North Bay Climate Ready

Sonoma County Regional Climate Protection Authority

North Bay Watershed Association

North Bay Climate Adaptation Initiative

Including Pepperwood, USGS, Point Blue Conservation Science, Sonoma Ecology Center

Funding: Coastal Conservancy, Sonoma County Water Agency, Marin Municipal Water District, Napa County, North Bay Watershed Association, Community Foundation Sonoma County

North Bay Climate Ready

- Project Overview
- Core Data Sets: “Climate-Hydro Futures,” Scenario Selection
- Sample Data Products
- Next Steps

North Bay Climate Ready

- Project Overview
  - Why?
  - Tasks
  - Teams
  - User Groups
  - Timeline

✓ What is RCPA? NBCAI?

✓ Why this project now?

✓ Objective:

Detailed future climate and hydrology
information, customized through manager input, for direct application to real-world climate adaptation challenges, using a consistent analysis framework, based on the highest-resolution climate projections available

North Bay CLIMATE ADAPTATION INITIATIVE

RCPA
regional climate protection authority

SONOMA COUNTY WATER AGENCY

SONOMA LAND TRUST

SONOMA COUNTY AGRICULTURAL PRESERVATION AND OPEN SPACE DISTRICT

SAN FRANCISCO BAY JOINT VENTURE

CLIMATE PROTECTION CAMPAIGN

SONOMA STATE UNIVERSITY FIELD STATIONS & NATURE PRESERVES

USGS science for a changing world

Audubon Canyon Ranch

Coastal Conservancy

Pepperwood PRESERVE
Inspiring conservation through science

SONOMA ECOLOGY CENTER

Gold Ridge Resource Conservation District

Point Blue Conservation Science

Laguna de Santa Rosa Foundation

COMMUNITY FOUNDATION SONOMA COUNTY

THE UNIVERSITY OF CALIFORNIA BERKELEY 1868

PRUNUSKE CHATHAM, INC.

Creekside Center for Earth Observation

RCPA
regional climate protection authority

Creating multi-agency, multi-jurisdictional capacity to respond to climate change

climate action 2020
A Regional Program for Sonoma County Communities

Our members:

10 jurisdictions, ~490k people

2 countywide agencies

Our goals:

- Reduce GHGs by 25% from 1990 levels by 2015
- Reduce GHGs by 40% from 1990 levels by 2035
- Assess vulnerabilities and ID key adaptation strategies

Convening:

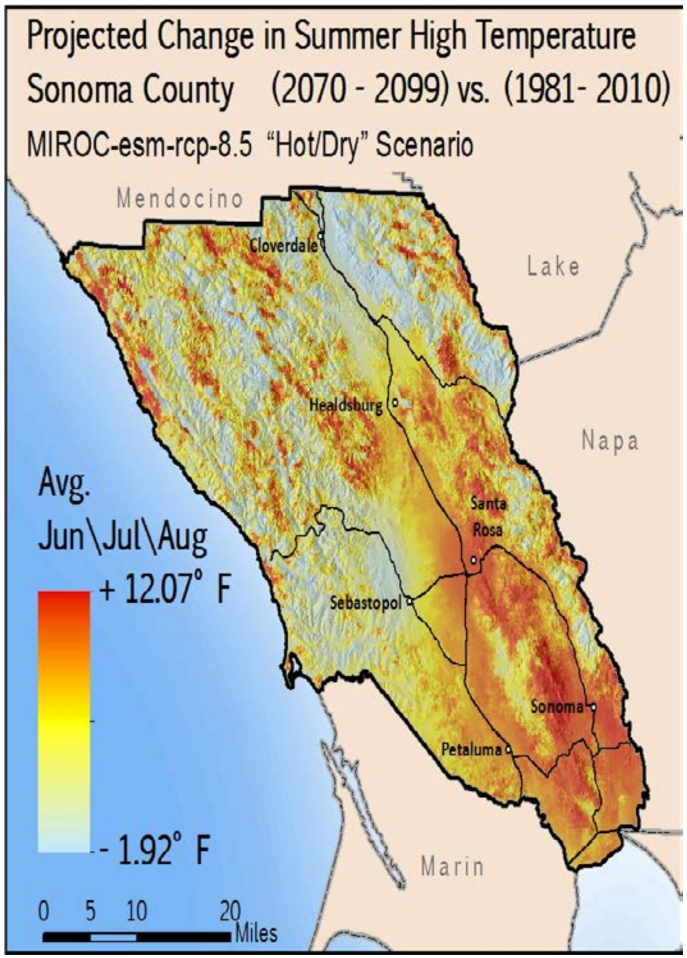
- Cities
- County Departments
- Sectors, Experts, Public
- Regional partners (CRNB)

NORTH BAY WATERSHED ASSOCIATION

16 regional and local public agency members

…helps regulated regional and local public agencies work cooperatively on water resources issues, across traditional boundaries, to promote stewardship of the North Bay watershed.

Translating landscape-level climate-hydro projections into actionable info



Source: NBCAI science team, 2014

- Warmer days and nights, more extremely hot days
- Longer and more severe droughts
- More and worse wildfires
- More and worse floods
- Rain in unusual amounts at unusual times
- Erosion, landslides
- Damage to buildings, roads, forests, fields from extreme weather- heat, flood, fire
- (Not Sea Level Rise!)

North Bay Climate Ready

- Project Overview
  - Why?
  - Tasks
  - Teams
  - User Groups
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✓ 1 Project Management

✓ 2 User Needs Definition

✓ 3 Vulnerability Assessment

✓ 4 Climate Smart Info Exchange

✓ 5 Adaptation Pilots

North Bay Climate Ready

- Project Overview
  - Why?
  - Tasks
  - Proj Teams
  - User Groups
  - Timeline

✓ Project Management: RCPA, NBCAI/Pepperwood, NBCAI/Sonoma Ecology Center, SCWA

✓ Vulnerability Assessment: Pepperwood, USGS, NBCAI/Point Blue

✓ User Interface: RCPA, Pepperwood, SEC

✓ Climate Smart Info Exchange: NBCAI/Point Blue plus analysts

✓ Adaptation Pilots: RCPA, NBCAI/SEC

North Bay Climate Ready

- Project Overview
  - Why?
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Natural Resources User Group

- Russian River Basin plus Sonoma Co: SCWA, Open Space, County Parks, Mendocino Water and Flood
- Napa Valley: Napa County Planning, Public Works and Flood Control
- Marin: Marin Municipal Water District

Municipal User Group: all 9 cities in Sonoma County, public works, planners, transportation, health, via RCPA and Climate Action 2020

North Bay Watershed Association members (water suppliers, flood control, wastewater, watershed managers), plus invited

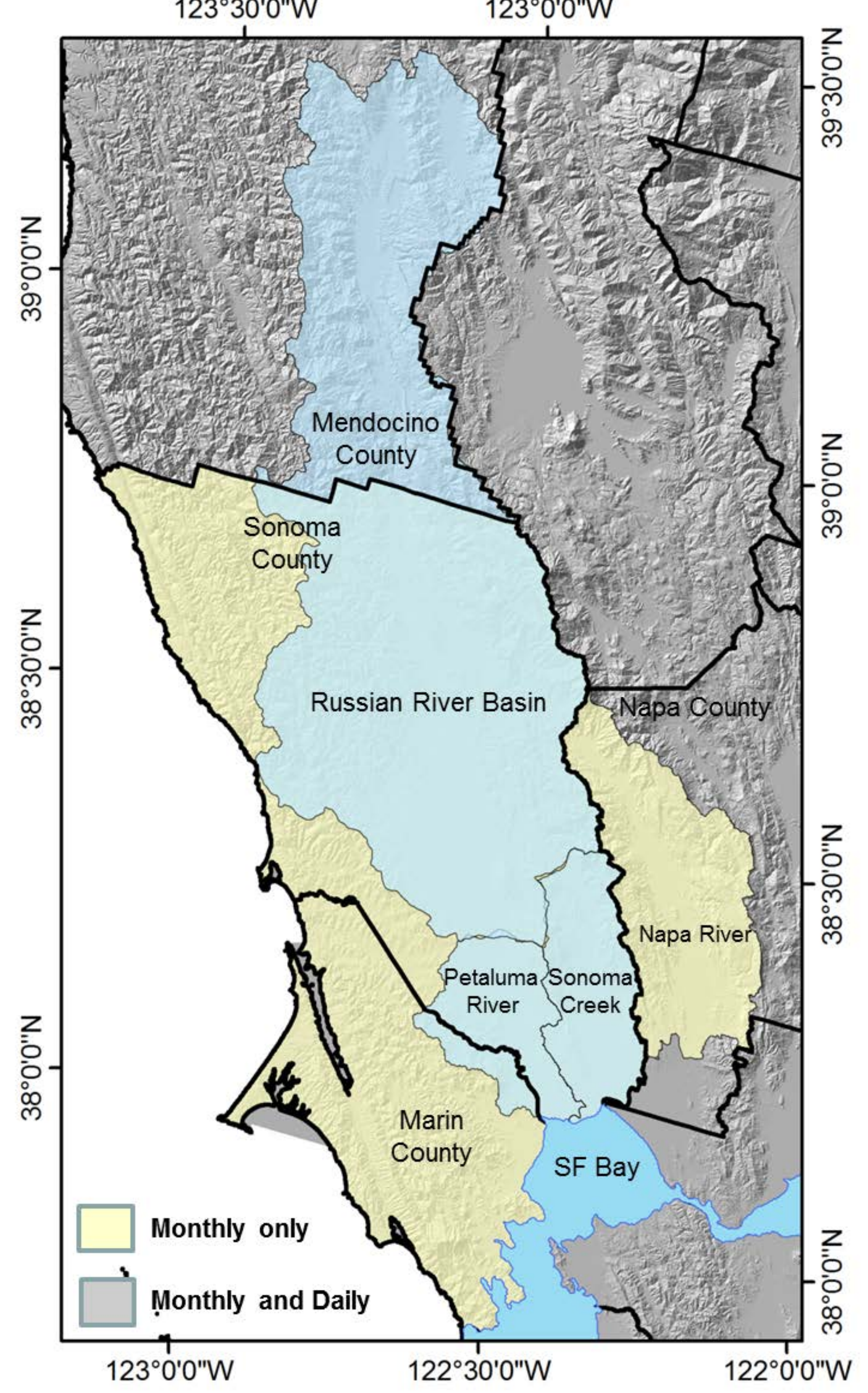
NORTH BAY CLIMATE READY WORKPLAN-RCPA-NBCAI

TASK	Subtask	Target Date	2014									2015											
		(complete by:)	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1 Project Management																							
	RCPA Board Approval of Coastal Conservancy Agreement	4/25/2014	X																				
	SCC approves work plan	6/15/2014			X																		
	Invoicing	ongoing				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Kick-off internal planning meeting-Whole Team-Proj Mgt, VA, CS Info Exchange	6/28/2014			X																		
	Vulnerability Assessment Team Review, User Group Intro Prep Products	7/15/2014				X																	
	Project Mgt Leads-check in meetings	ongoing		X						X		X	X				X			X		X	X
	VA/CS Team meetings	ongoing									X		X	X	X	X	X	X					
	Adaptation pilot management meetings	9/1/2015																		X	X	X	X
	Final reports and wrap up coordination	12/1/2015																			X		X
2 Vulnerability Assessment User Group Needs Definition																							
2.1 Scoping 1: Climate Scenario Selection	Provide background on scenarios, and propose criteria and options for selection	9/25/2014					X	X															
2.2 Scoping 2: Define Customized Reports	Define geographic boundaries, time periods, and report format for custom data products; introduce implementation pilot objectives.	10/25/2014						X	X														
2.3 Scoping 3: Prelim VA Product review	Review draft customized reports	12/15/2014									X												
2.4 Scoping 4: Revised VA Product review	Present final VA products and set goals for Climate Smart Info Exchange, identify pilot projects	4/15/2015												X	X								
2.5 Regional Users Forums	Presentations of regional VA products, CS Info Exchange training, and sharing implementation strategies.	9/1/2015															X			X			
3 Climate Projection Analysis and Data Product Development																							
3.1 Water availability and reliability	Recharge mapping, drought assessment, extreme heat risk, daily flows and flooding	8/1/2014					X																
3.2 Environmental demand	Wildfire risk, agricultural demand, landscape CWD change, soil moisture	9/15/2014						X															
3.3 Document results and provide guidance	Participate in User Group Scoping meetings and incorporate feedback into draft and final products	4/1/2015					X	X	X		X				X								
3.4 Final reports process and annotated results	Provide final reports on process and annotated data products	12/1/2015																					X
4 Climate Smart Information Exchange																							
4.1 Gather reports & define objectives	Collect data and guidance products from VA team and work with User Groups to define objectives for Climate Smart Info Exchange	5/1/2015														X							
4.2 Build Climate Commons page	Design and build web portal for Climate Ready data product access	8/1/2015														X	X	X	X				
4.3 User training materials	Develop and deliver CS Info Exchange Training	9/1/2015																		X			
4.4 Final reports	Provide content for final report on CS Info Exchange development and use	12/1/2015																					X
5 Climate Smart Implementation pilots																							
5.1 Synthesize VA process and results	Final reports review and edit	9/1/2015																		X			
5.2 Support Climate Smart Pilot projects	Support subset of Users in the application of VA products in specific plans or projects; specific case studies to be identified during Task 2	5/1/15 - 11/1/15														X	X	X	X	X	X	X	
5.3 Final Report	Document results and lessons learned in applying results to Climate Smart projects	12/1/2015																					X

Climate Ready North Bay Study Area

yellow = monthly data only

blue overlay = monthly + daily data



"Climate-Hydro Futures"

- Full IPCC data set: 23 models x 4 RCPs (AR5) x 3 emissions scenarios (AR4)
- Proposed Selection Criteria:

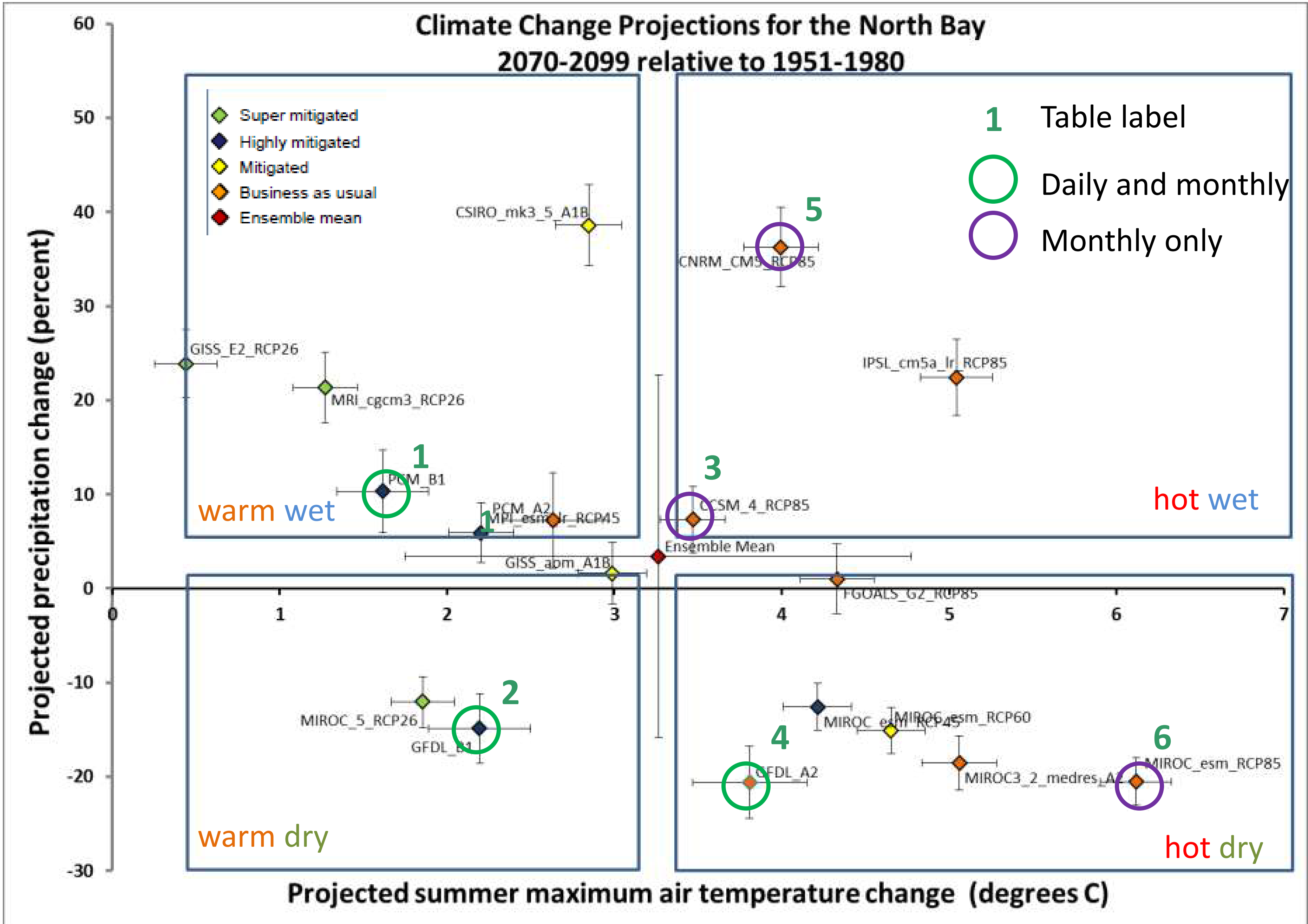
"Reasonable" number to apply -3 to **5**?

