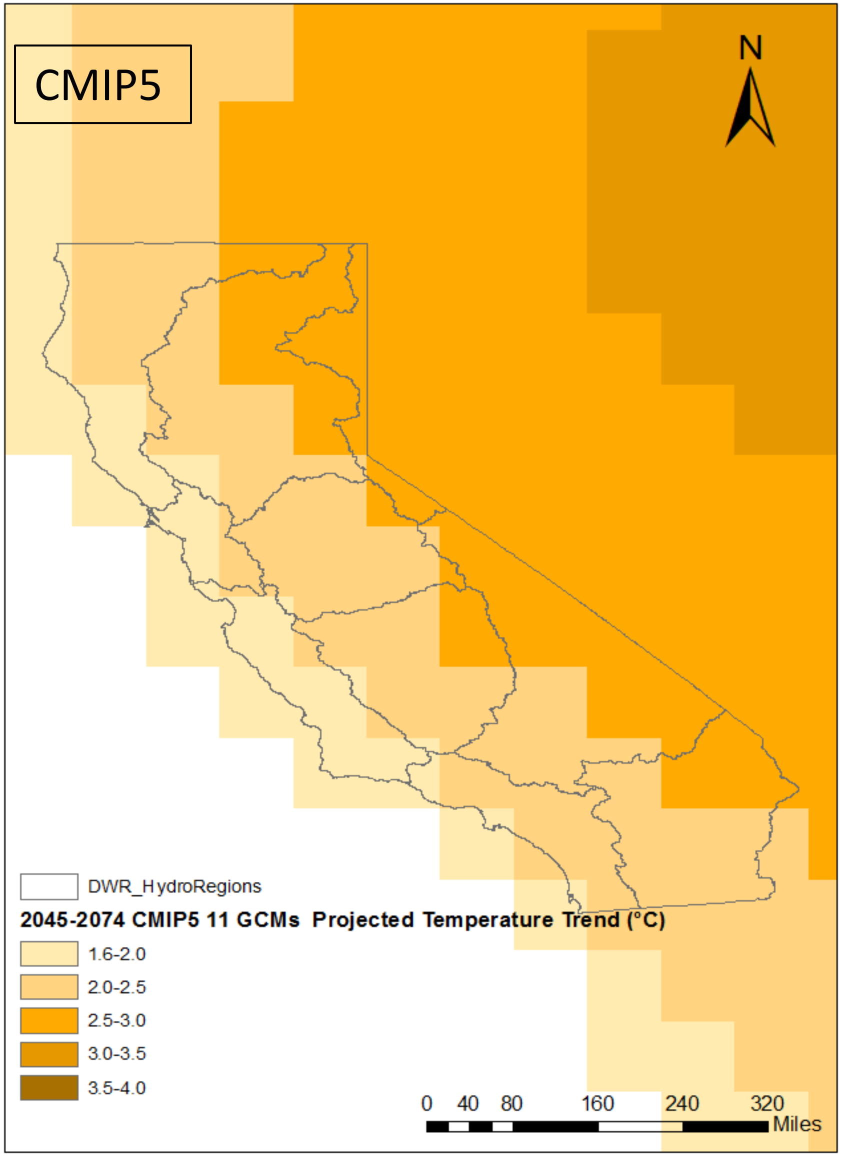
Selection of CMIP3 GCM Projections					
Model	**Institution**	**Ensemble Run**	**SRES**		**Subtotal**
MPI-ECHAM5	Max Planck Institute for Meteorology of German	1	A2	B1	2
GFDL-CM2.1	GFDL (USA)	1	A2	B1	2
NCAR PCM1	NCAR (USA)	1	A2	B1	2
NCAR CCSM3	NCAR (USA)	1	A2	B1	2
CNRM-CM3	National Centre for Meteorological Research of France	1	A2	B1	2
MIROC3.2-MED	Center for Climate System Research of Japan	1	A2	B1	2
				Total Projections	12

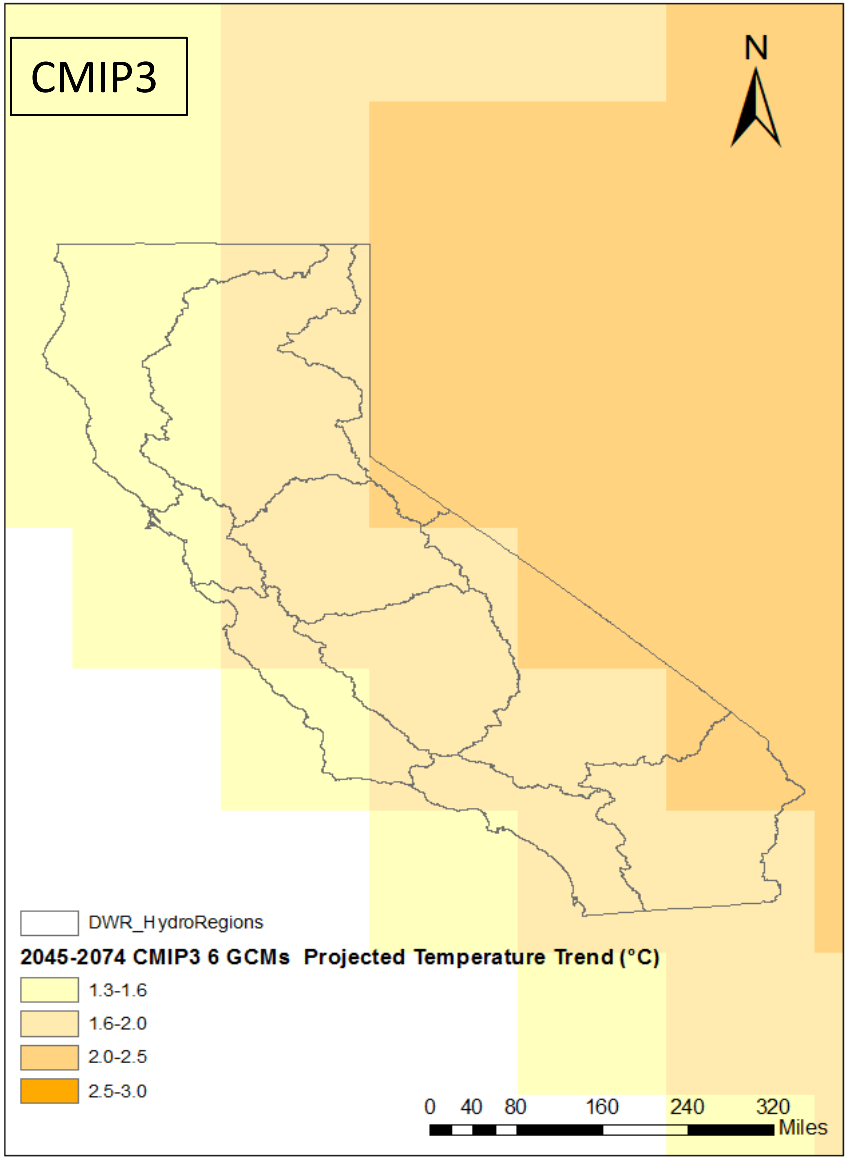
Precipitation Trend Projected By Selected CMIP3 and CMIP5 Projections



