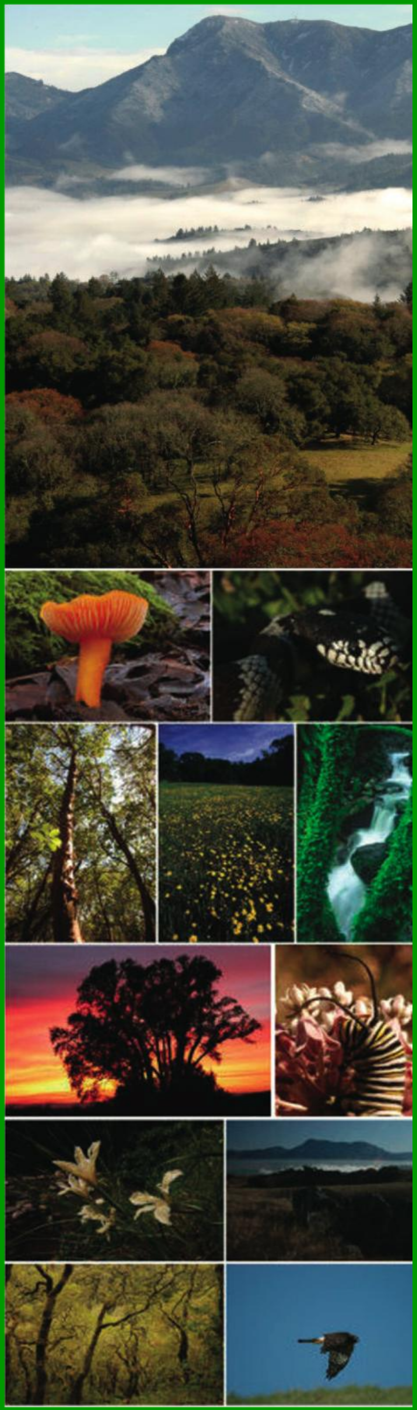


Pepperwood PRESERVE

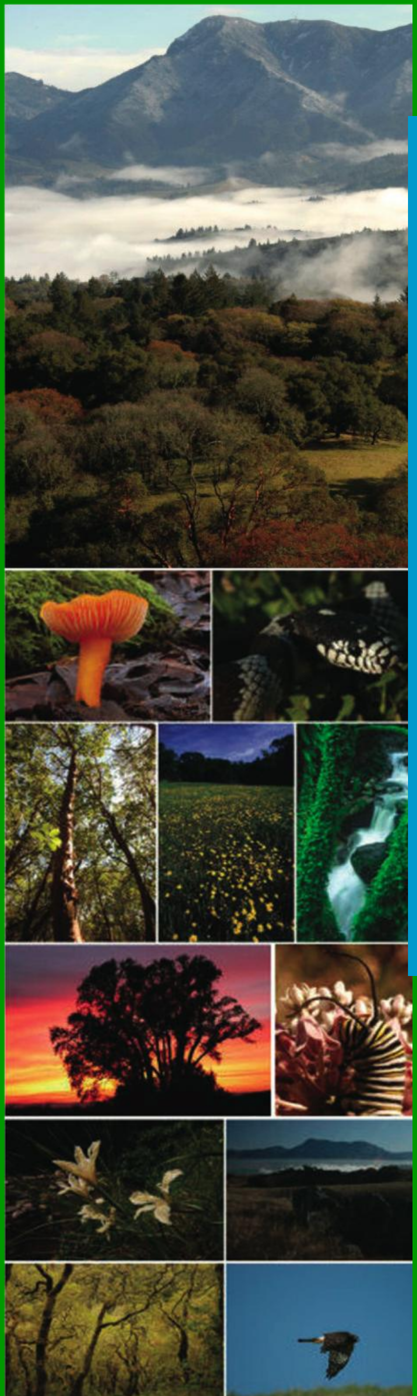
Inspiring conservation through science

Climate vulnerability of North Bay watersheds

NBWA 2012 Annual Conference

April 13, 2012

Dr. Lisa Micheli



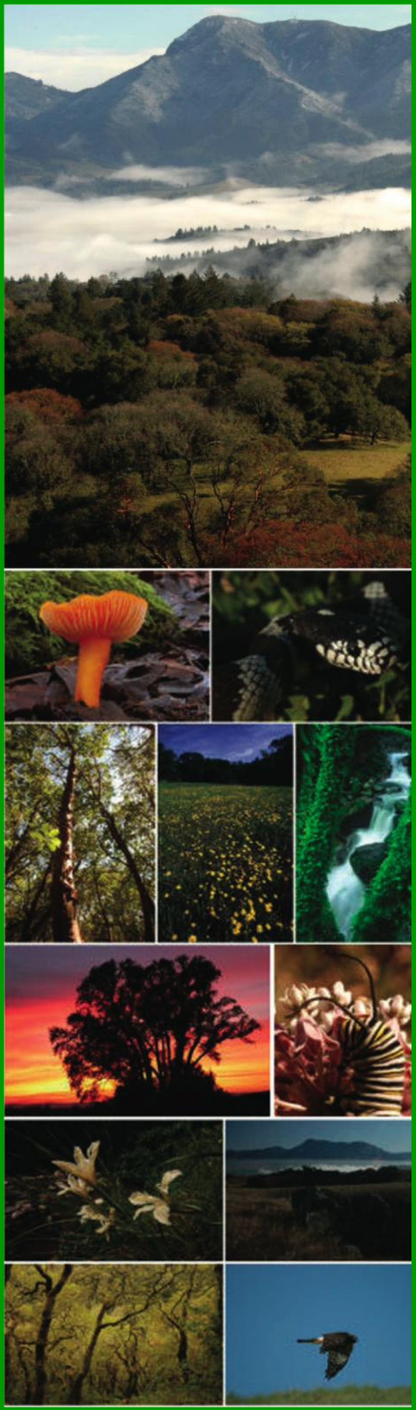
outline

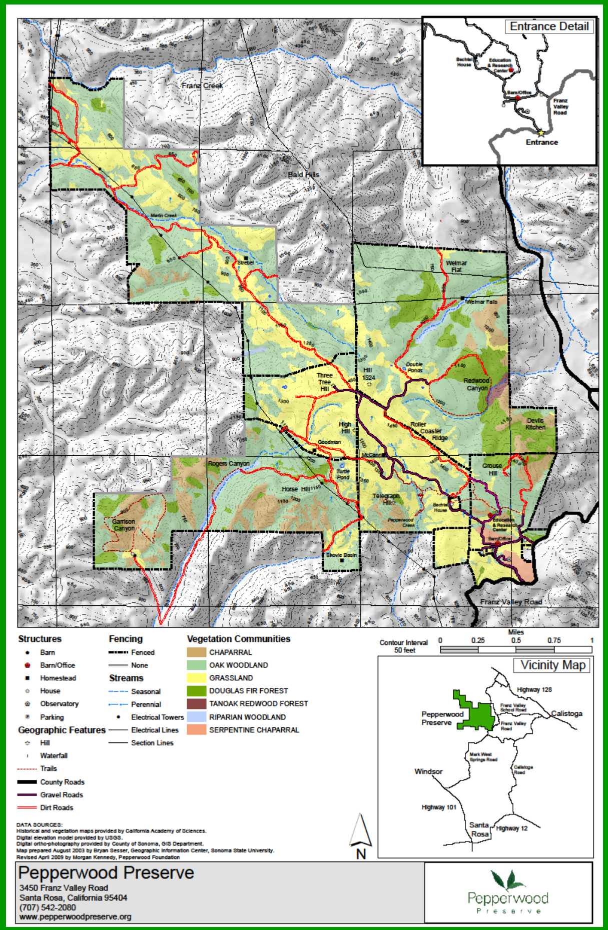
What is Pepperwood?
Take home message
Climate projections and vulnerability
Implications for watershed managers
Next steps

Pepperwood
PRESERVE
Inspiring conservation through science

MISSION