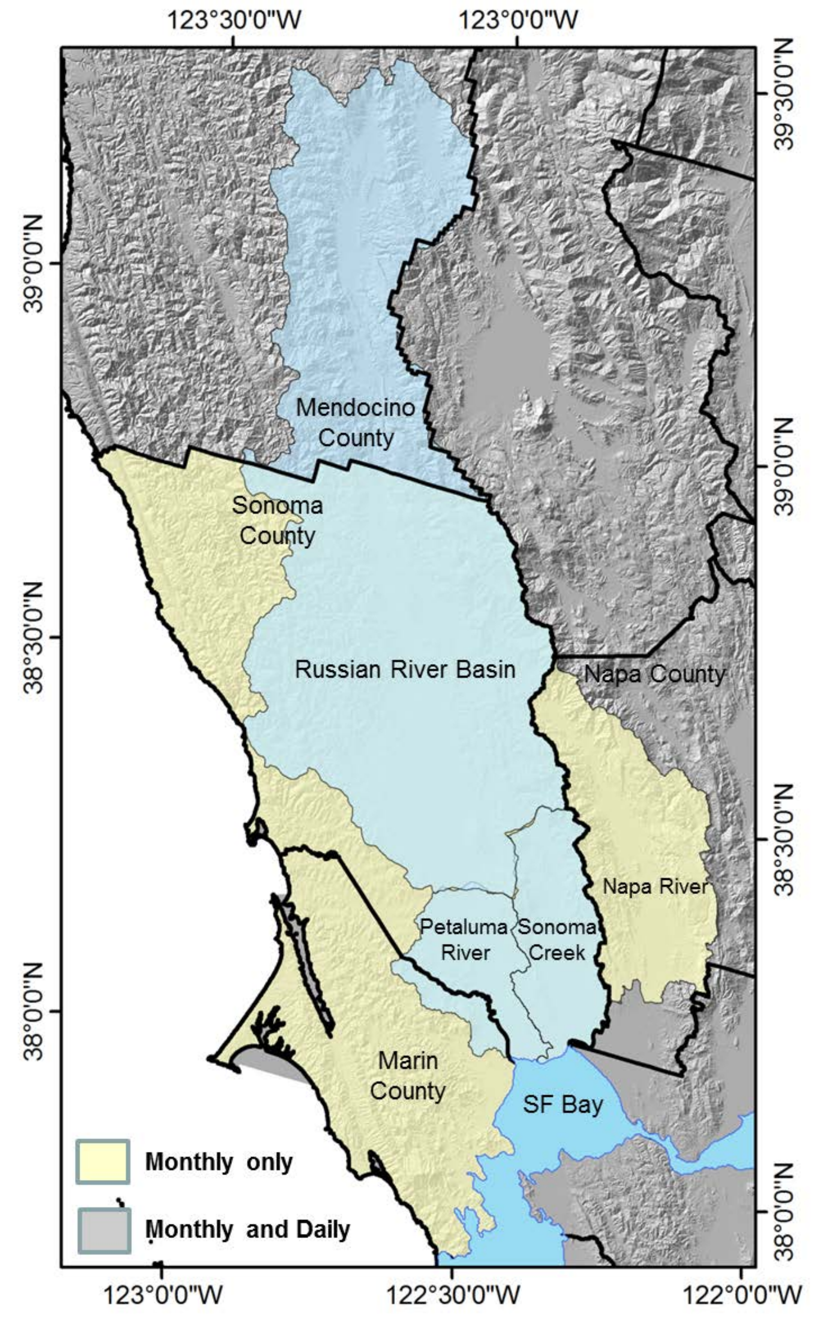
"Realistic"-capture "Business as Usual" and include mitigated scenarios to show change will happen even under best case.

"Representative Range" get central tendency plus rep range of projected change-"middle of the road" (near ensemble mean) and 'extremes"/"worst case scenarios"-(which are probably still conservative)

Consistent with State-California Climate Change Technical Advisory Group recommendations for model skill in representing precipitation patterns

North Bay Climate Ready: Selected Futures for Regional Vulnerability Assessment



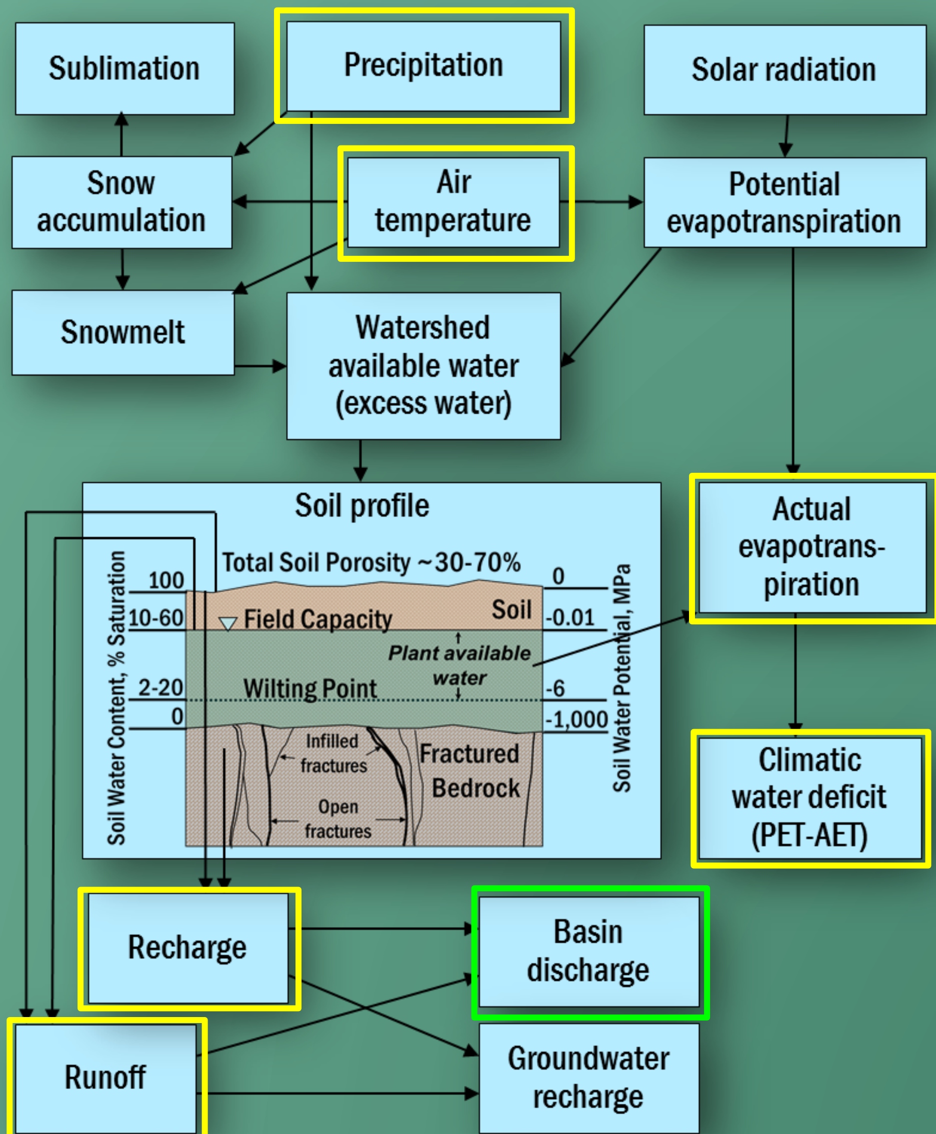


Basin Characterization Model

- INPUTS Climate
  - Precipitation
  - Air temperature
- OUTPUTS Hydrology
  - Recharge
  - Runoff
  - Streamflow (daily area)
  - Actual evapotranspiration
  - Climatic water deficit

USGS
science for a changing world

Basin Characterization Model

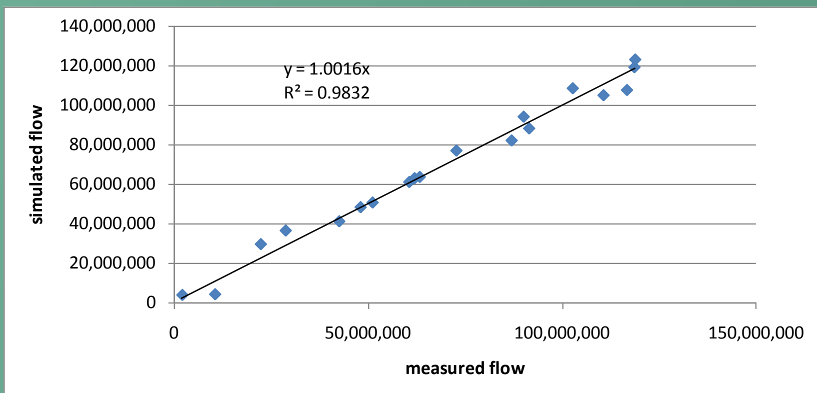


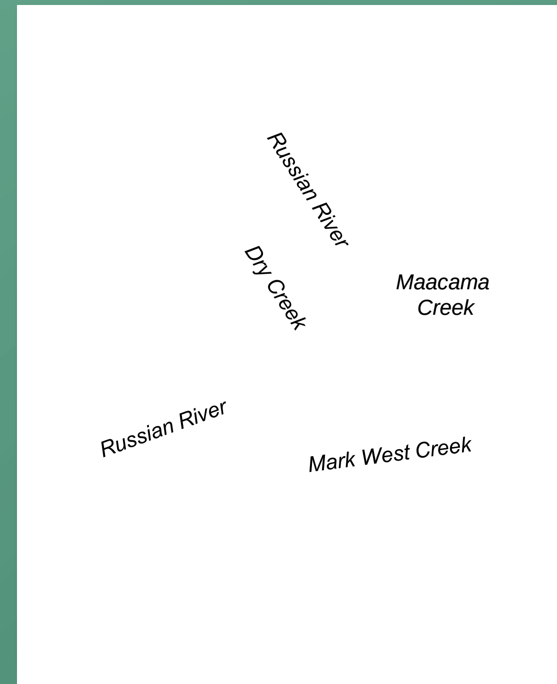
Monthly and daily

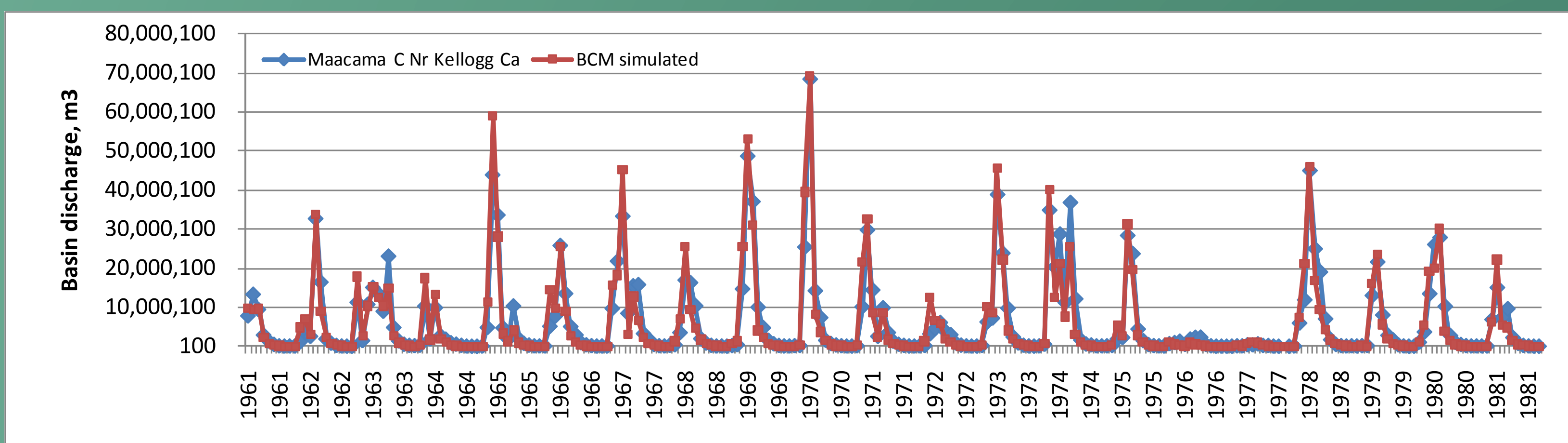
Daily

USGS science for a changing world

Calibration Using Discharge Measurements from unimpaired streams



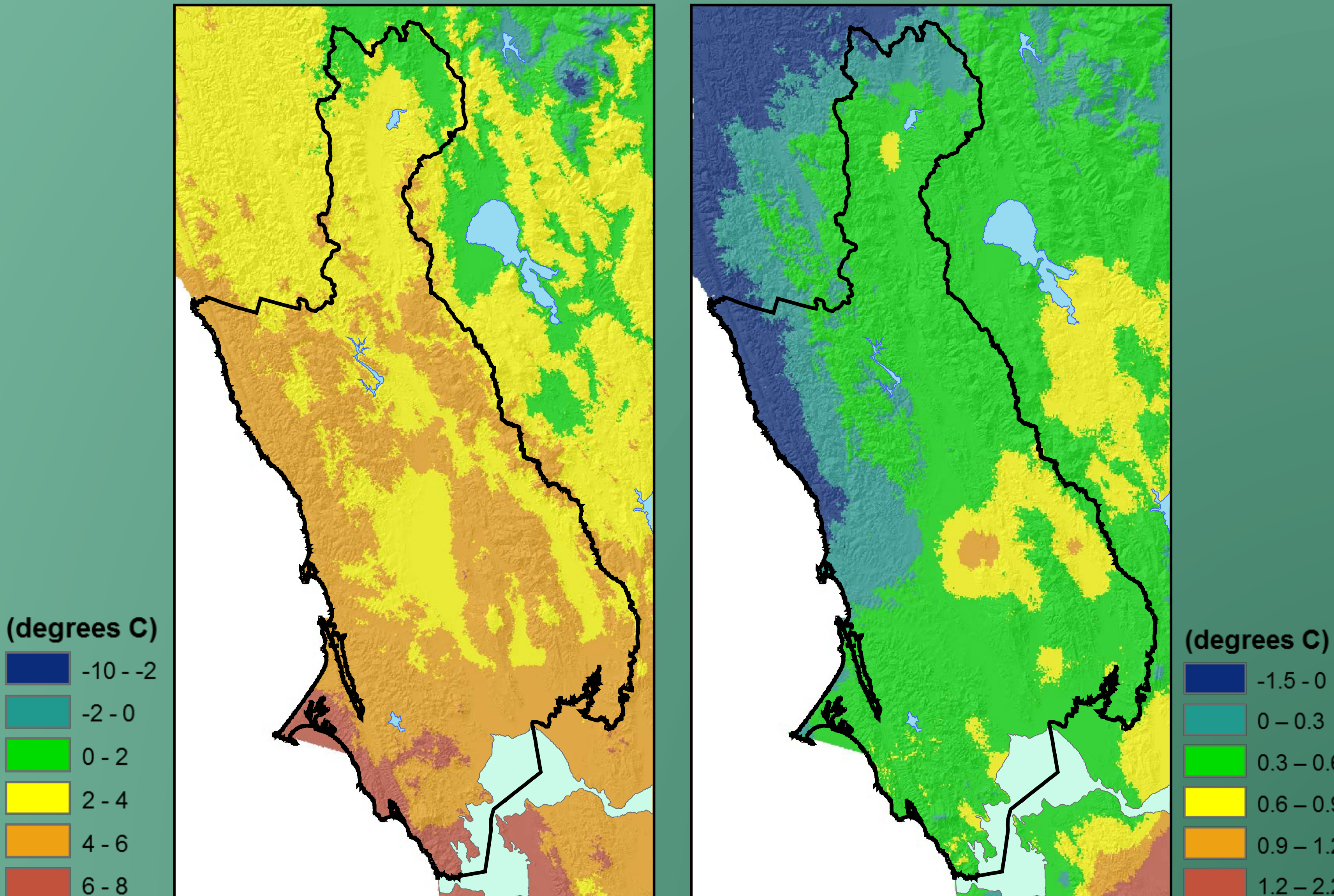




Change from (1951-1980) to (1981-2010)