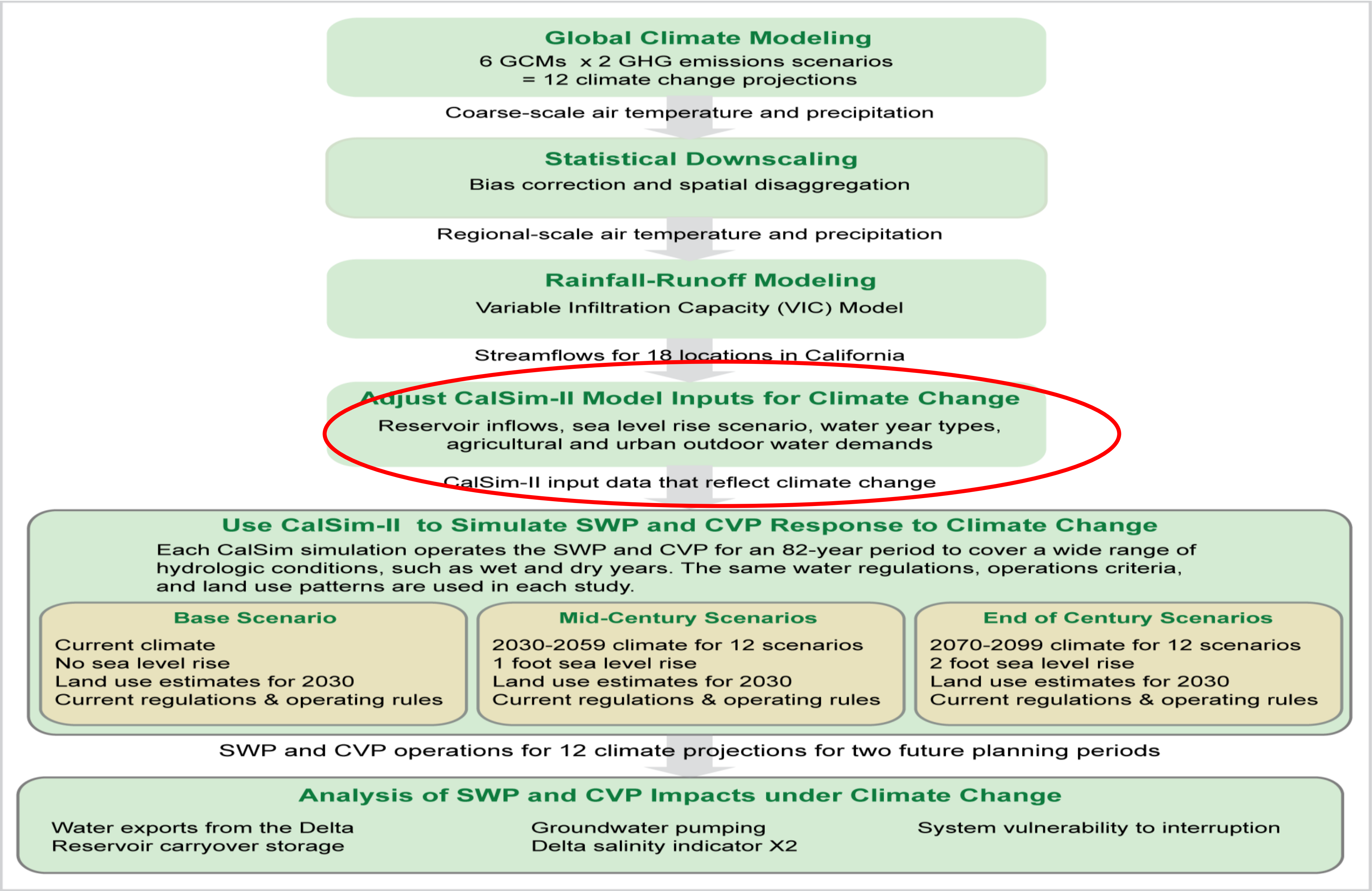


Temperature Trend Projected By Selected CMIP3 and CMIP5 Projections





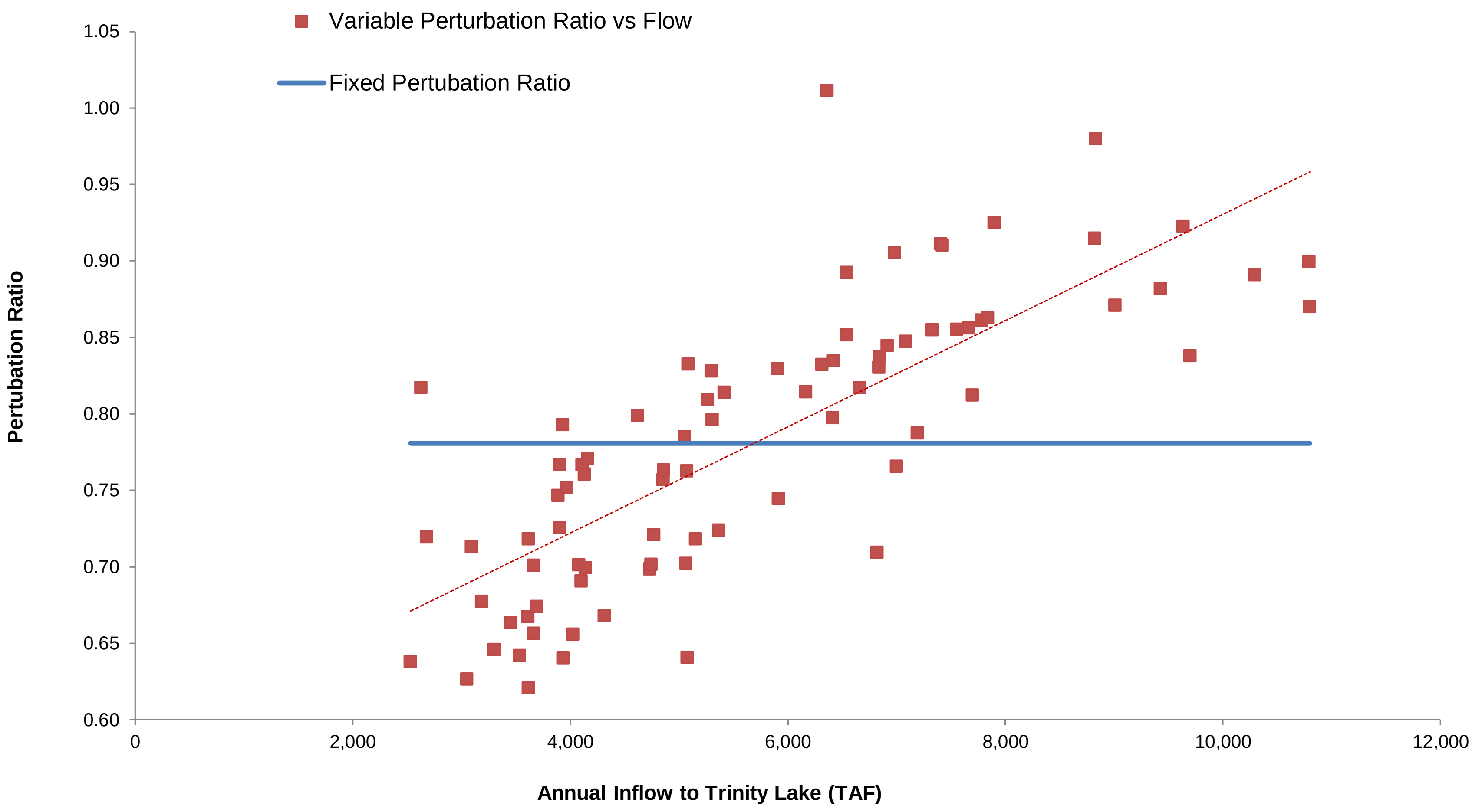
Approach for Assessing Potential Impacts of Climate Change: *Perturb Rim Inflow*