to advance science-based conservation throughout our region and beyond





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Pepperwood
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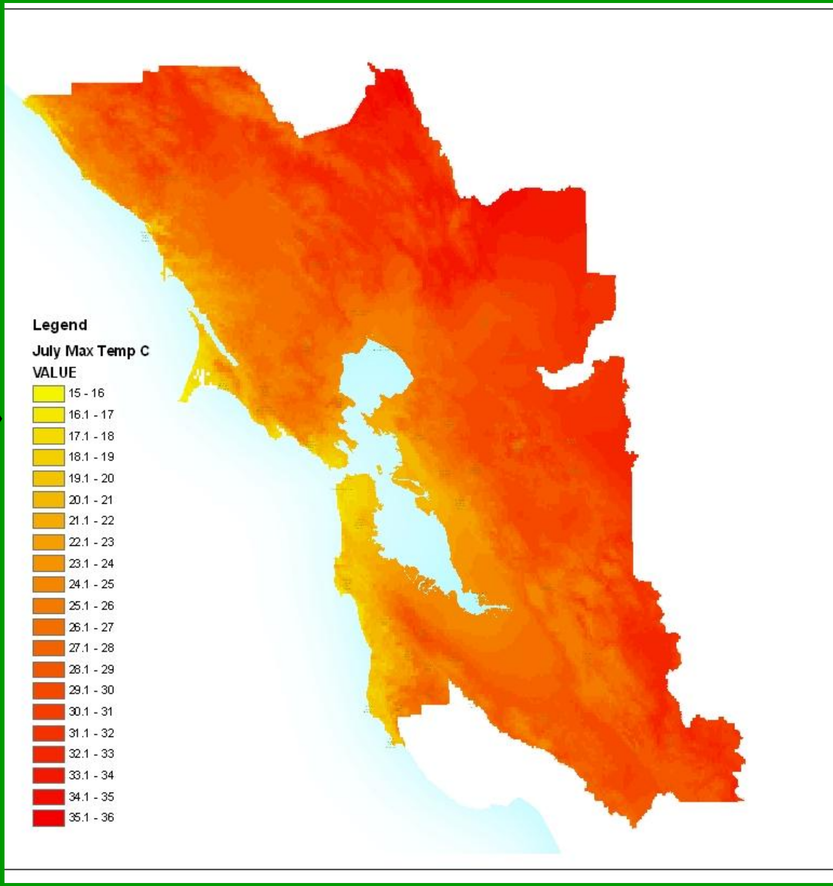
we explore



making the global local to learn how to cope with climate change

Take home message(s)

The future is expected to be warmer and drier (in terms of increased summer aridity)

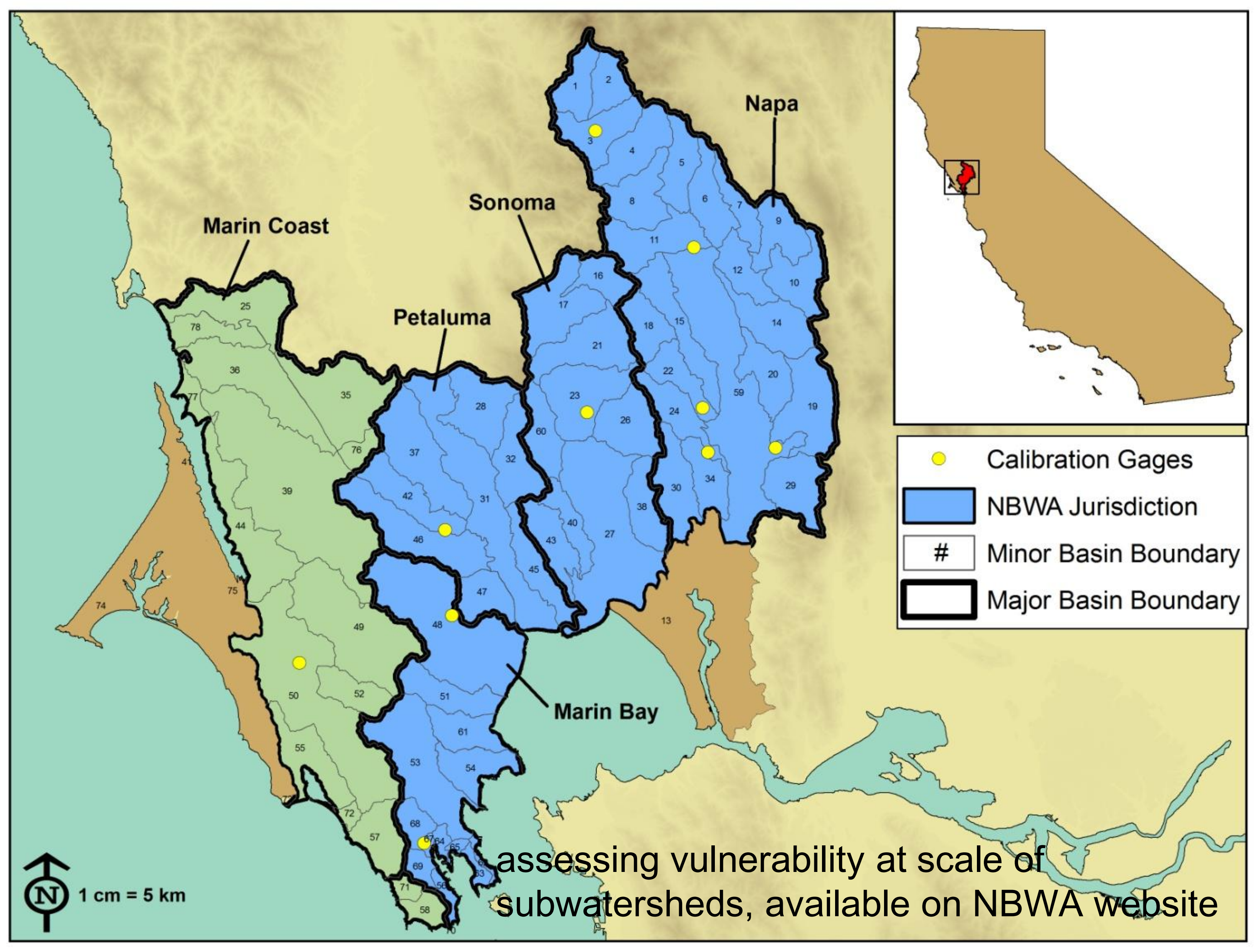
(regardless of whether the North Bay experiences more or less rain as a result of climate change)