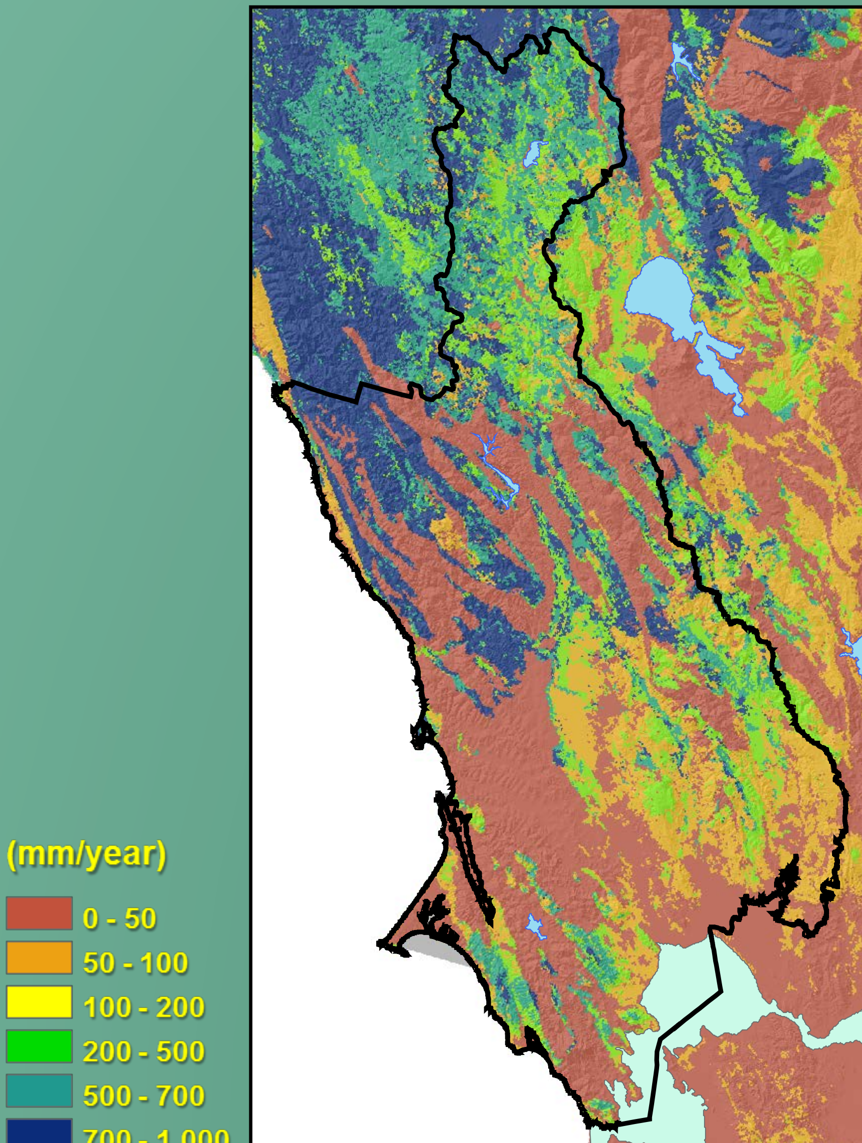
Winter Minimum Air Temperature

Change

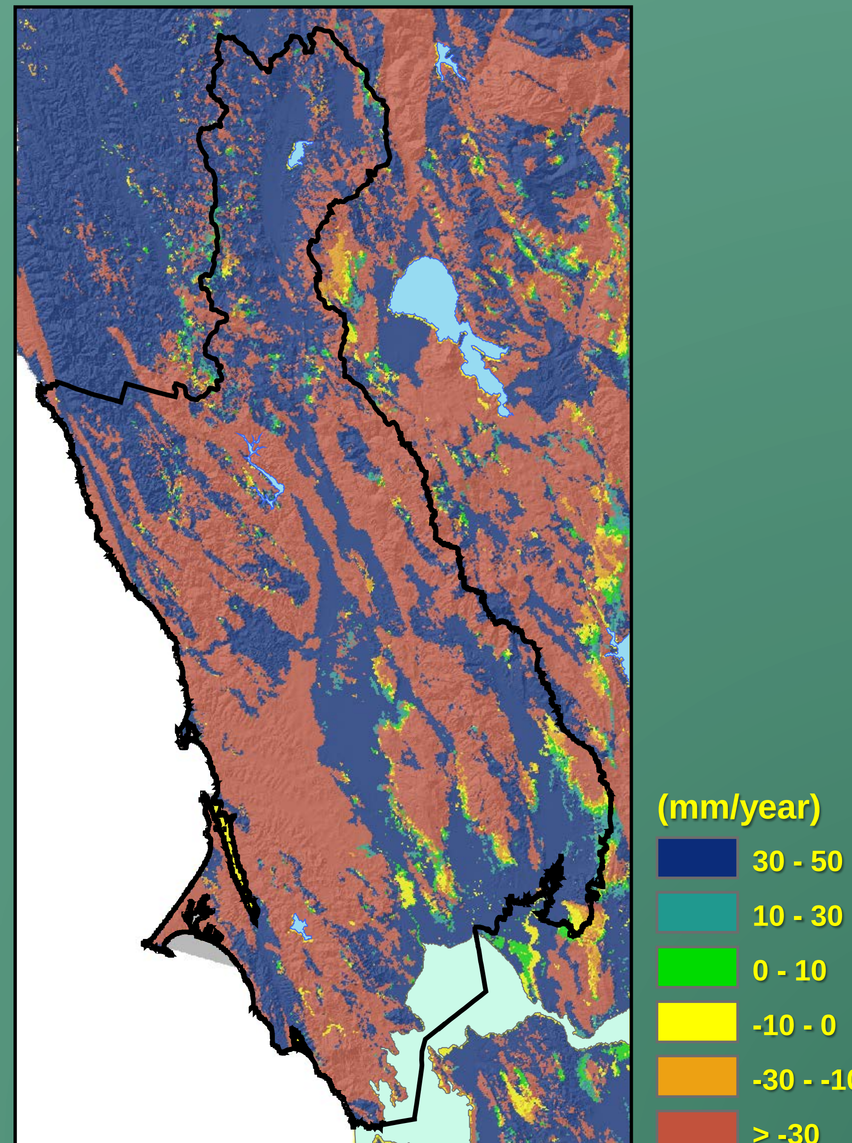


Change from (1951-1980) to (1981-2010)

Recharge



Change

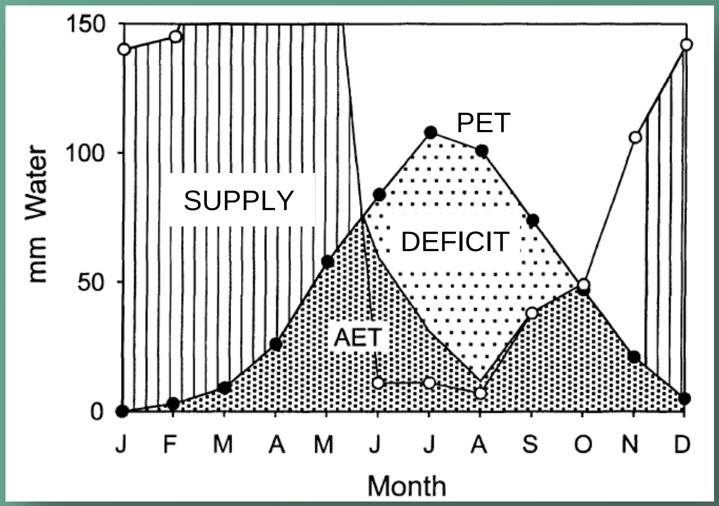


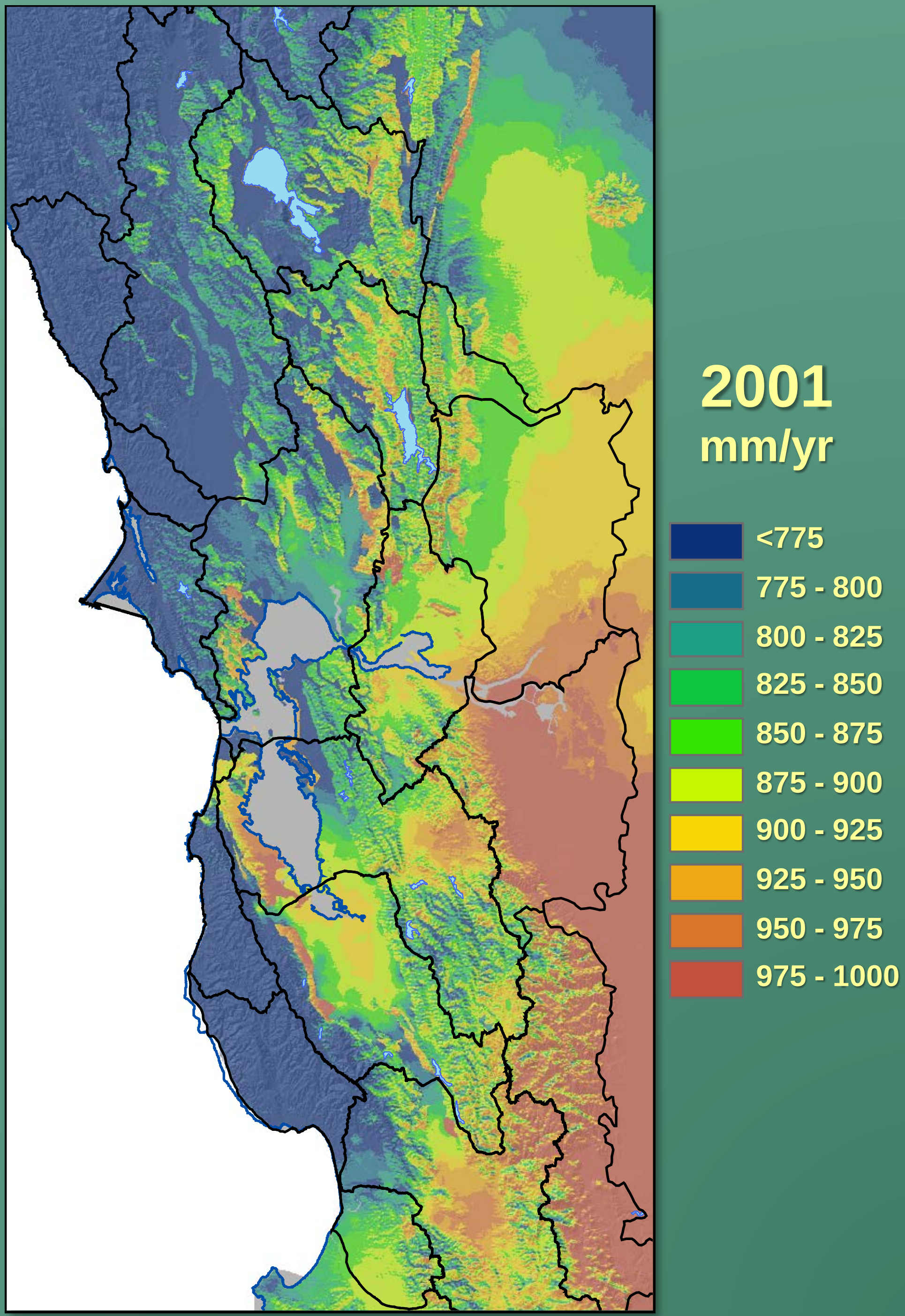
Climatic Water Deficit

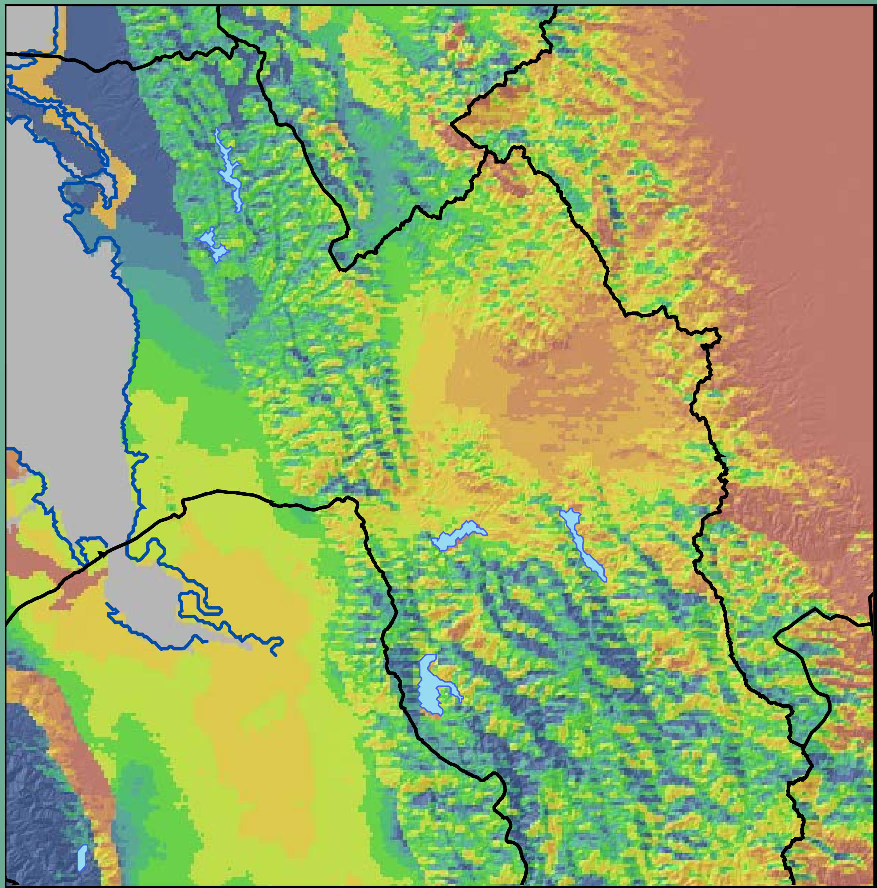
Annual evaporative demand that exceeds available water