Climate Change (CC) Modified Water Supply and Water Demand

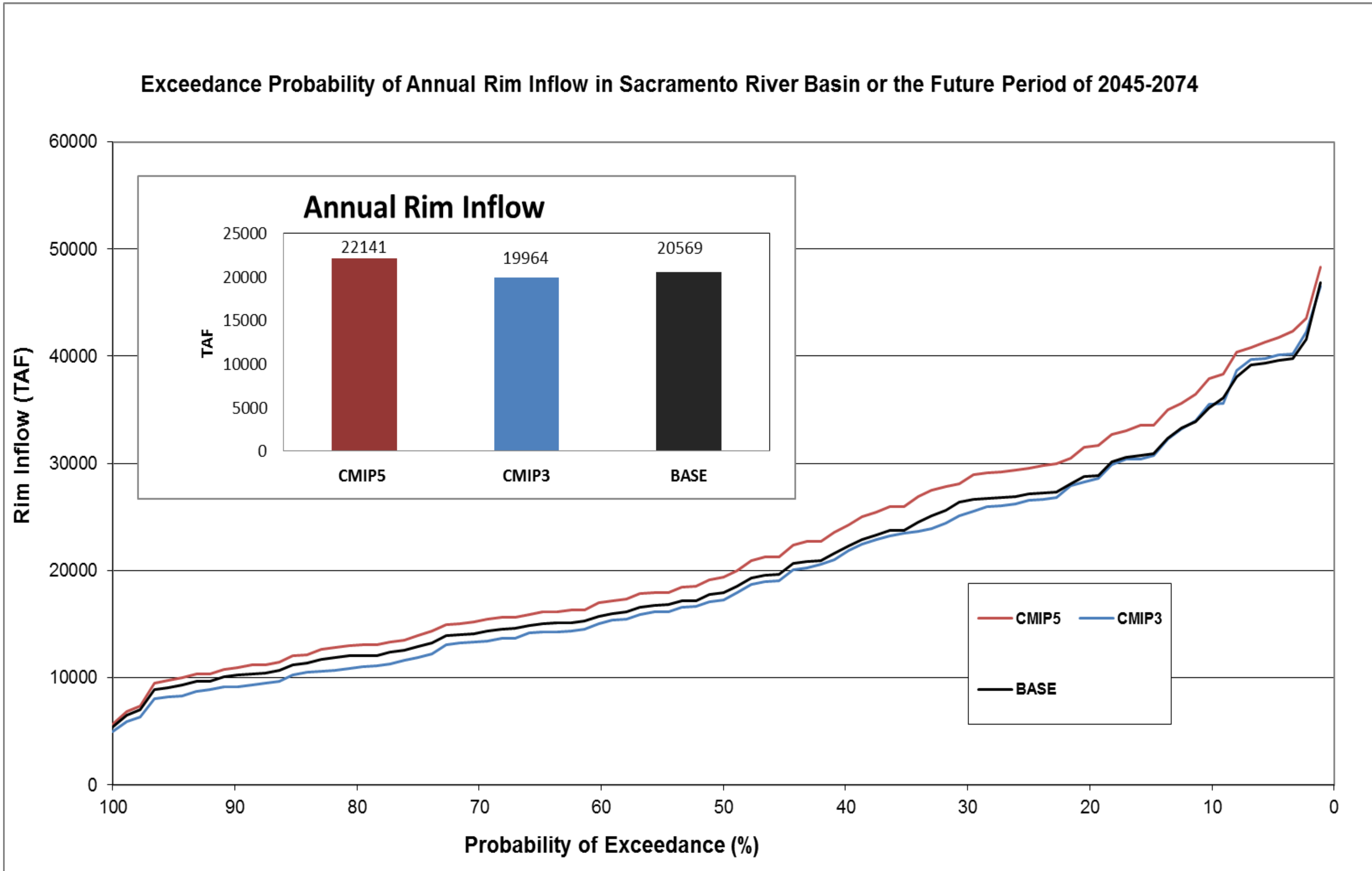
- CC water supply: Perturb Rim inflow
- CC water demand: Perturb Applied Water