the uncertainty is about
how fast these changes will occur

in order to adapt effectively we need to start measuring patterns of change now

North Bay Watershed Association Case Study: multiple scales of analysis

Micheli, Flint, Flint, Weiss, Kennedy *in press*

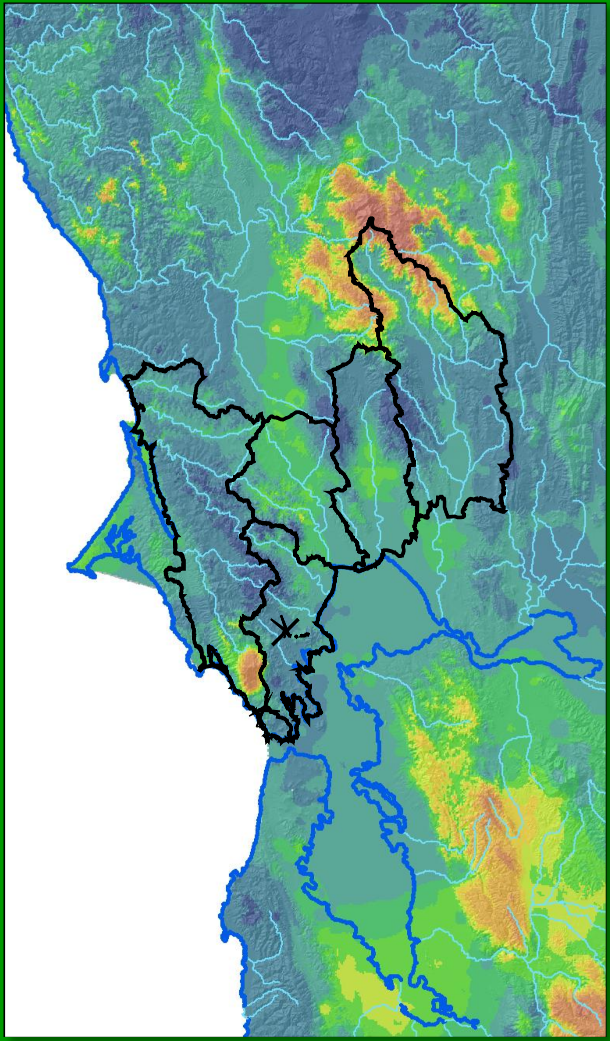


assessing vulnerability at scale of subwatersheds, available on NBWA website

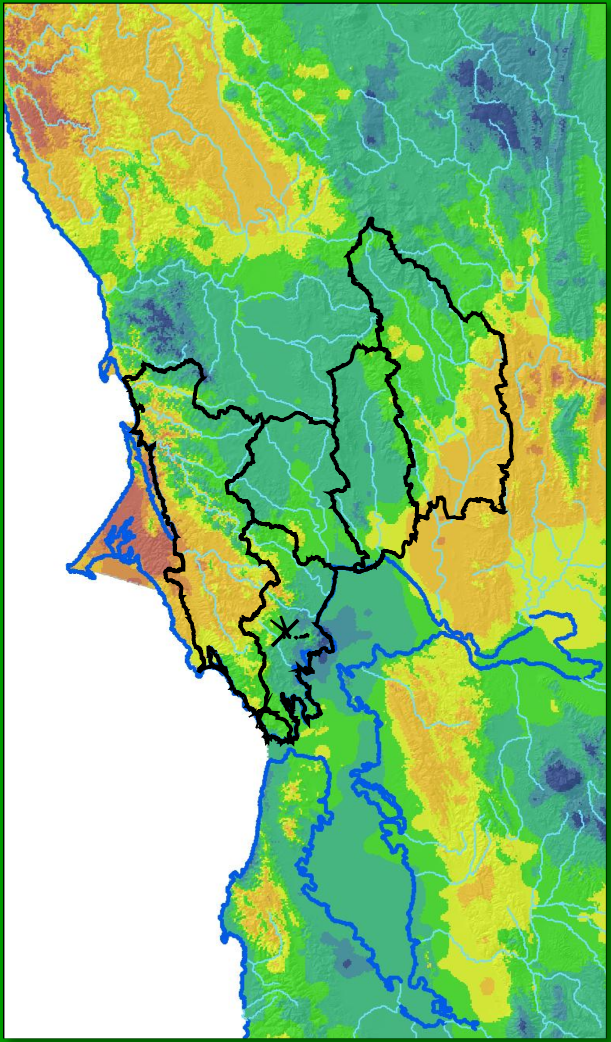
Changes in annual climate 1970-2007

understanding historic patterns of variability