Potential – Actual Evapotranspiration

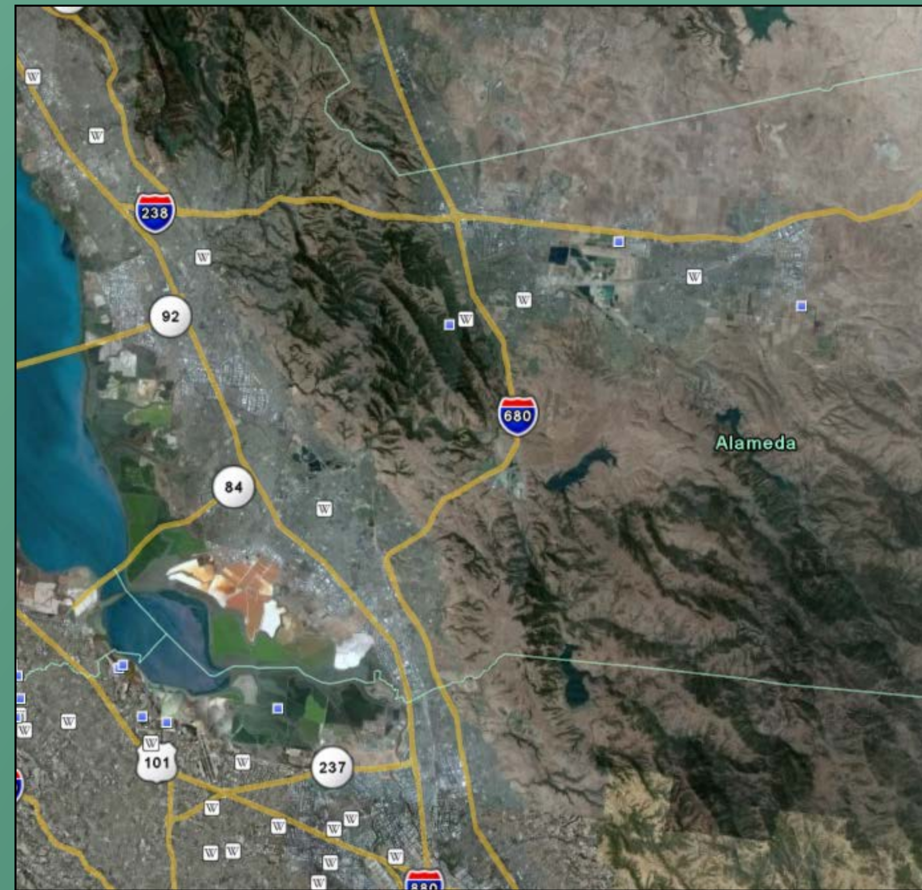
- Integrates climate, energy loading, drainage, and available soil moisture storage
- Vegetation independent (indicator)
- Address irrigation demand
- Generally increases with all future climate scenarios







Climatic Water Deficit in South Bay

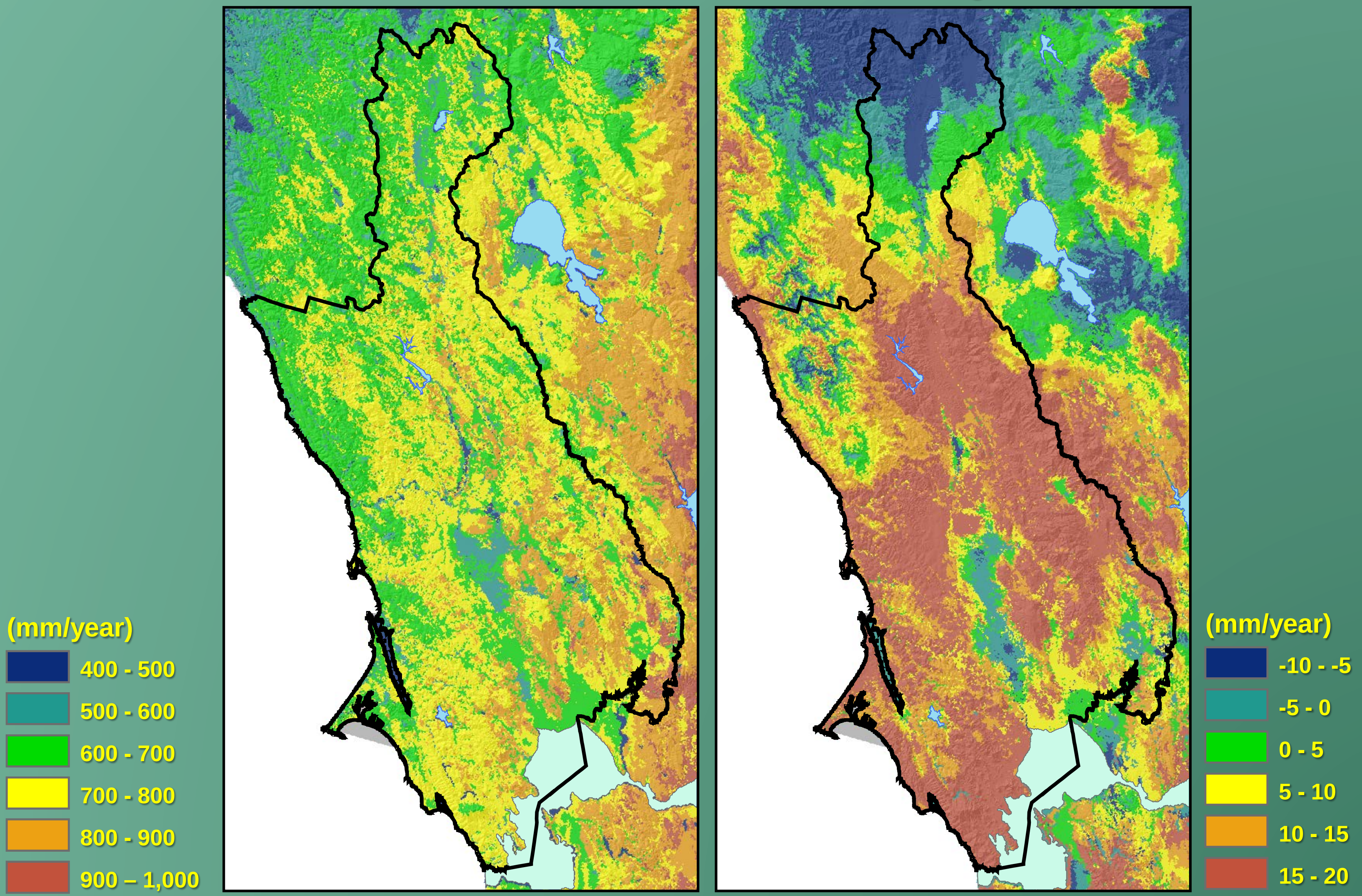


Google Earth Image of South Bay

Change from (1951-1980) to (1981-2010)

Climatic Water Deficit

Change



Menu of Analyses

Mapped distribution of a variable; time series for a certain area

- Monthly, seasonal, or annual
- Temp, rainfall, recharge, runoff, streamflow
- Extremes, e.g. months below lowest historical 5%
- Correlations, e.g. of CWD with ag water demand, vegetation cover, fire risk

Spatial extent

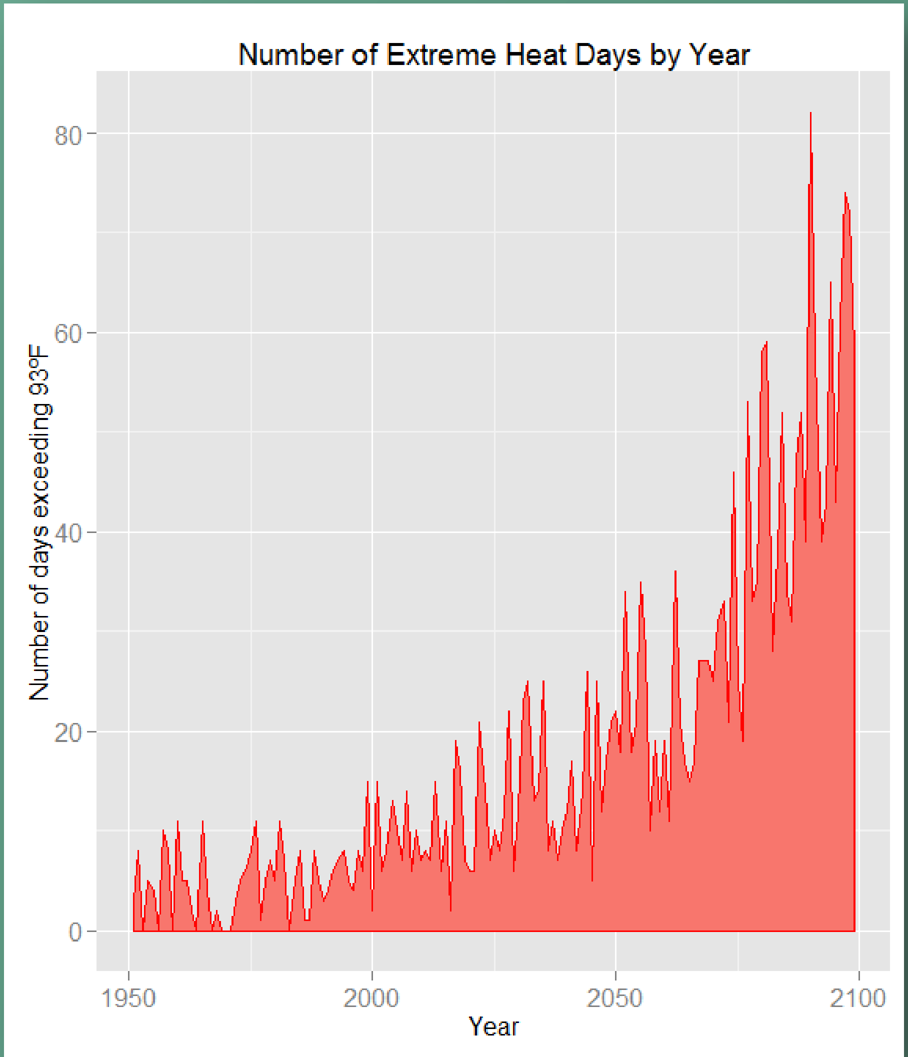
- Watersheds, planning areas, watersheds above reservoirs
- Parks or preserves
- Watersheds above stream gages*

Thresholds

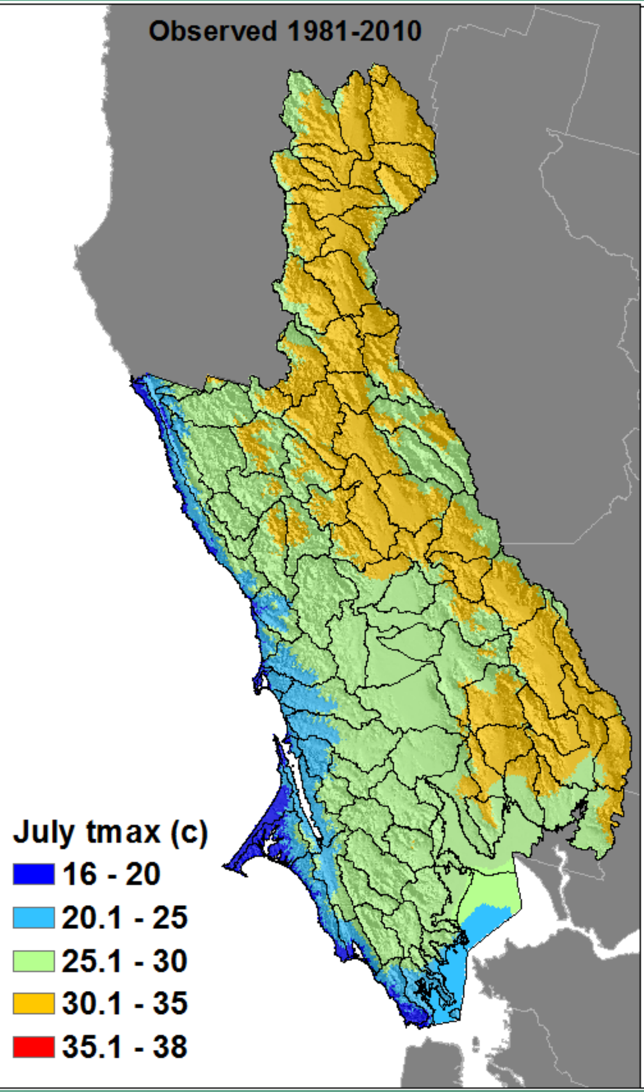
- Historical analogs
- Frequency, duration
- Running averages
- Growing degree days
- Freezing days