Variable Perturbation Ratio vs. Fixed Perturbation Ratio



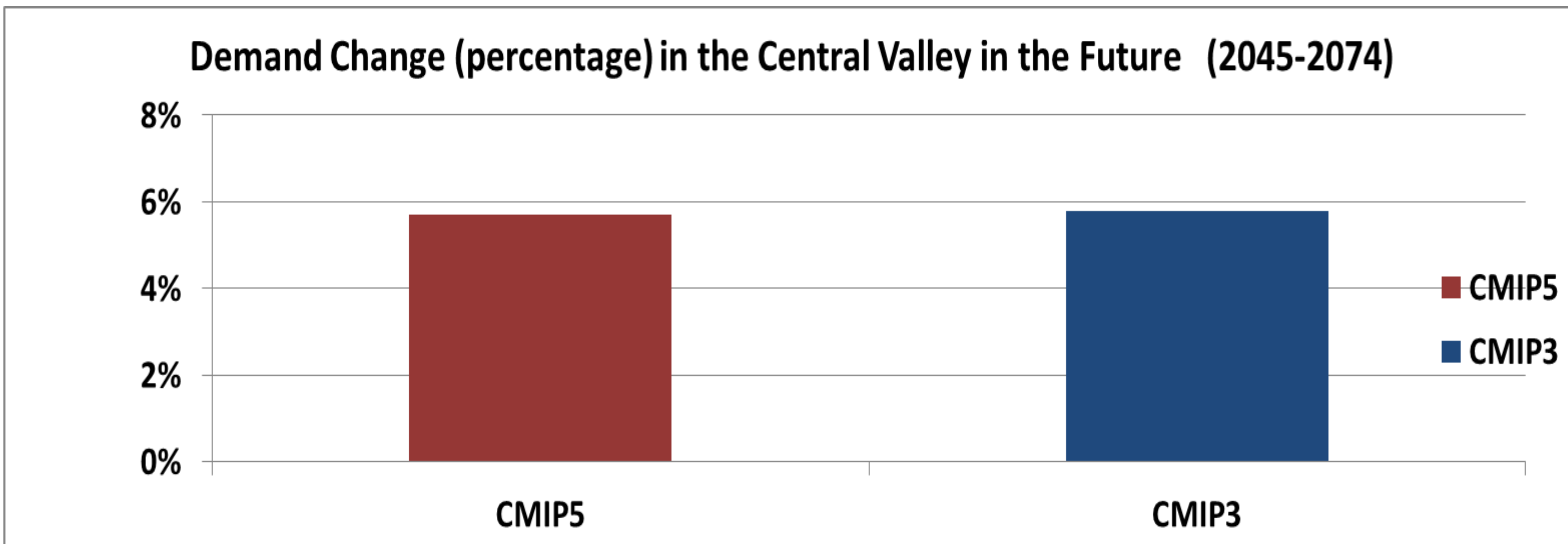
Variable Perturbation Ratio for Inflows to Trinity Lake under the BDCP Climate Change Scenario Q2

Perturbed Rim Inflow (1)

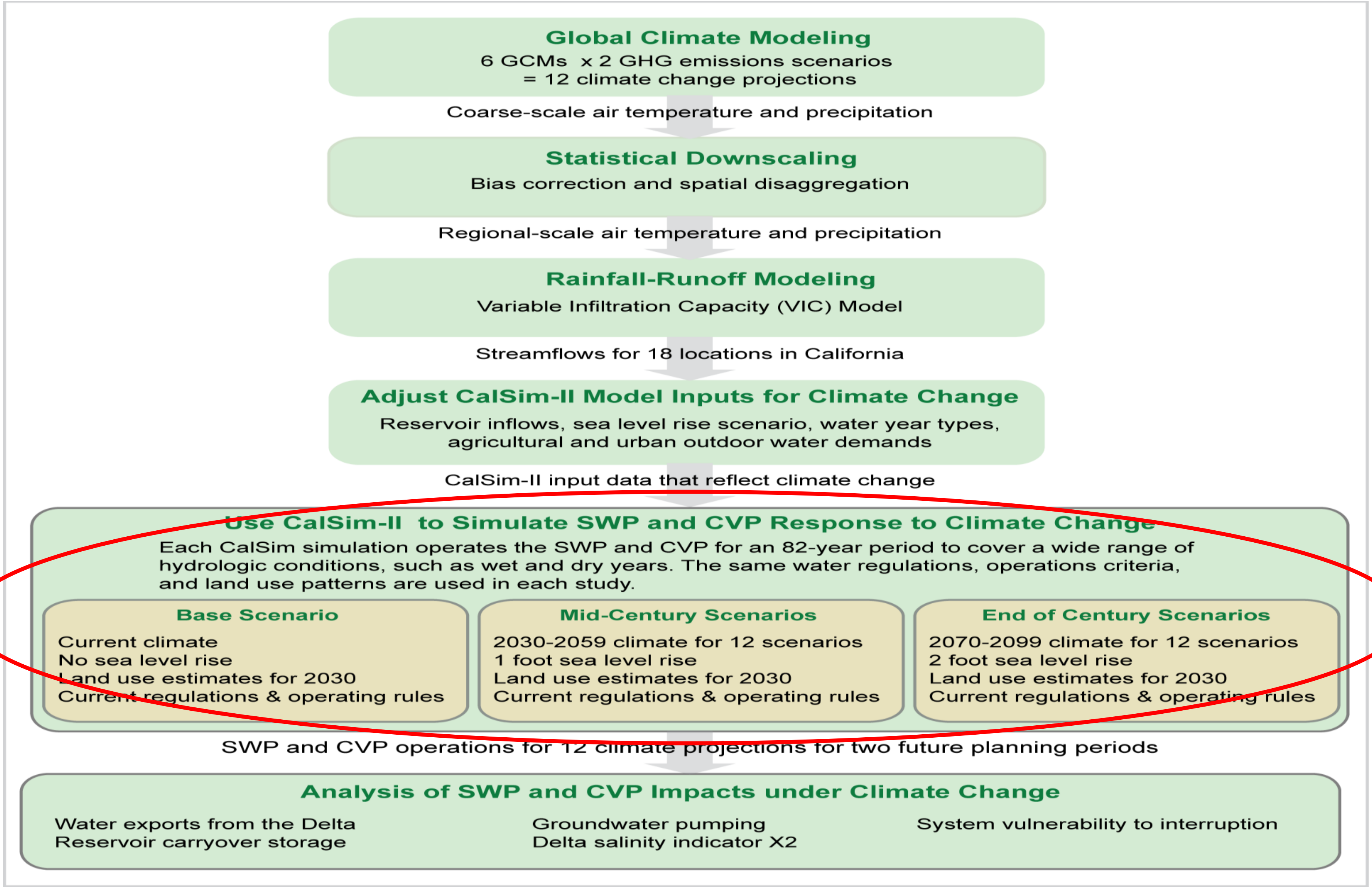


Perturbed Water Demand

- Perturb Temperature
- Perturb Precipitation
- Perturb Evaportranspiration
  - $ET_{crop\text{-}cc} = ET_{crop} * (T_{future} + 17.8) / (T_{historical} + 17.8)$