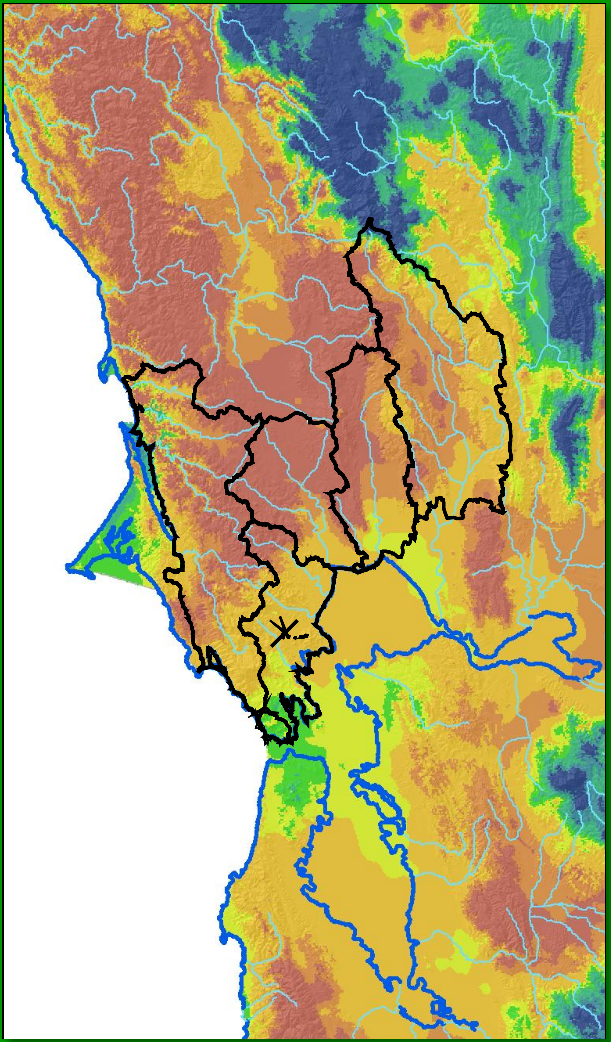
Precipitation



Maximum Air Temperature

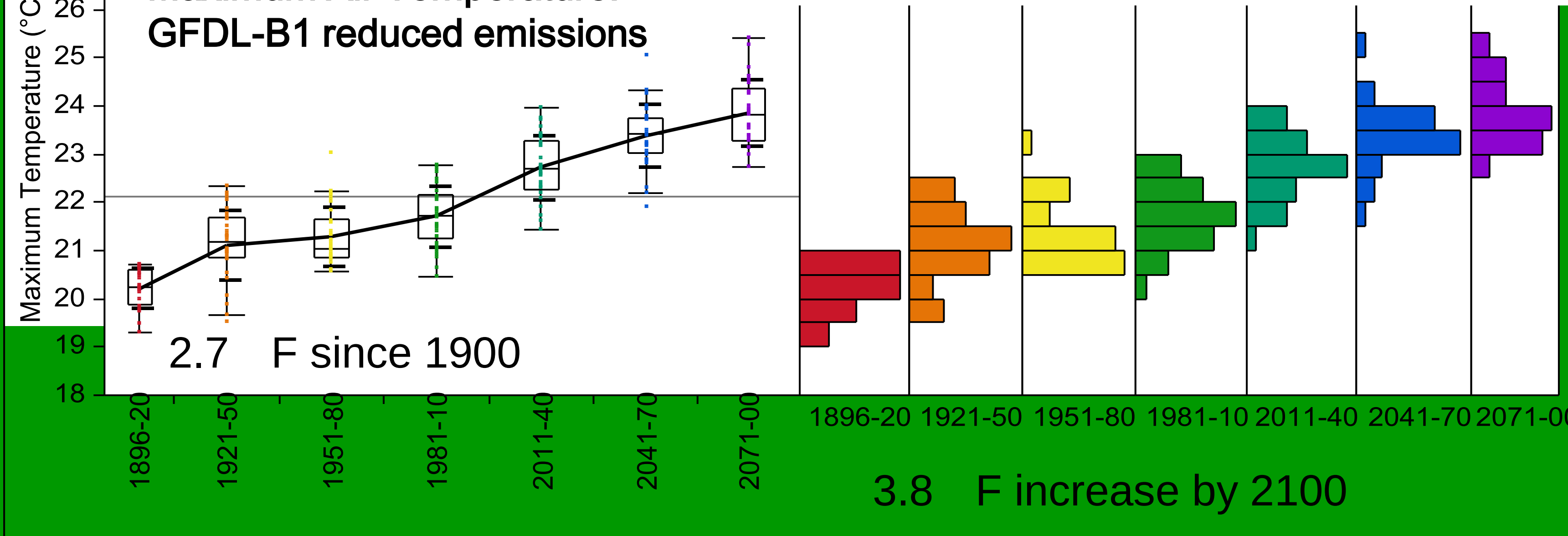


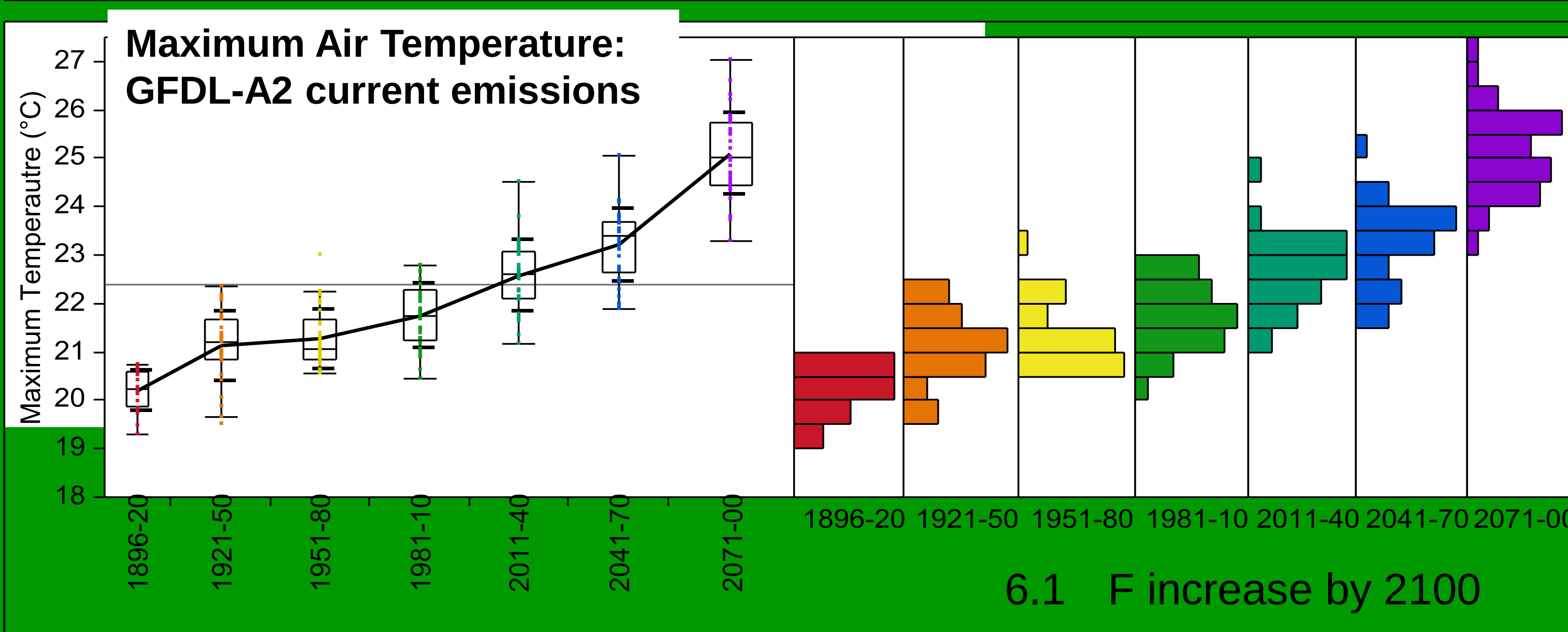
Minimum Air Temperature



Warm colors drier and warmer, cool colors wetter and cooler

North Bay Regional Climate Scenarios

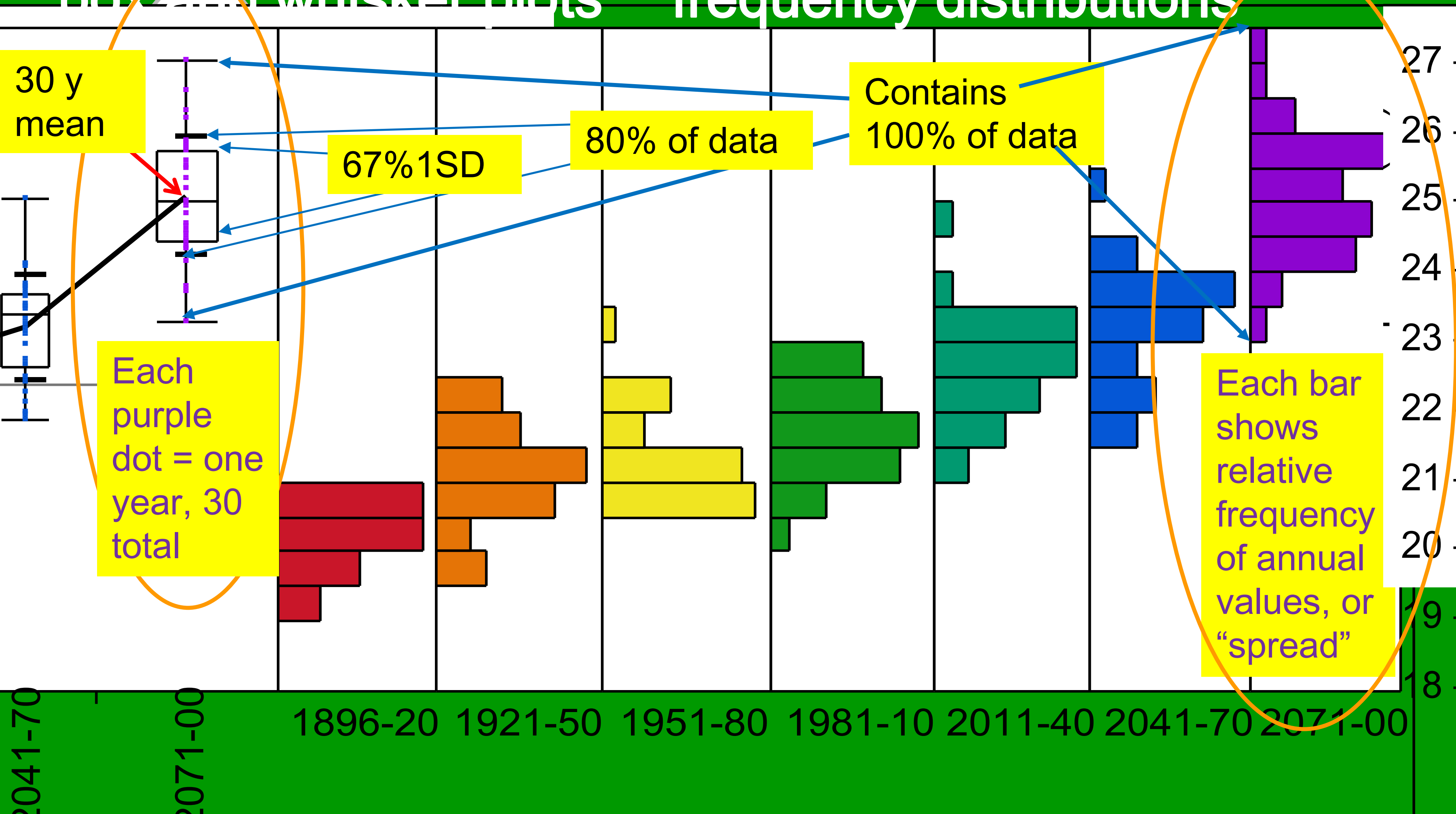




North Bay Regional Climate Scenarios

Unpacking the statistics—differences in means are statistically significant when boxes do not overlap