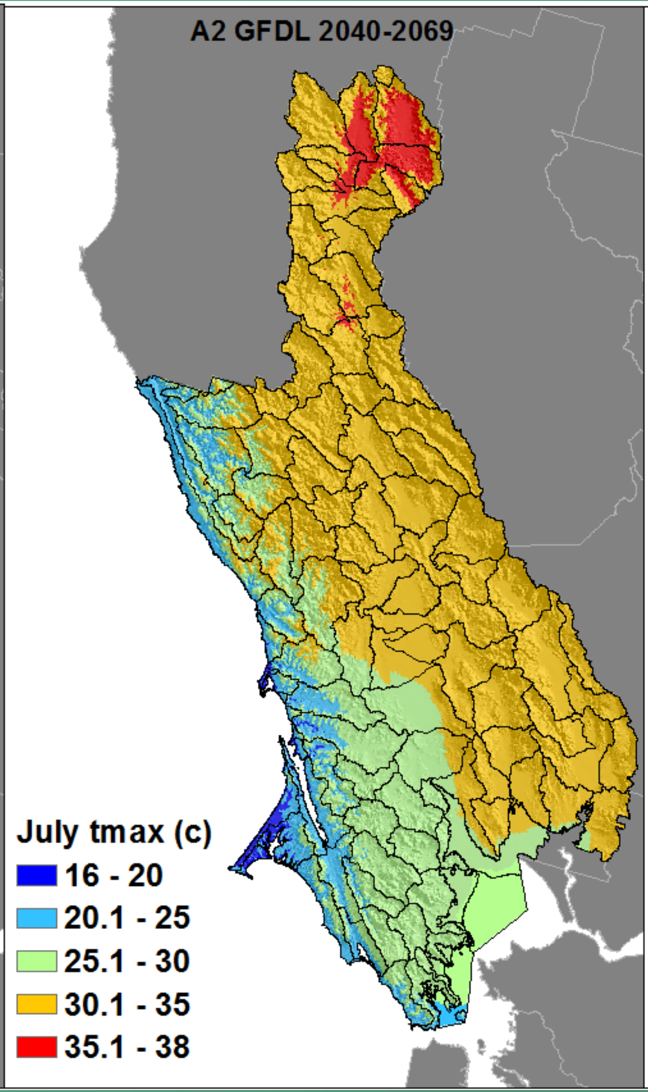
Extreme heat days in Santa Rosa

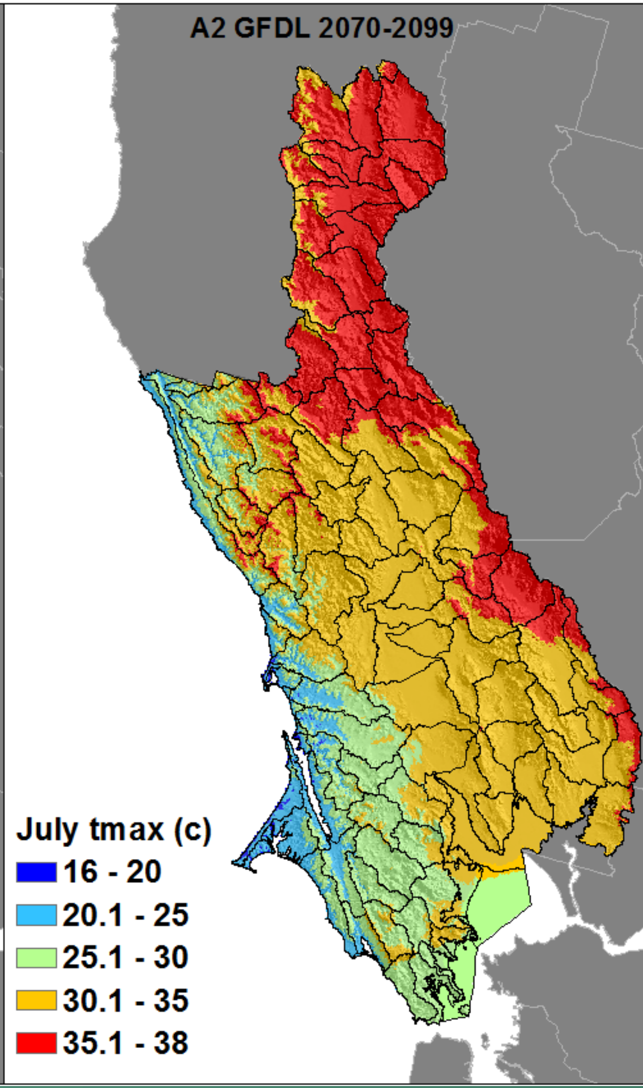
Fixed threshold example



Change in Summer Maximum Air Temperature

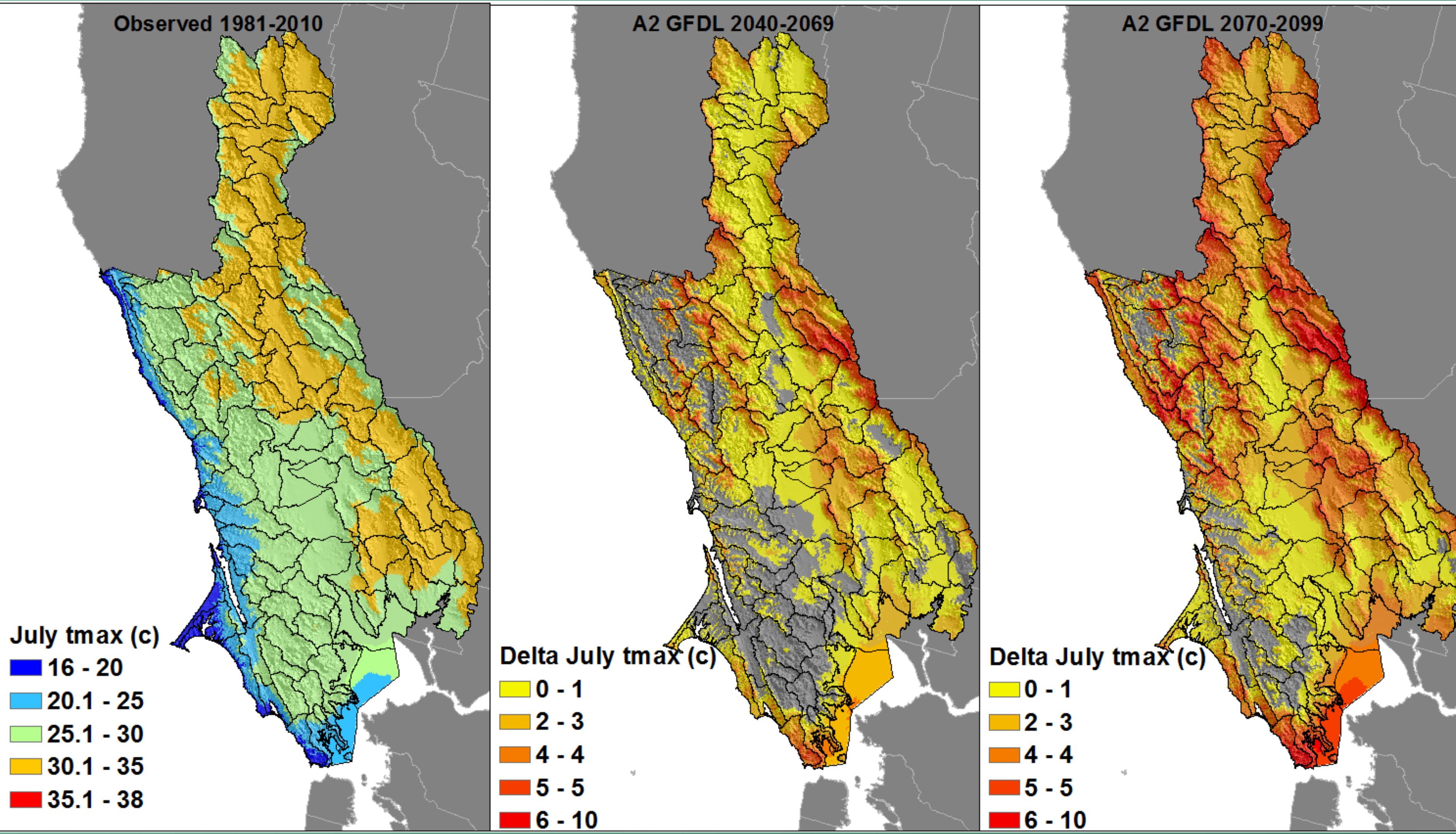






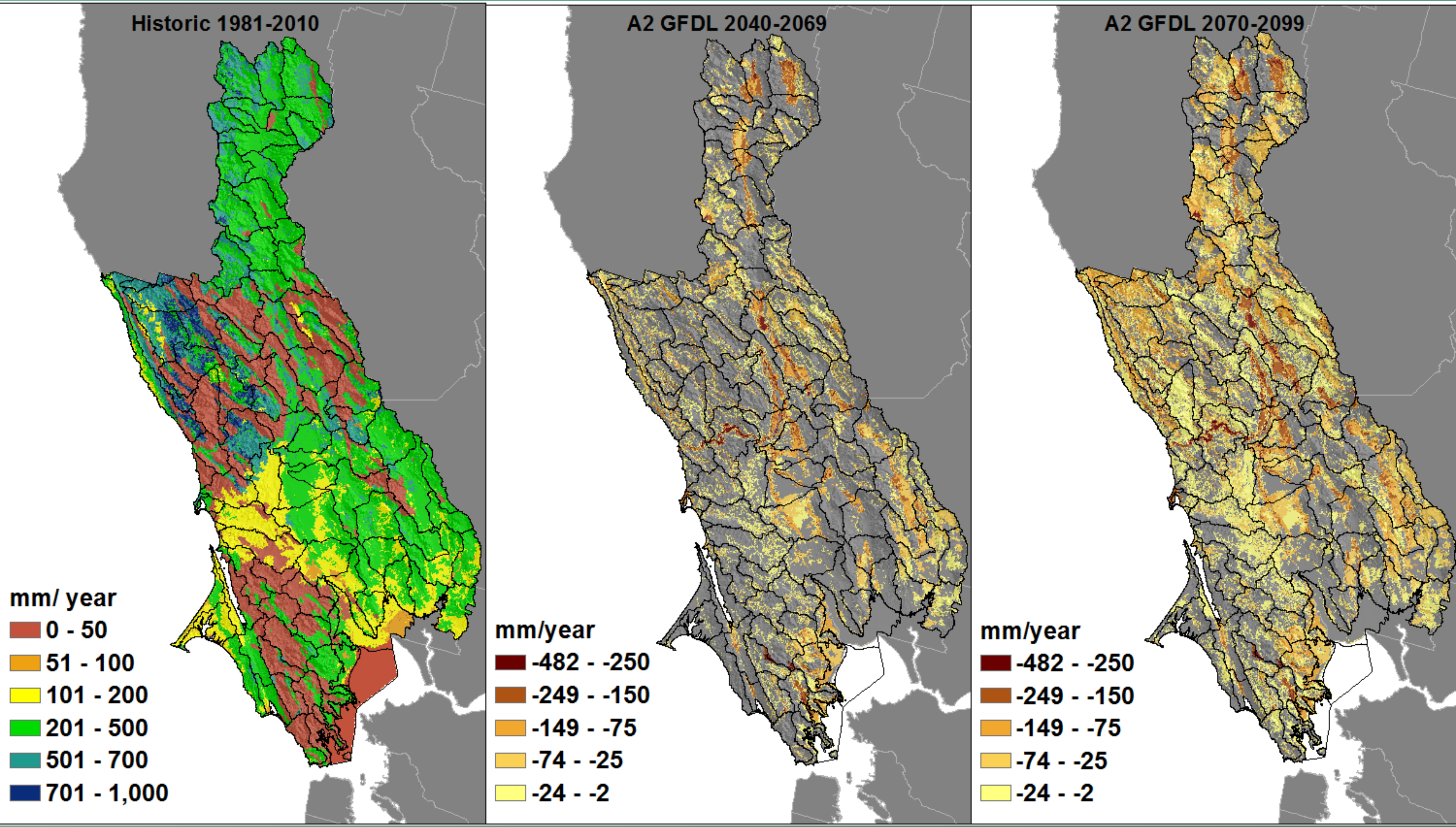
a comparison of absolute values over time

Change in Summer Maximum Air Temperature



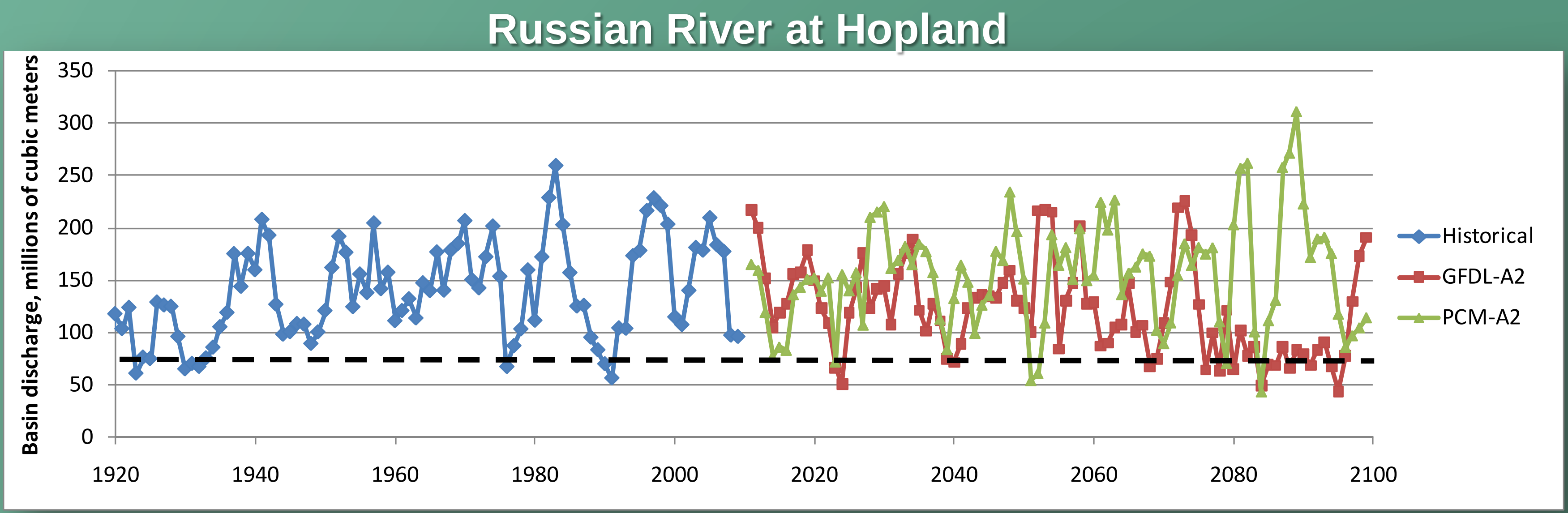
evaluation of total change above variable threshold (this case, range of historic variability)

Change in Recharge

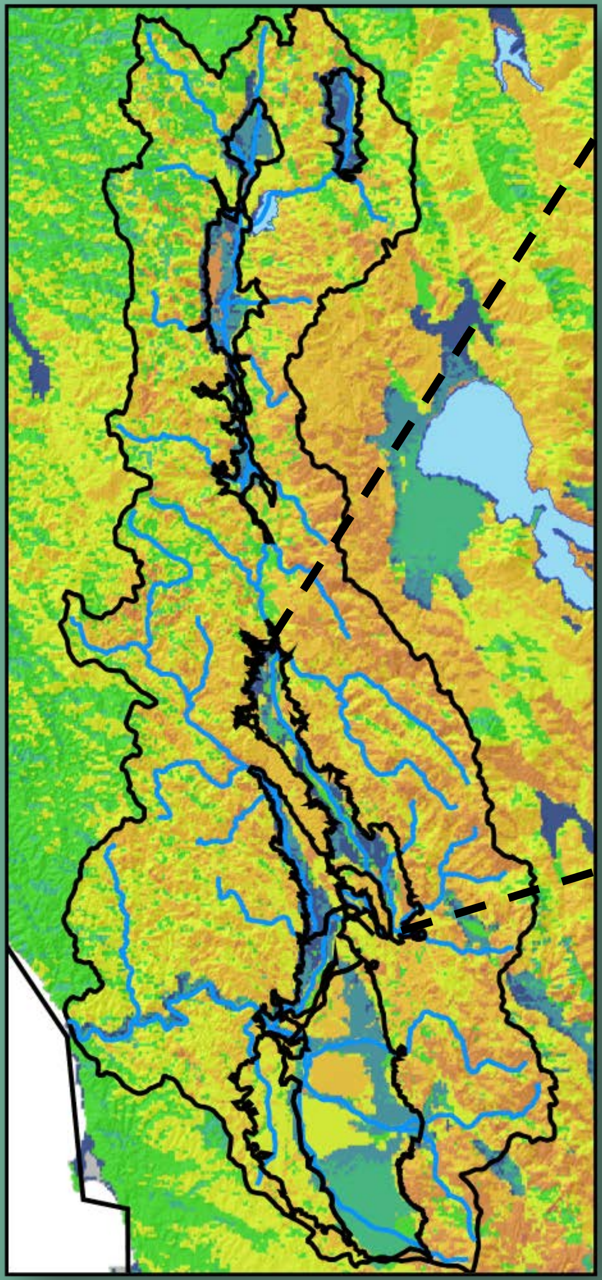


evaluation of total change above variable threshold (this case, range of historic variability)

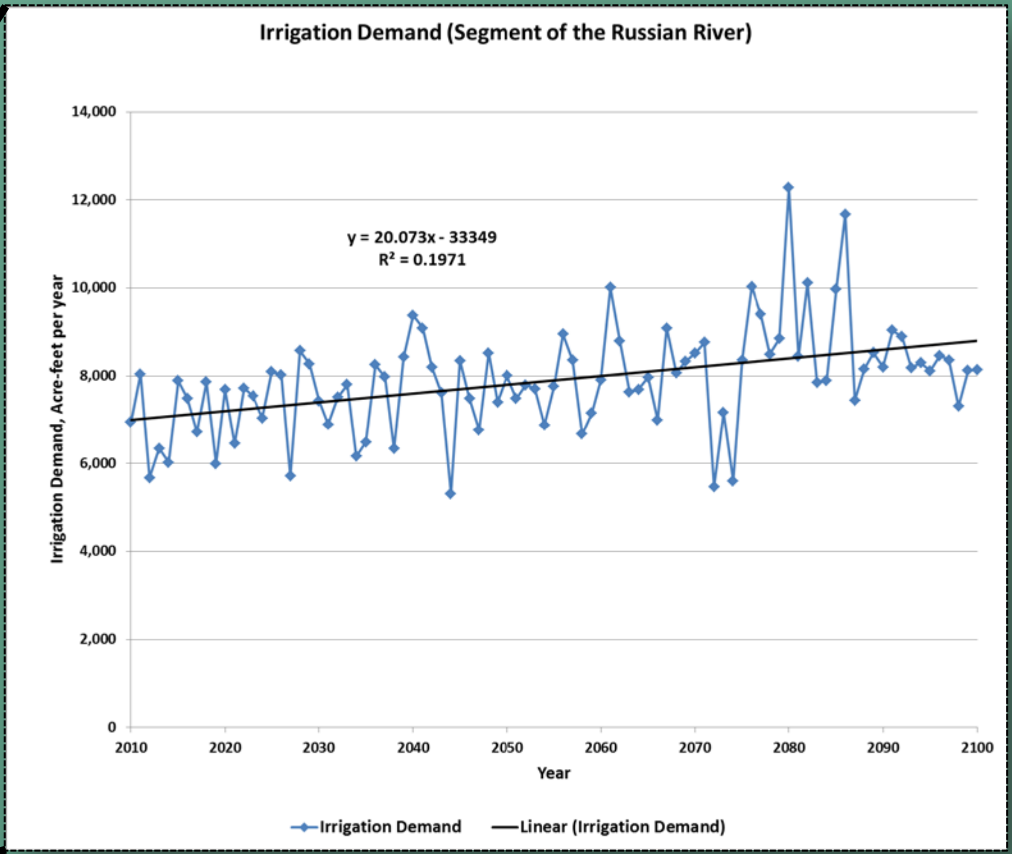
Applications: Future Drought Conditions - Stream flow



Trendlines are annual 3-year running averages.
Dotted line represents historical droughts.
Drought frequency projected to increase.