Approach for Assessing Potential Impacts of Climate Change:
Use CalSim 3.0 to Simulate SWP/CVP Response to Climate Change



New Water Planning Model : CalSim 3.0

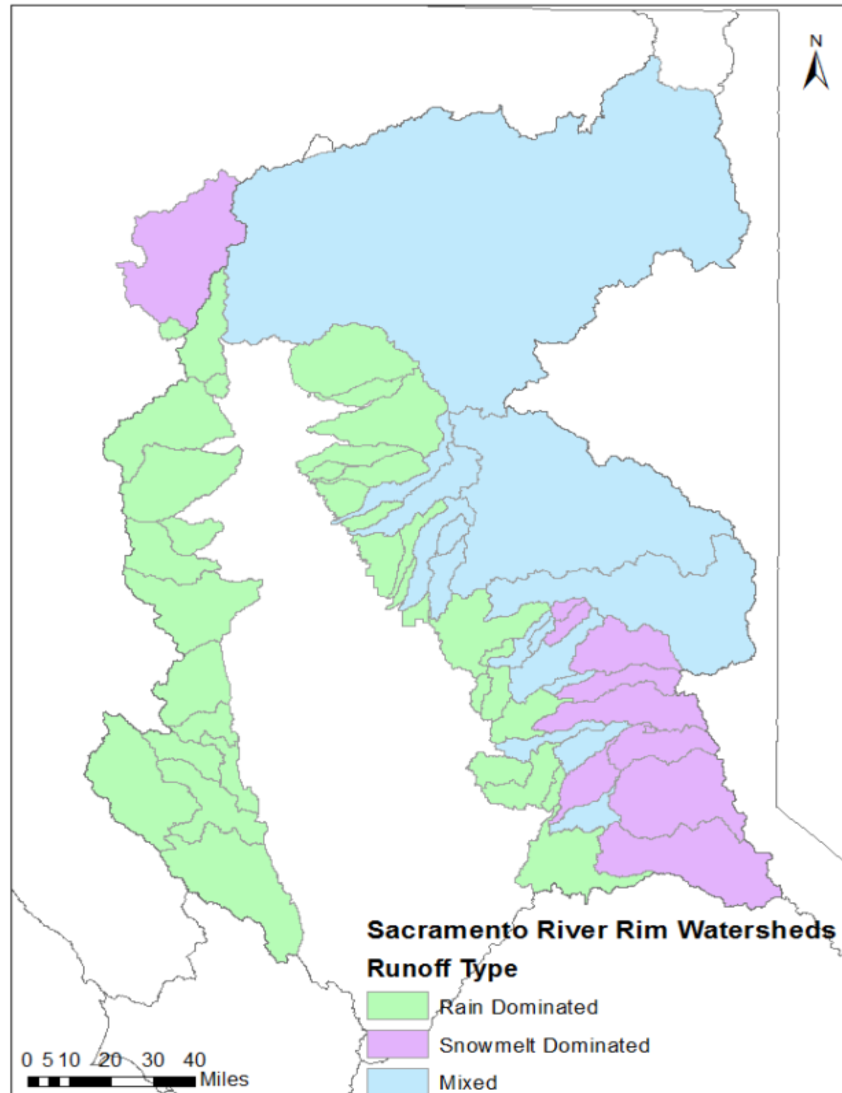
Many improvements in CalSim 3.0 will facilitate a better understanding of climate change impacts:

- Increased spatial resolution of rim and expanded representation of water control facilities in rim watersheds
- Consistent and transparent representation of Central Valley floor hydrology facilitates the representation of climate change effects on agricultural, urban, and managed wetland water demands.
- Coupled representation of surface water and groundwater allows impacts of climate change on groundwater to be evaluated and potentially supports long-term management of groundwater resources.

Runoff Types

- Rainfall runoff dominated watersheds:

  runoff peaks in January-February
- Snowmelt runoff dominated watersheds: runoff peaks in April-May
- Mixed watersheds: runoff peaks in March



Variable Sea Level Rise

- Planning Period: 2045-2074
- For each climate model projection CalSim 3.0 runs twice, with zero and 1.5ft sea level rises, respectively.
- Total runs: 2*(44+12) =112
- The Martin Vermeera and Stefan Rahmstorfb (2009) approach for the estimate of future sea level rise for each climate projection
- Interpolation using CalSim 3.0 run result of zero and 1.5ft sea level rise