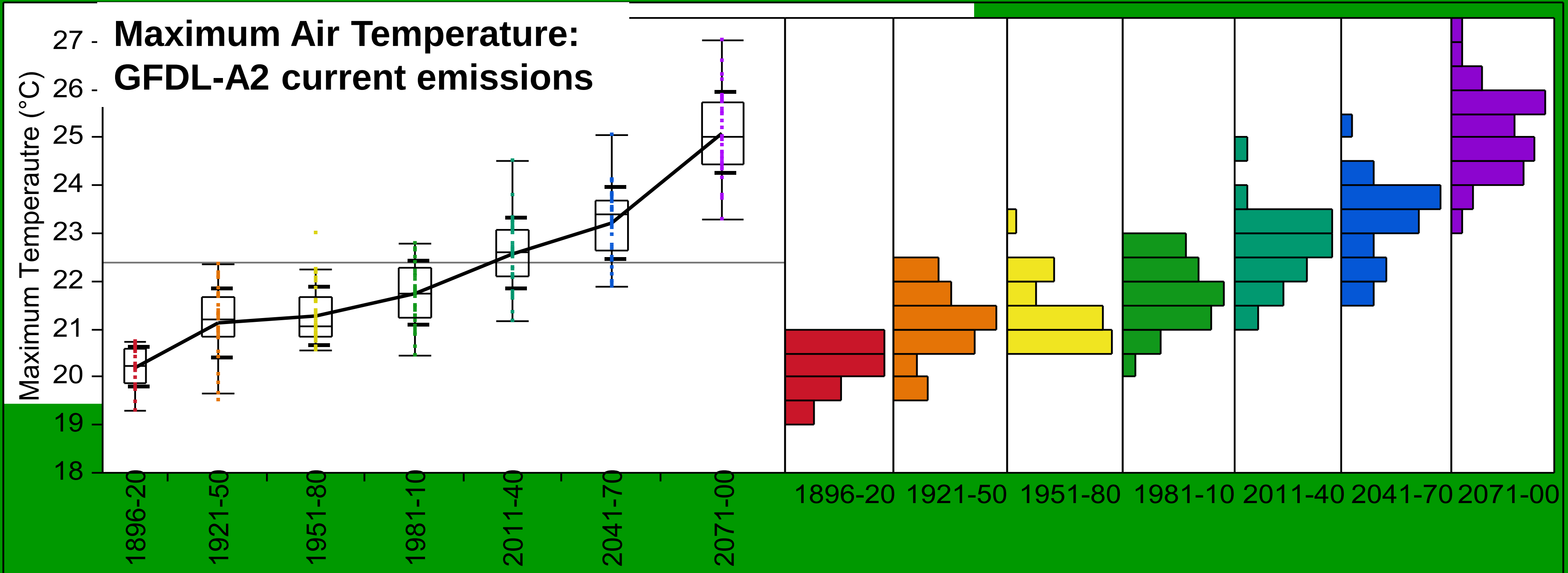
“box and whisker plots” “frequency distributions”