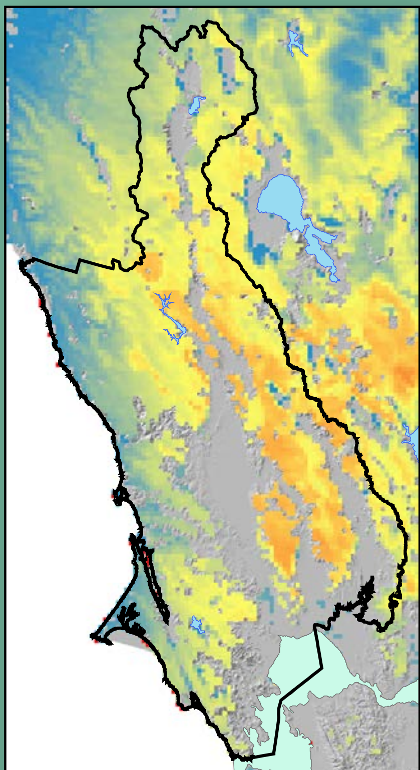
CWD 1981-2010 (mm/yr)
0 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1,000



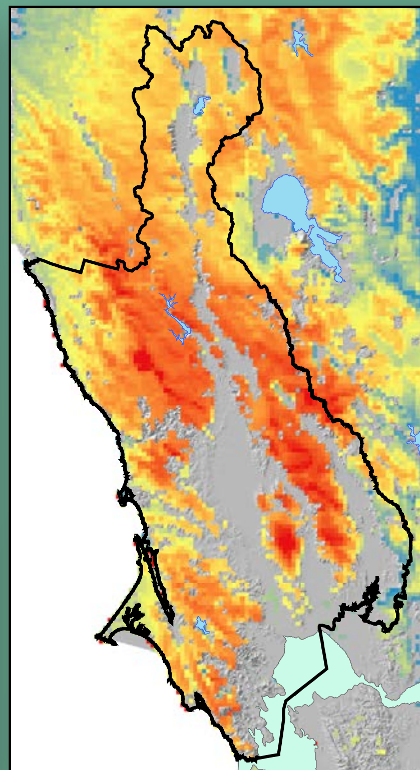
Environmental Demand Methodology

Probability of Burning Two or More Times

1970-2000

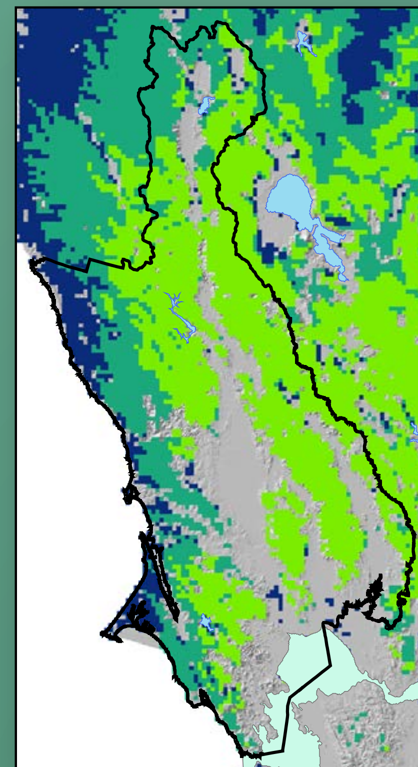


2070-2100

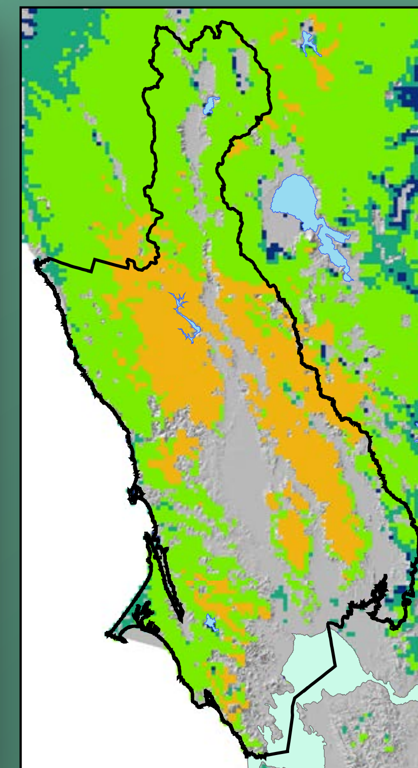


Mean Fire Return Interval

1970-2000



2070-2100



Dry Climate Scenario (GFDL-A2)

Urban, agricultural, and water are masked in grey

Napa River Priorities

- Risks to surface water supply
- Risks to groundwater supply
- Impacts to fishery streams from drought
- Urban flood risk
- Natural vegetation change and fire risk
- Impacts to viticulture

Look ahead to seeing results next spring

Next Steps

North Bay Climate Ready

- ✓ Fall 2014: meet with Natural Resources User Group to detail their priority information needs.
- o Winter 2014: produce both universal and customized data products.
- o Early spring 2015: Edits based on Natural Resources User Group review.
- o Spring 2015: Present to Municipal and NBWA User Groups.
- o Spring 2015: Final formats, goals for Climate Exchange website, assist with applications, identify pilots for implementation.
- o Summer 2015: regional training and roll-out.


Climate Ready North Bay
Tools and Available Data:
Choosing Climate-Hydro Futures and
Demonstrating Data Products

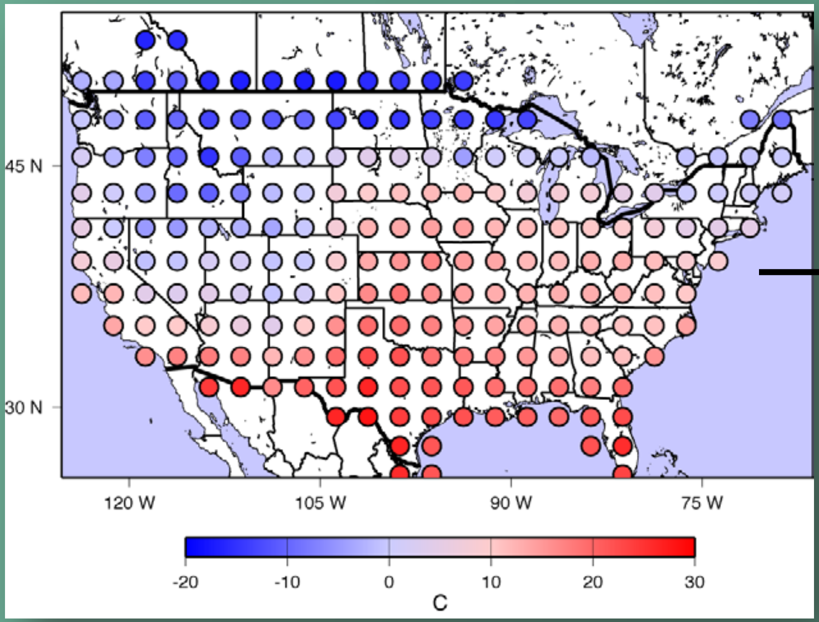
Outline

- Selection of Climate Futures
- Downscaling tools and sample products
- Next steps

From Global Climate Models (GCMs) to → High Resolution Climate-Hydro Futures

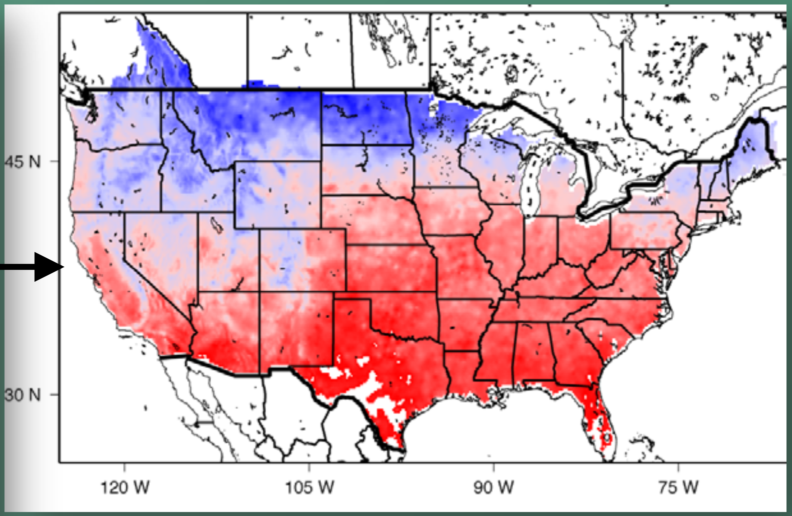
- Climate model data (precipitation, air temperature) are available from the IPCC at 2.5 degree resolution, ~ 275-km grid cells
- IPCC model data downscaled to 12-km via statewide efforts (USGS, Scripps)
- 12-km statewide data spatially downscaled to 270-m for hydrologic model applications via a gradient-inverse distance squared interpolation (BCM, Flint and Flint) to incorporate historical weather-hydro data (PRISM, stream gages)

GCM output

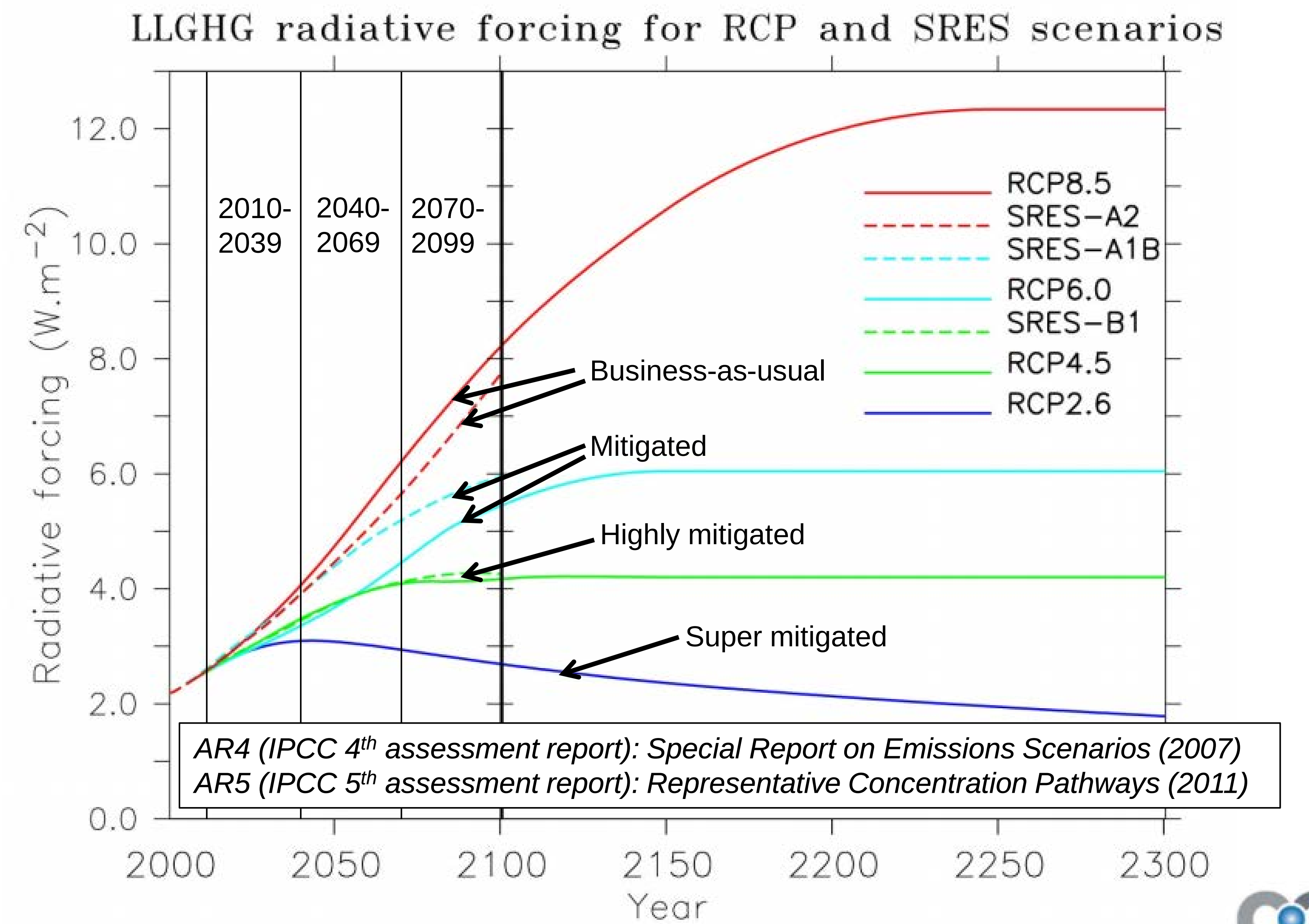


275 km grid cells

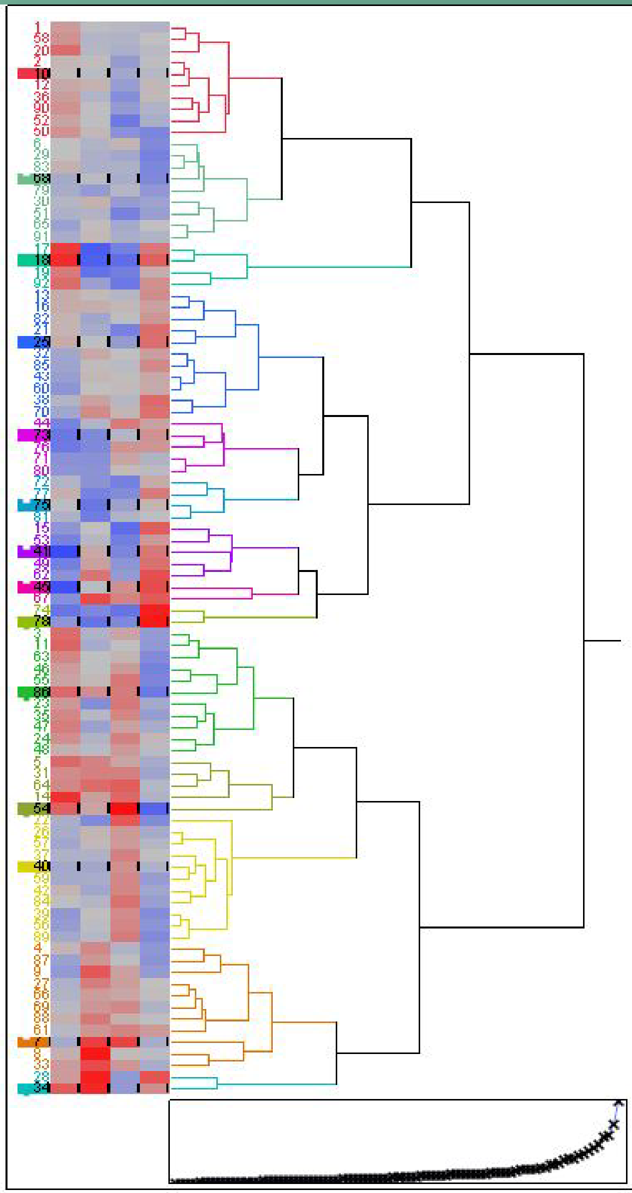
Downscaled



12-km grid cells


LLGHG radiative forcing for RCP and SRES scenarios
Radiative forcing (W.m−2)
Year
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2000
2050
2100
2150
2200
2250
2300
2010-2039
2040-2069
2070-2099
RCP8.5
SRES−A2
SRES−A1B
RCP6.0
SRES−B1
RCP4.5
RCP2.6
Business-as-usual
Mitigated
Highly mitigated
Super mitigated
AR4 (IPCC 4th assessment report): Special Report on Emissions Scenarios (2007)
AR5 (IPCC 5th assessment report): Representative Concentration Pathways (2011)