Biological Opinion

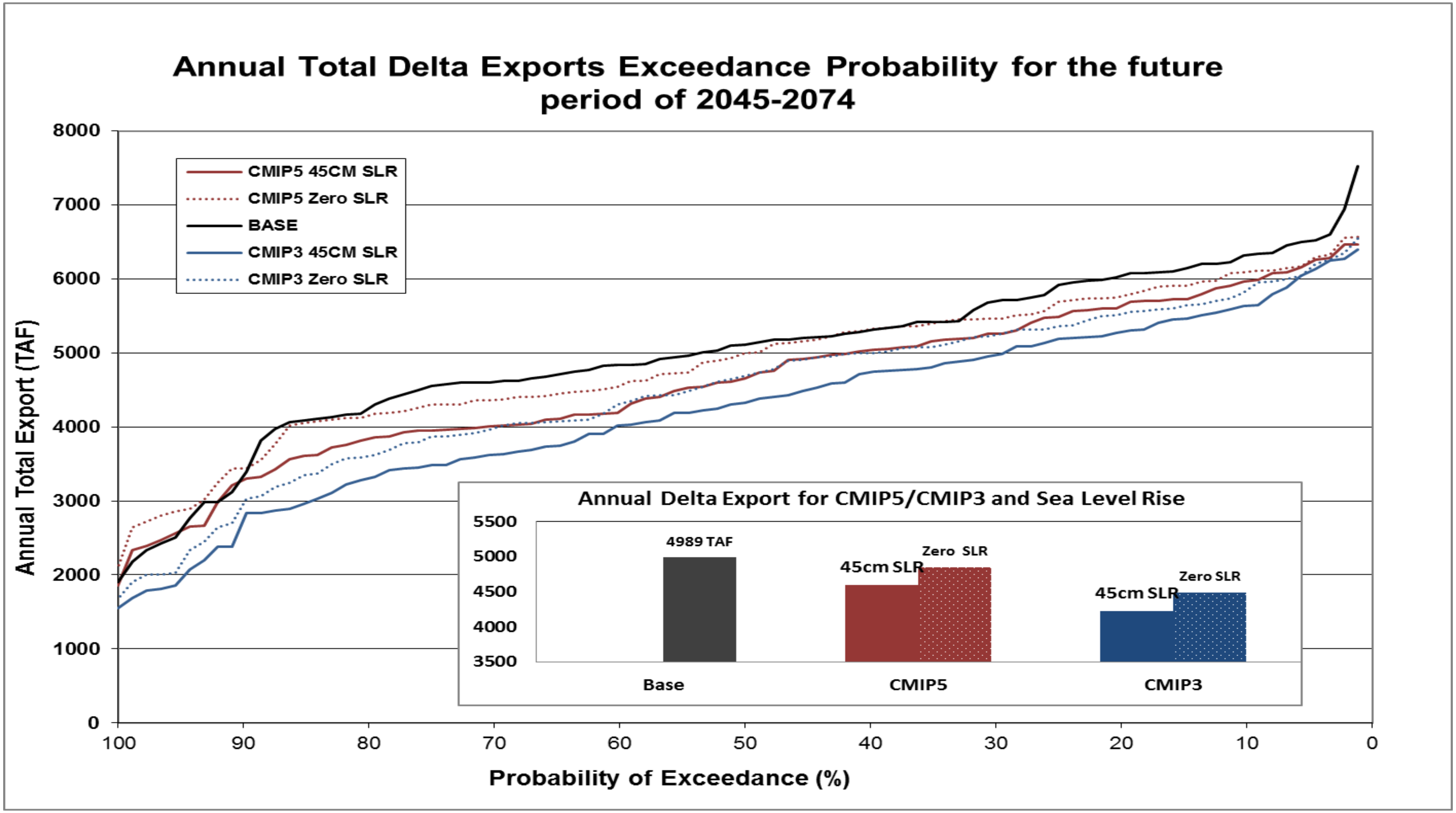
- A biological opinion (BO) on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project
- Regulate Old and Middle River (OMR) flow to protect Delta Smelt.

Climate Change Impact on SWP/CVP

- Delta Export
- Carryover Storage
- Delta Inflow/Delta Outflow
- X2
- Dead Stoarge

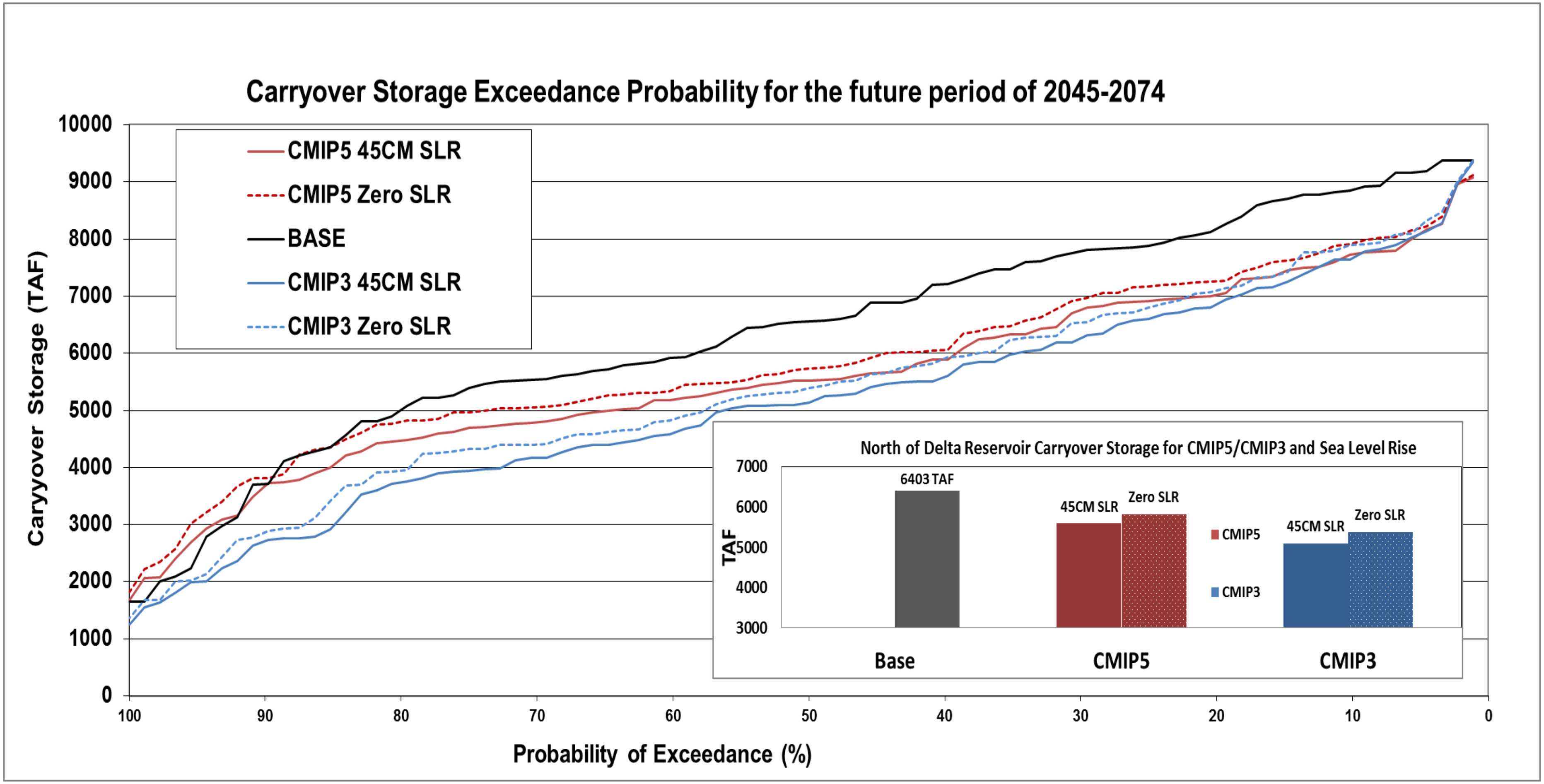
Delta Export

- Annual Delta export all reduced for CMIP5 and CMIP3 by -3% and -10% , respectively.
- After adding 45cm sea level rise, the export reduced by -8% and -15%, respectively.