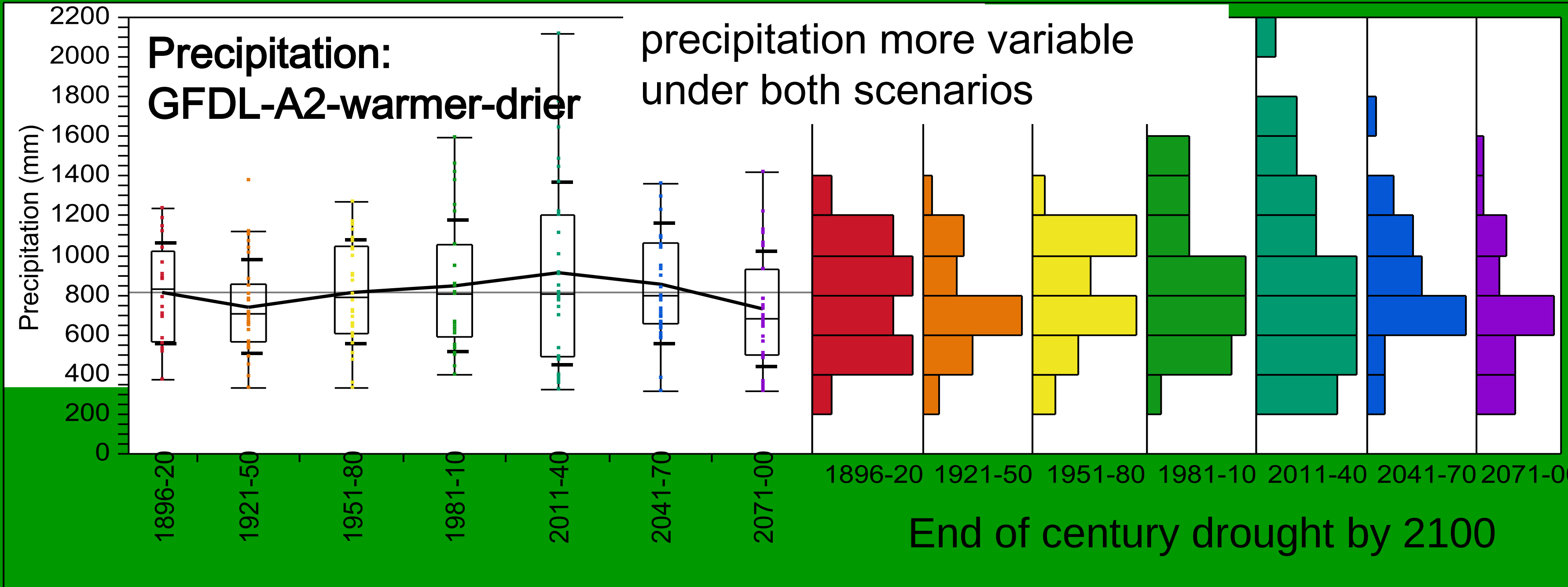
North Bay Regional Climate Scenarios

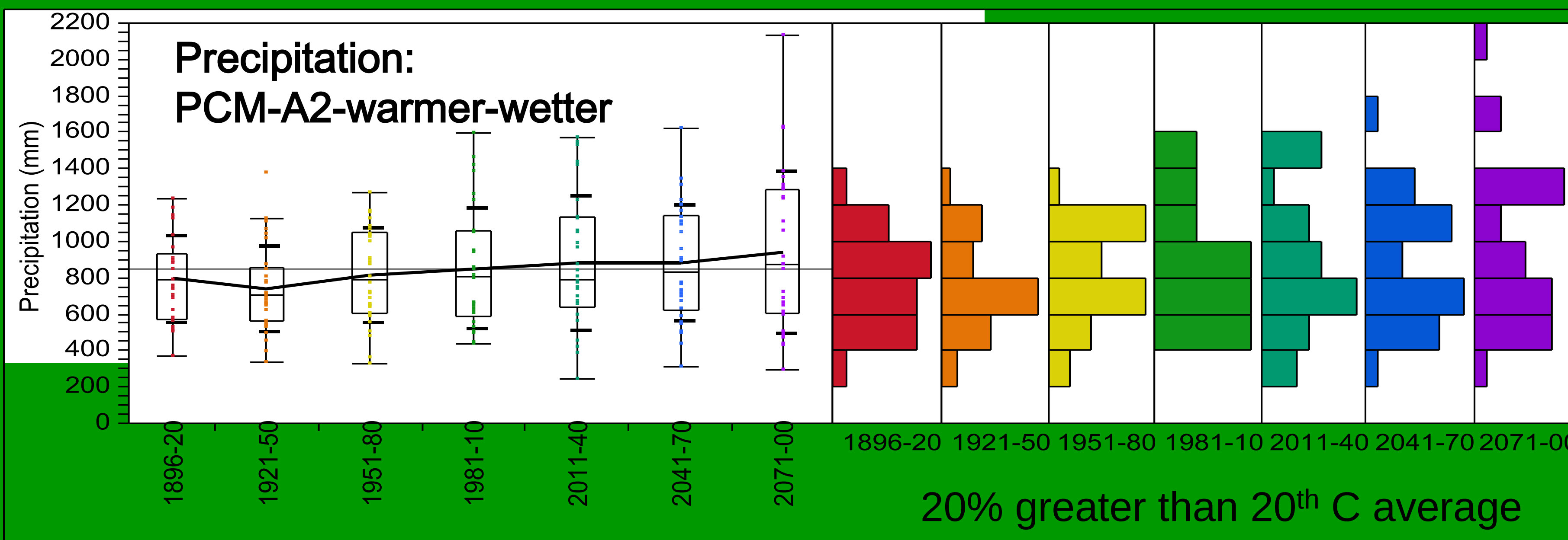
Quantifying uncertainty/variability (the purpose of statistics)

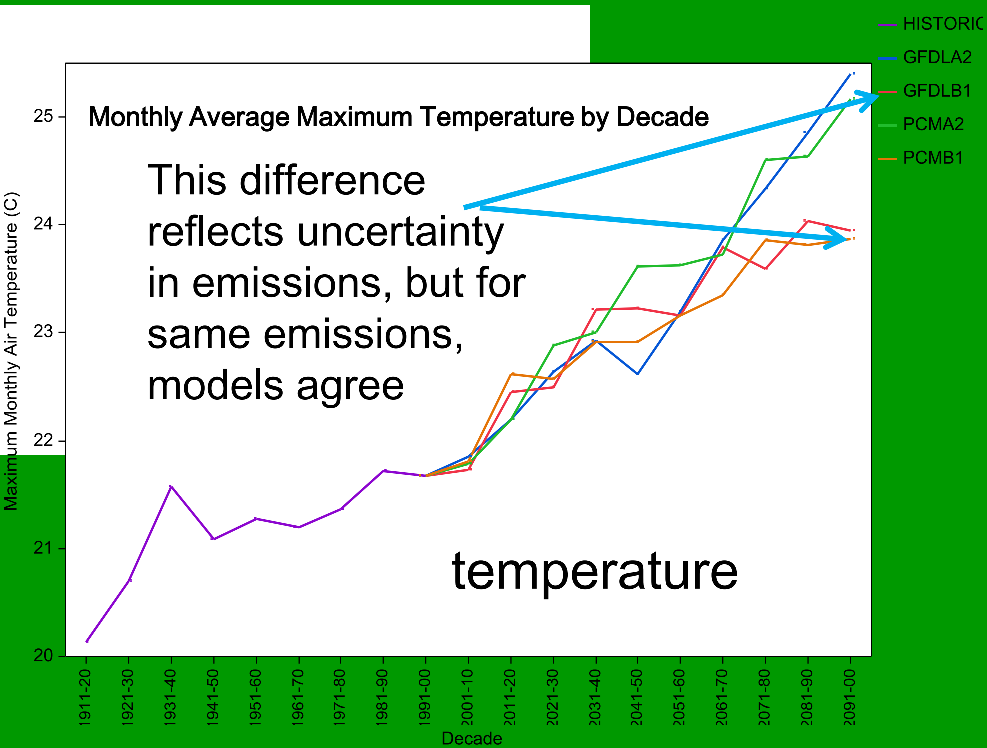
- Model error—use multiple models to generate a range of scenarios
- Natural variability—quantify variability of historic data
  - ensure physical model can reproduce historic variability
  - report long-term averages (underlying climate trends, not "weather")