TBC3 Screening-Global Circulation Models (IPCC 2007 and 2013)



SON PPT_avg	DJF PPT_avg	MAM PPT_avg	Ann_ Tmax_avg
0.6022	1.7094	0.9628	21.321
0.7292	2.2153	1.0957	22.029
0.8561	2.7213	1.2286	22.737
0.9831	3.2272	1.3615	23.446
1.1101	3.7332	1.4945	24.154
1.2371	4.2391	1.6274	24.862
1.364	4.7451	1.7603	25.571
1.491	5.251	1.8932	26.279
1.618	5.757	2.0262	26.987
1.745	6.2629	2.1591	27.696
1.8719	6.7689	2.292	28.404

Culled from 76 models to get the smallest set capable of representing range of future variation

- 76 monthly projections-compare range of factors –Temperature, PPT; Fall, Winter, Spring in 2070-2099 time window
- Cluster analysis, PCA, and other statistics
- Retrospect – given (reasonable?) bias towards newer data, choose AR5 (2011) over AR4 (2007) when possible.
- 14 clusters, one model randomly chosen on from each-added 4 from pilot-18 total

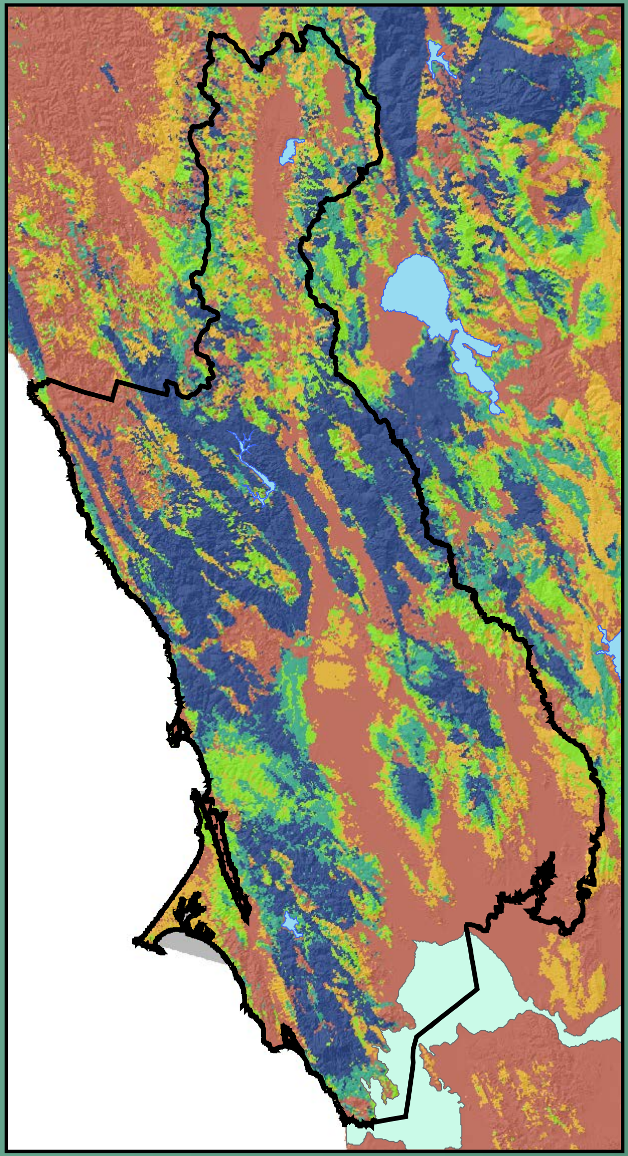
IPCC 4th (2007) and 5th (2013) Assessment Reports: BCSD

End of C GCM Model Selections for Climate Ready North Bay
(refer to table handout for details!)

6. MIROC ESM rcp 85, AR5 2013, hot dry, + 6.1 C, - 20% PPT
5. CNRM-cm5 rcp 85, AR5 2007, hot wet, + 4.0 C, + 36% PPT
4. GFDL A2, AR4 2007, middle hot dry, + 3.8 C, - 21% PPT
3. CCSM4 rcp 85, AR 5 2013, middle wet, + 3.5 C, + 7% PPT
2. GFDL B1, mitigated, warm dry +2.2 C, - 15% PPT
1. PCM B1, mitigated AR4, 2007, warm wet, + 1.6 C, + 10% PPT

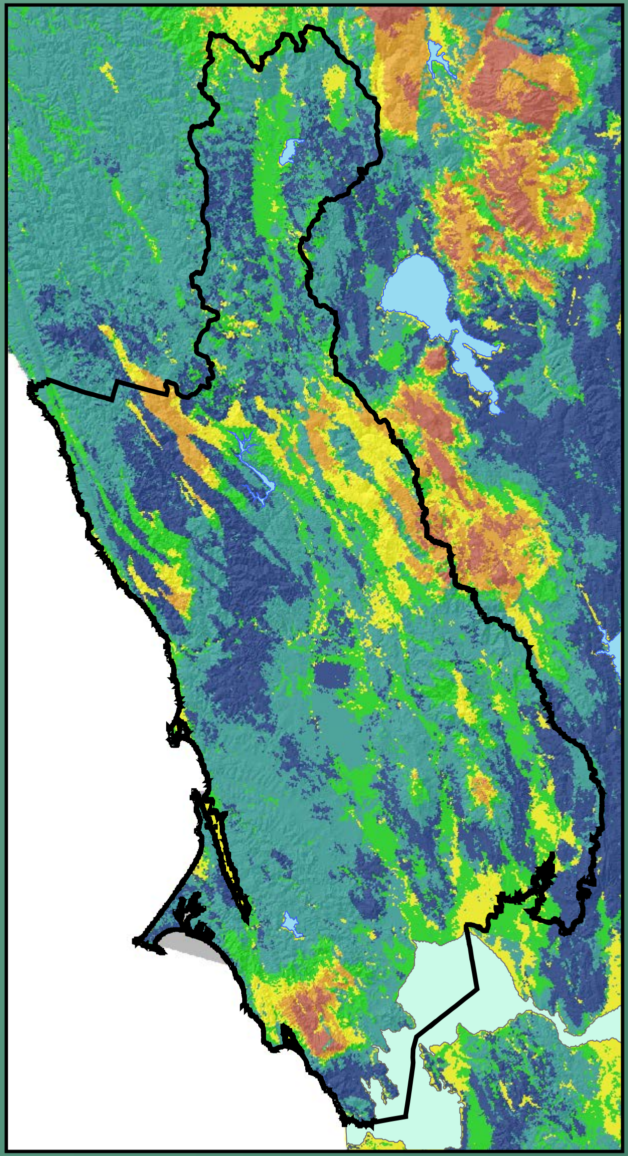
Change from (1951-1980) to (1981-2010)

Runoff



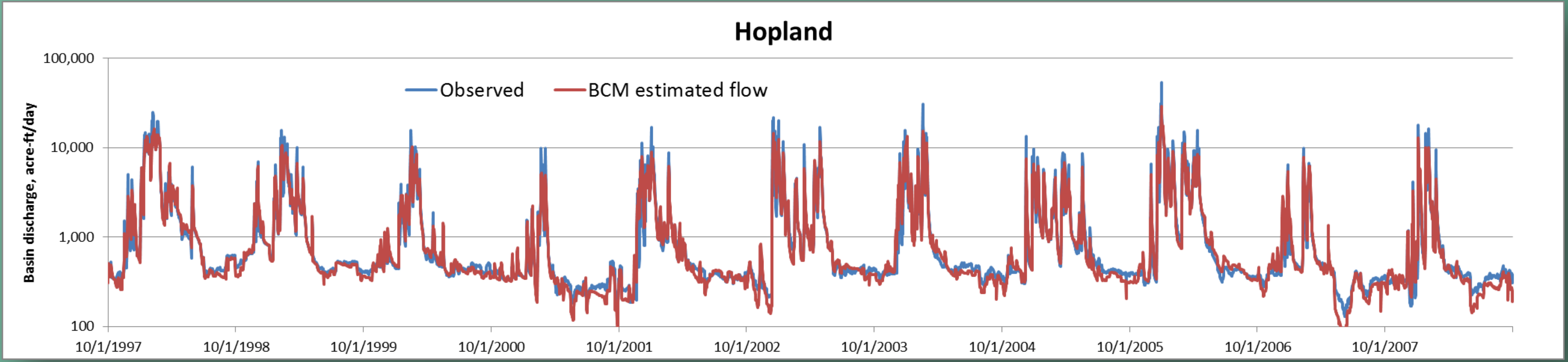
(mm/year)
0 - 50
50 - 100
100 - 200
200 - 500
500 - 700
700 - 1,000

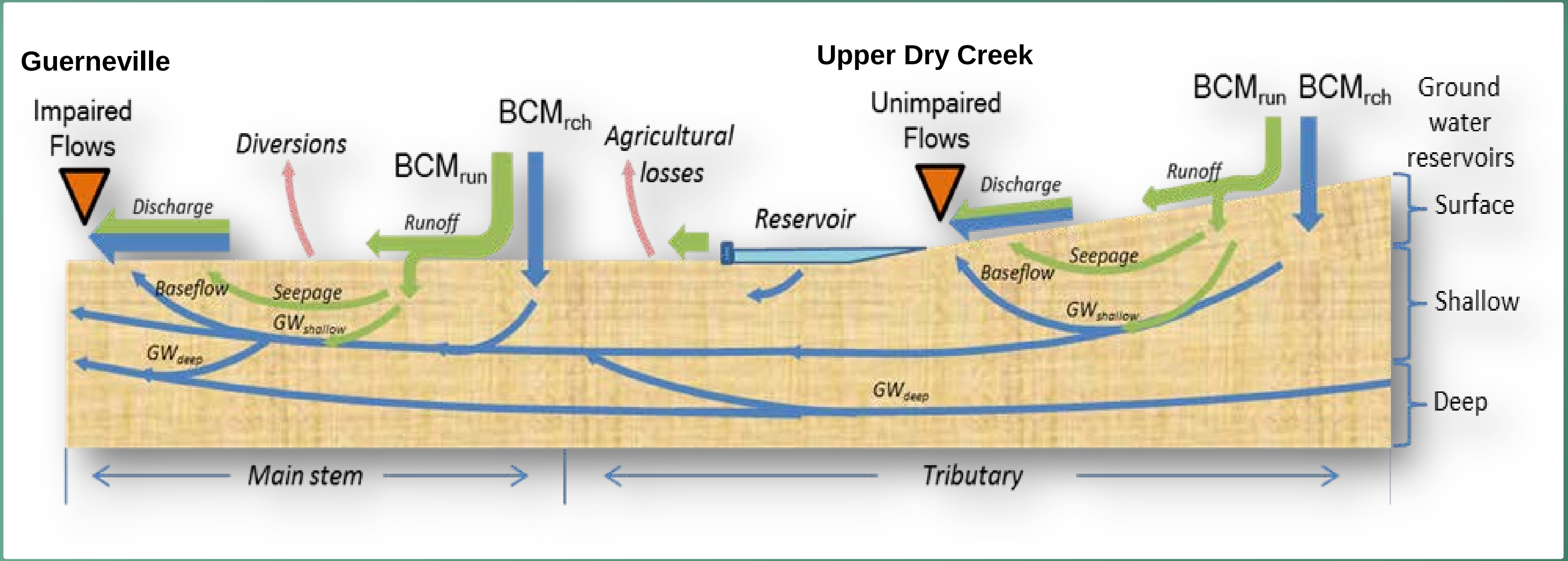
Change



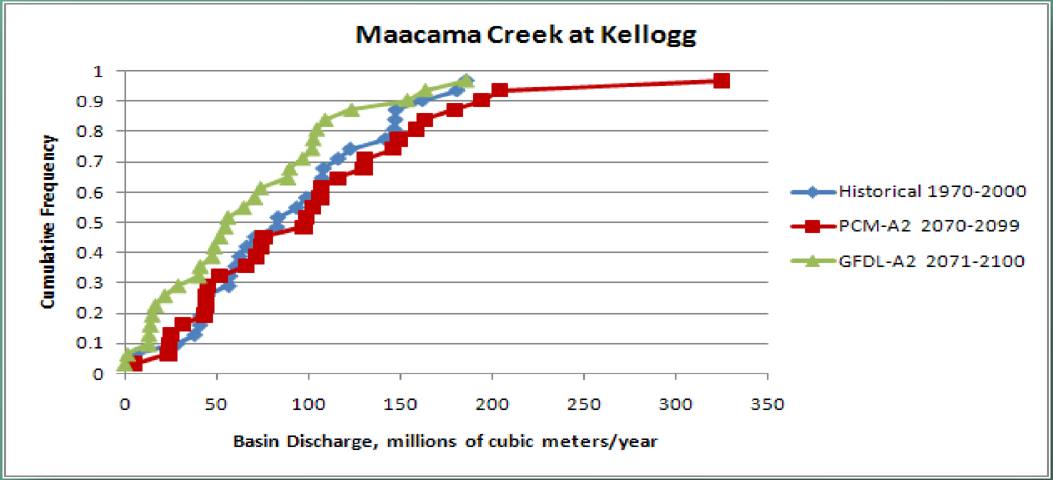
(mm/year)
30 - 50
10 - 30
0 - 10
-10 - 0
-30 - -10
> -30

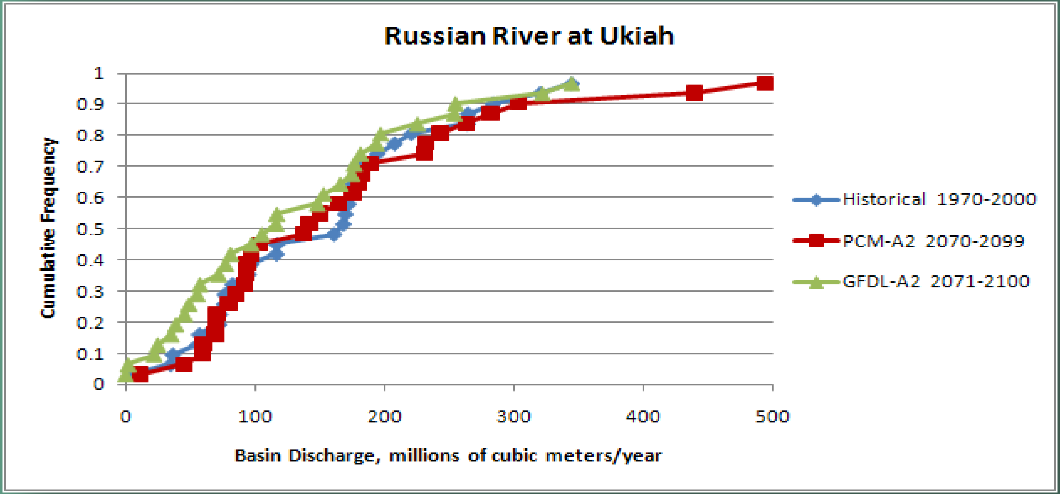
Calculating Basin Discharge from Recharge and Runoff to Match Streamflow Measurements