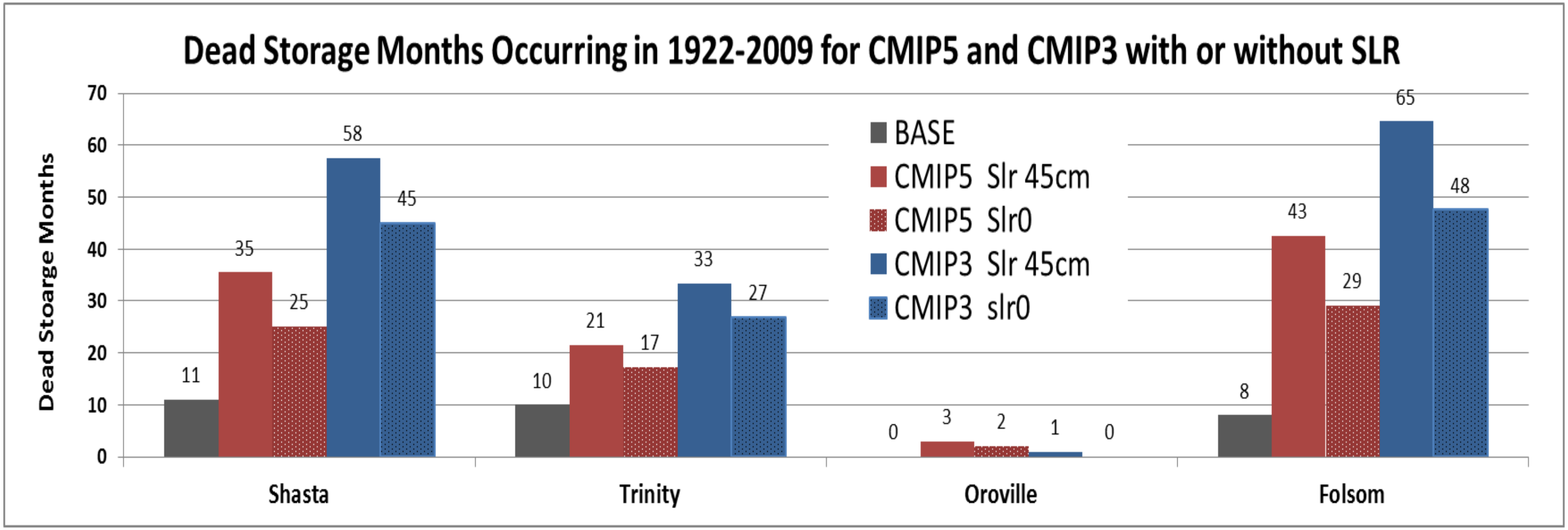
North of Delta Carryover Storage

- The carryover storage is reduced by 14% for CMIP5 and reduced by 23% for CMIP3 under 1.5ft Sea Level Rise in 2060
- The sea level rise of 1.5ft only contributes 4-5% reduction in carryover storage.