  - define appropriate spatial scale of interpretation (sub-watersheds, not pixels)



The hottest year of 1981-2010 is cooler than the coolest projected for 2071-2100

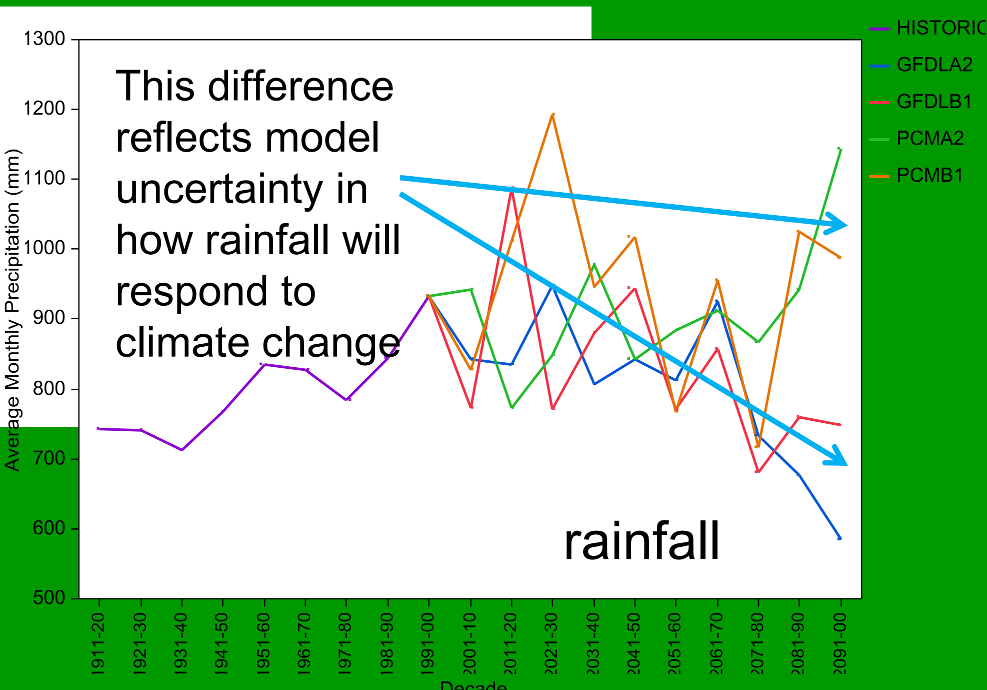

Precipitation:
GFDL-A2-warmer-drier
precipitation more variable
under both scenarios
Precipitation (mm)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1896-20
1921-50
1951-80
1981-10
2011-40
2041-70
2071-00
End of century drought by 2100