Applications: Change in Streamflow Frequency and Magnitude



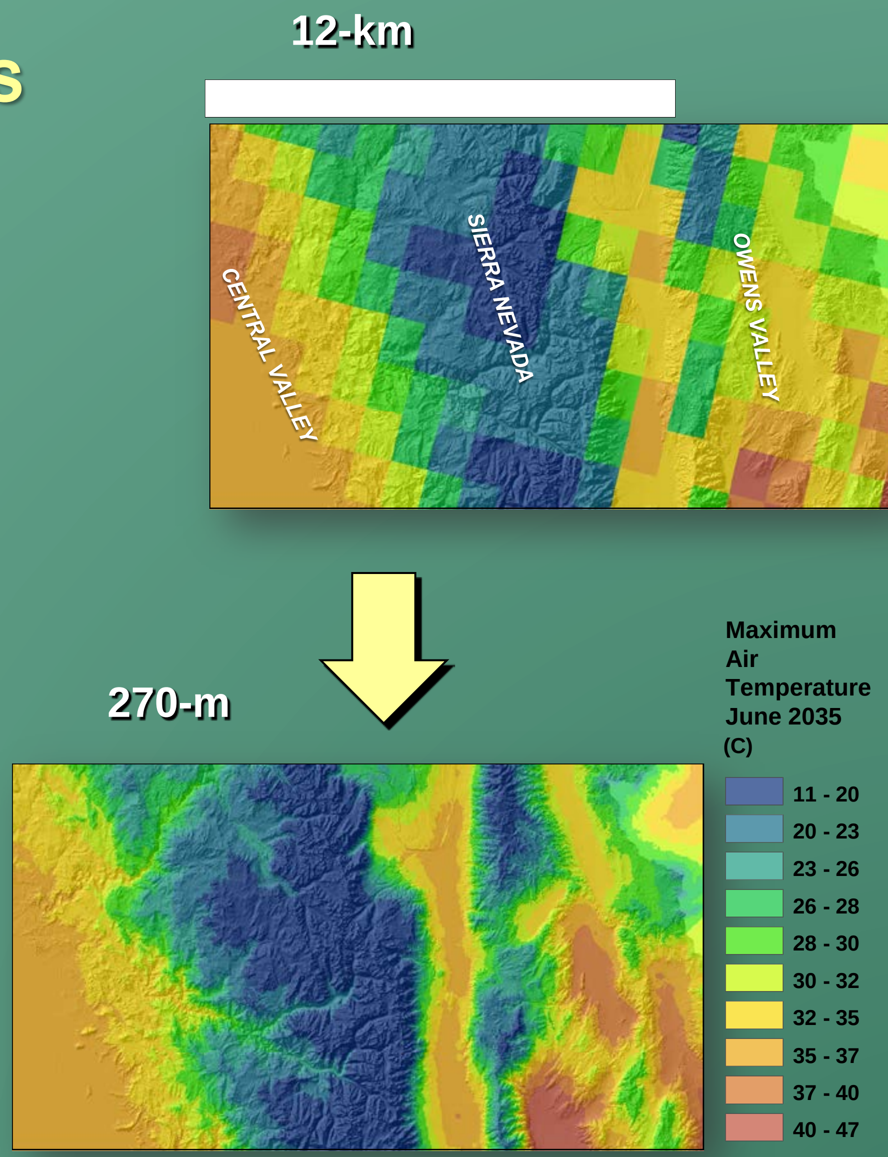


Menu of Analyses

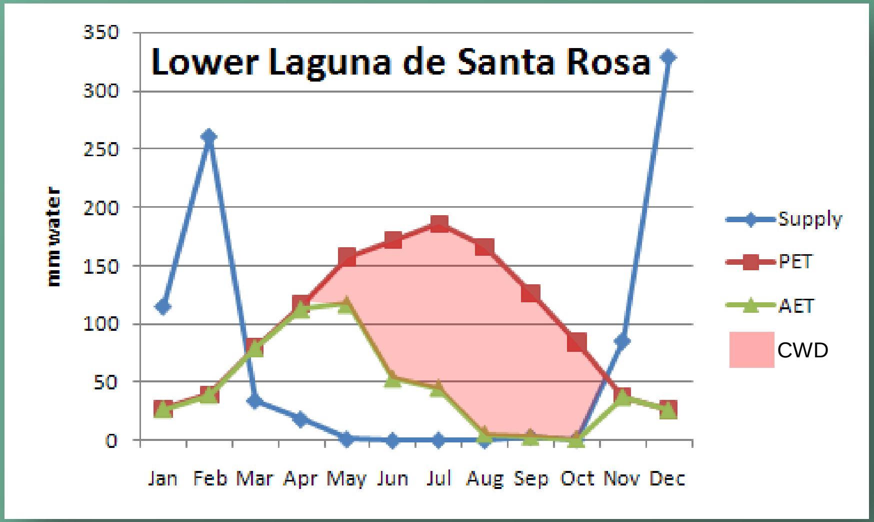
- Universal products for study region: major trends for planning basins: 30-yr averages of key variables
- Custom-designed for users' needs

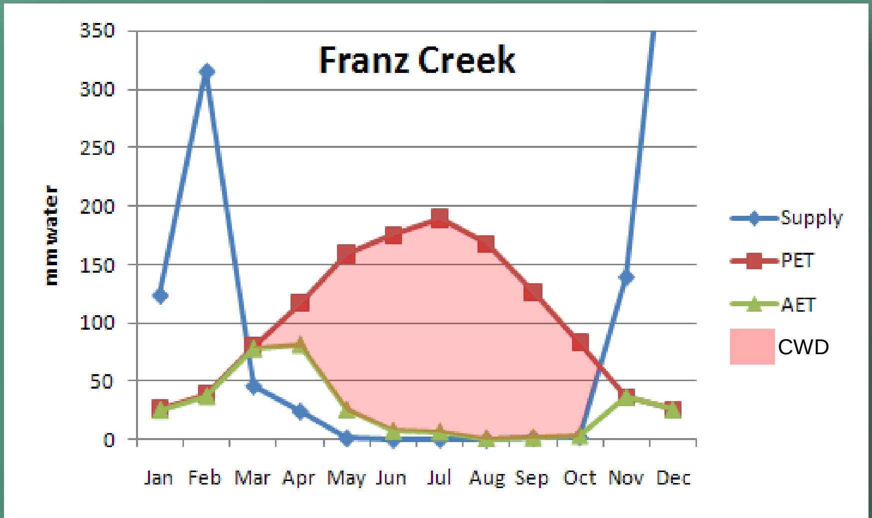
Downscaling Climate Change Futures

- Data are spatially downscaled to 270-m using Gradient-Inverse-Distance-Squared interpolation for hydrologic model application
- For every month an equation is developed for every grid cell using northing, easting, and elevation to incorporate elevational and regional gradients



Impact of Soil Storage on Climatic Water Deficit

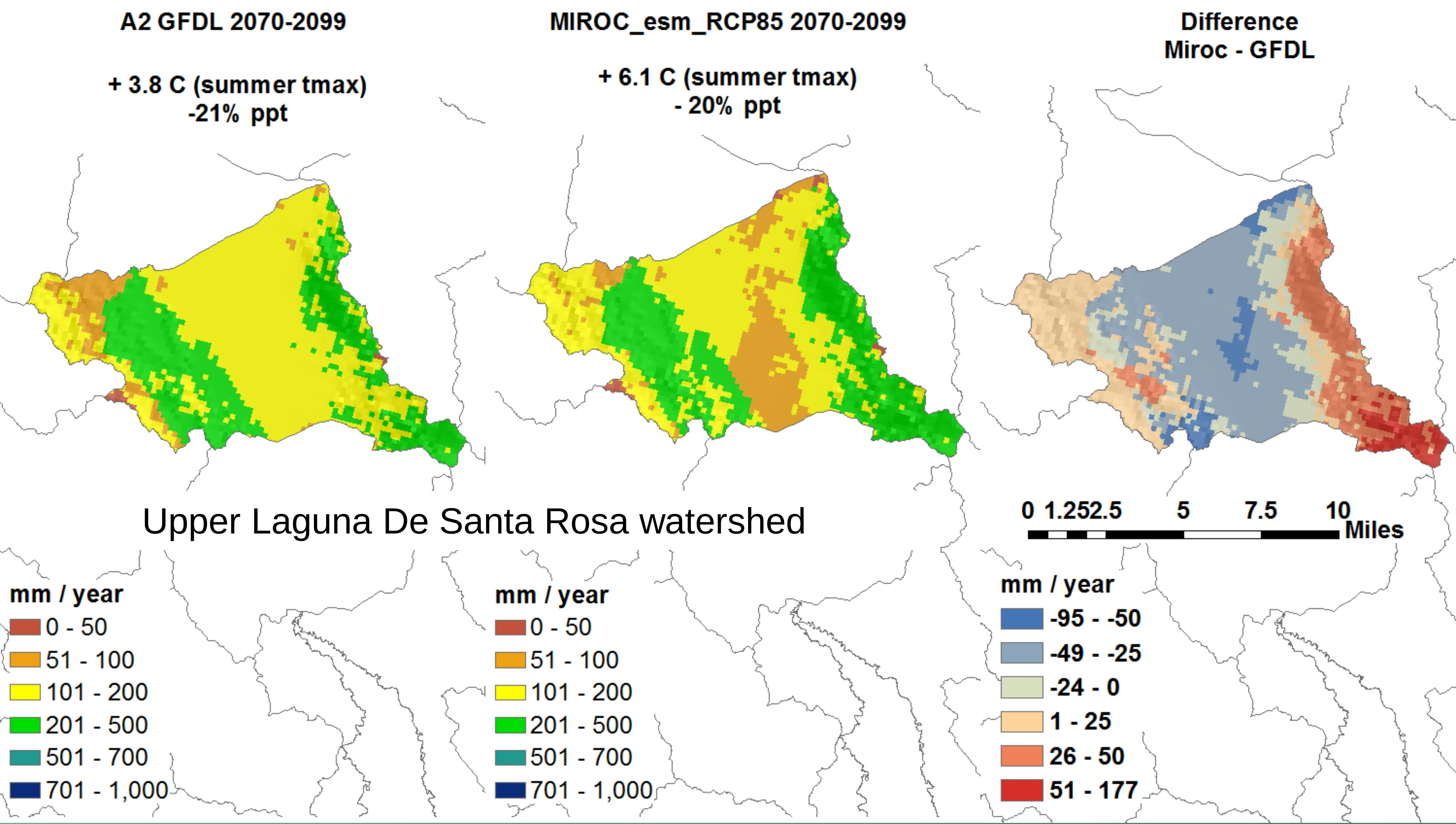




Supply	847 mm/yr
PET	1,218
AET	547
Soil Storage	303
CWD	671

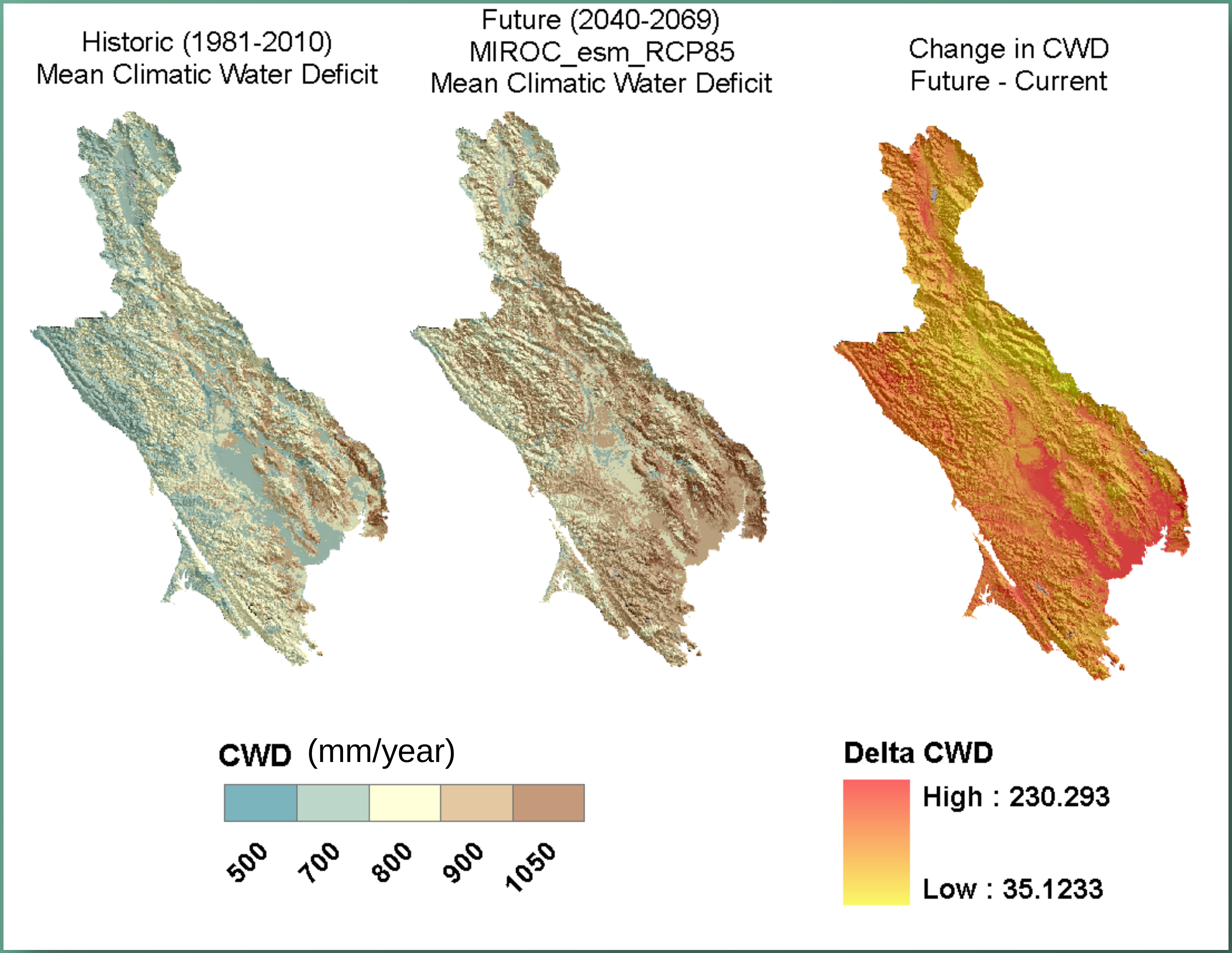
Supply	1,161 mm/yr
PET	1,224
AET	330
Soil Storage	117
CWD	892

Change in Recharge



A comparison of results from two different models

Change in Climatic Water Deficit



evaluation of total change as delta between past and future

Applications: Estimate Agricultural Demand

Climatic Water Deficit

Potential – Actual Evapotranspiration

- Irrigation from wells near the Russian River can reduce flow from the Russian River and is an indicator of demand
- Agricultural land areas are mapped out to estimate irrigation needs to meet the water deficit
- Estimated from loss of stream flow between gages