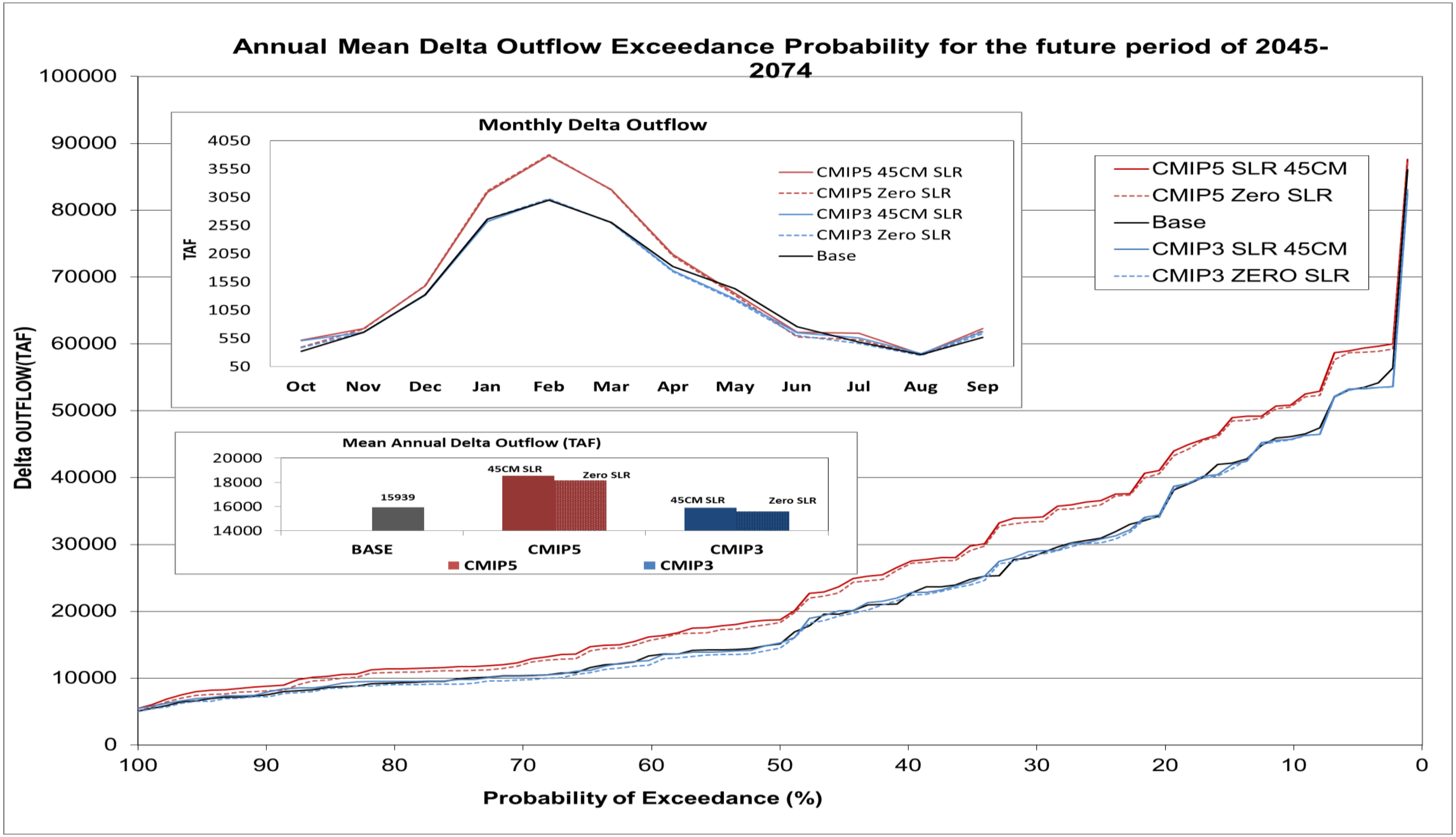
Dead Storage

- CMIP3 triggers more dead storages than CMIP5
- Sea level rise causes more dead storages
- Dead storage of Oroville reservoir in 2060 is fewest and not sensitive to SLR and CIMP3/CMIP5 due to the installation of a new low valve.
- Dead storage is more sensitive to the selection of climate model projection (CMIP3/CMIP5) than the selection of sea level rise.



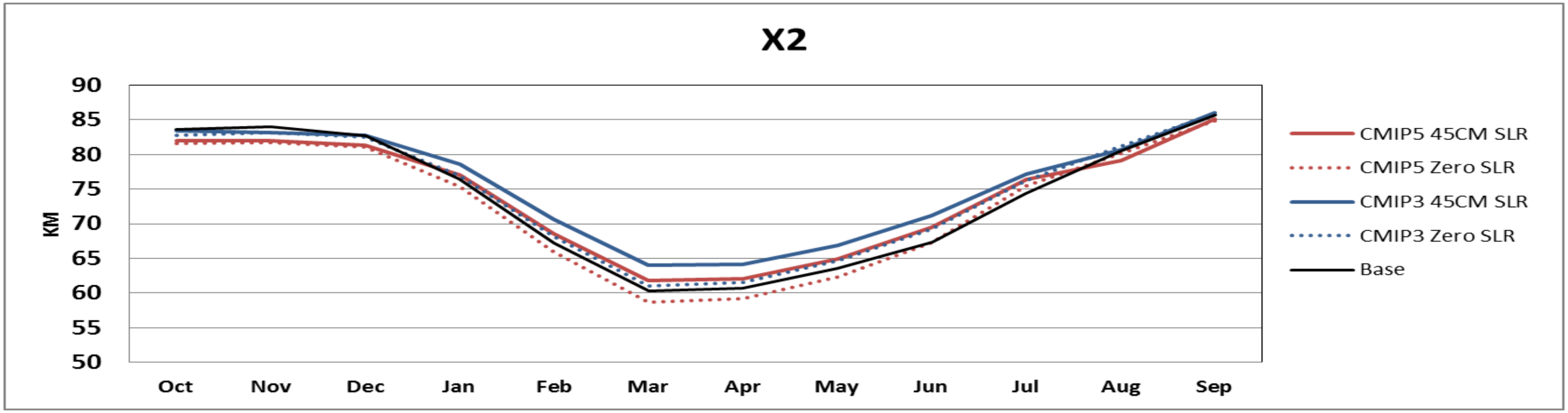
Delta Outflow

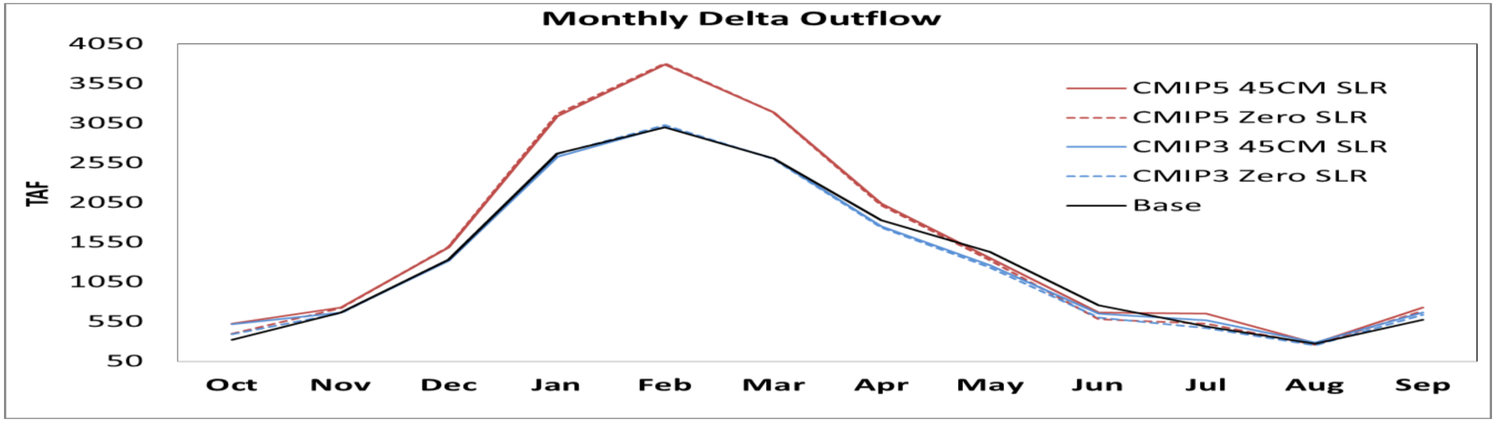
- Delta outflow increase 16% in 2060 for CMIP5; No change for CMIP3
- 45cm sea level rise boosts Delta outflow by 2%
- Increased delta outflow in CMIP5 occurs in winter months mostly



Salinity in the Bay-Delta area: X2

- CMIP3 projects higher Salinity than CMIP5 in 2060 (assuming 1.5ft SLR)
- Salinity in the Bay-Delta area is more sensitive to the selection of SLR than the selection of climate model projection (CMIP3/CMIP5)





Conclusion

- The CC impact uncertainty caused by the selection of climate model projection (CMIP3 vs CMIP5) is about 7% in terms of Delta export and about 9% in terms of north of Delta carryover storage.
- The CC impact uncertainty caused by the selection of sea level rise (Zero vs 1.5ft SLR) is about 5% in terms of Delta export and about 4-5% in terms of North of Delta carryover storage.