Precipitation:
PCM-A2-warmer-wetter
Precipitation (mm)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1896-20
1921-50
1951-80
1981-10
2011-40
2041-70
2071-00
20% greater than 20th C average



A2 scenario higher end of century temperatures

B1 scenario lower end of century temperatures



Much higher uncertainty about future rainfall than temperatures!

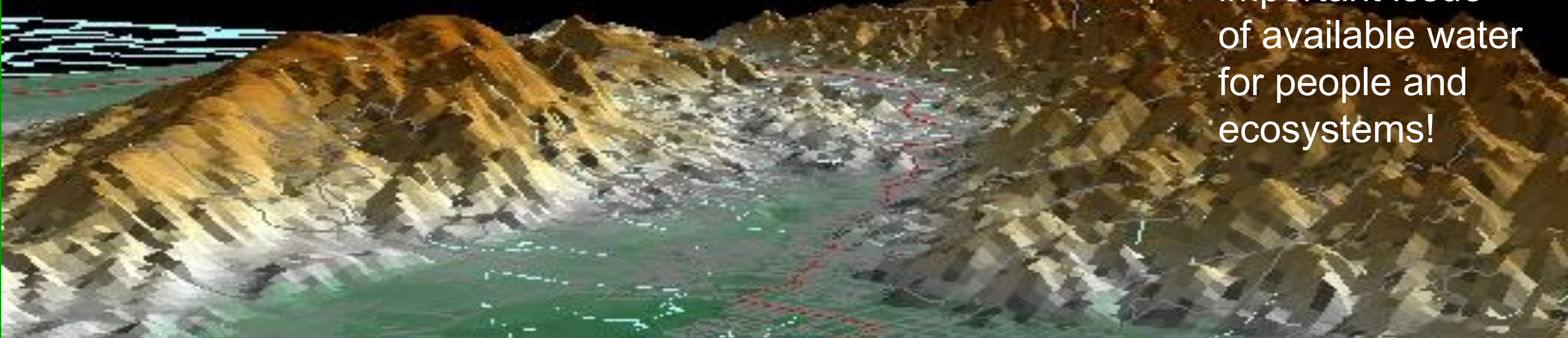
“wet” (PCM) model higher end of century precipitation

“dry” (GFDL) model declines in precipitation

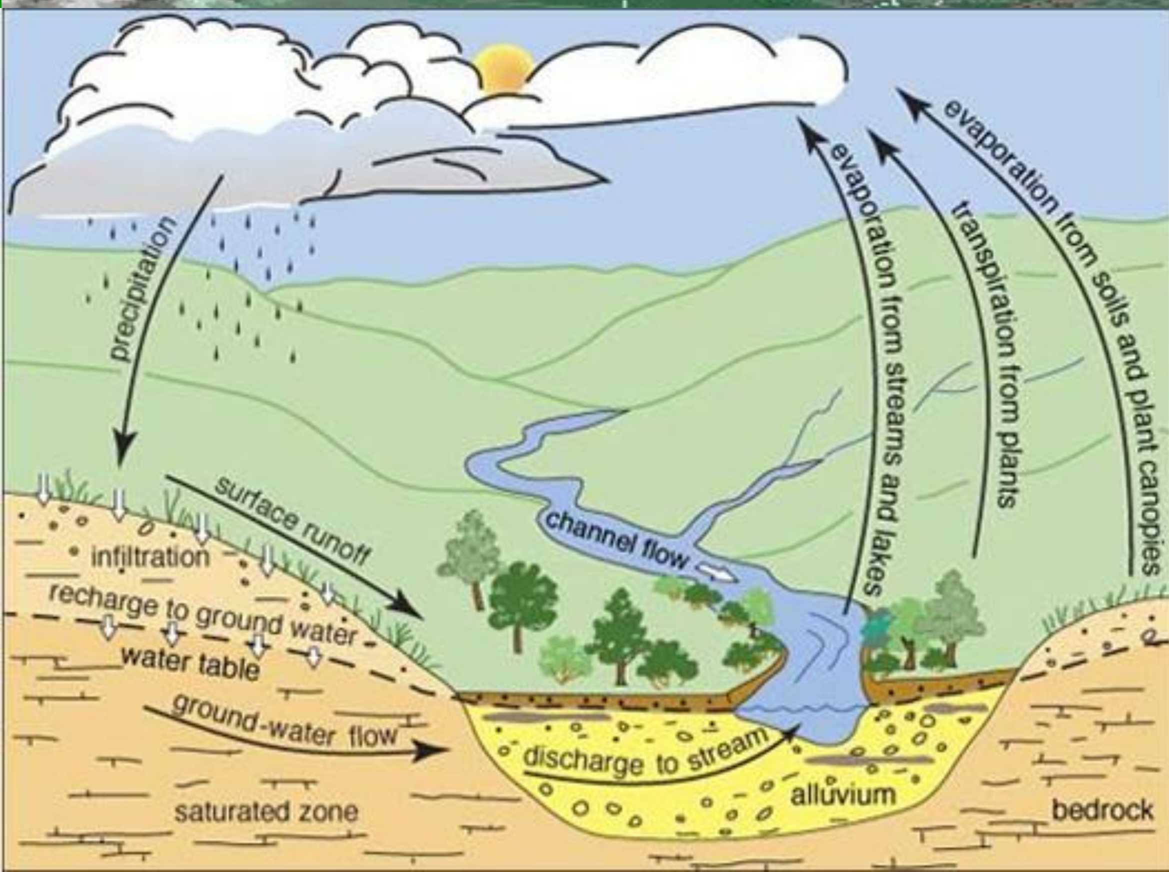
Four-scenario comparison

decade time steps

Basin Characterization Model

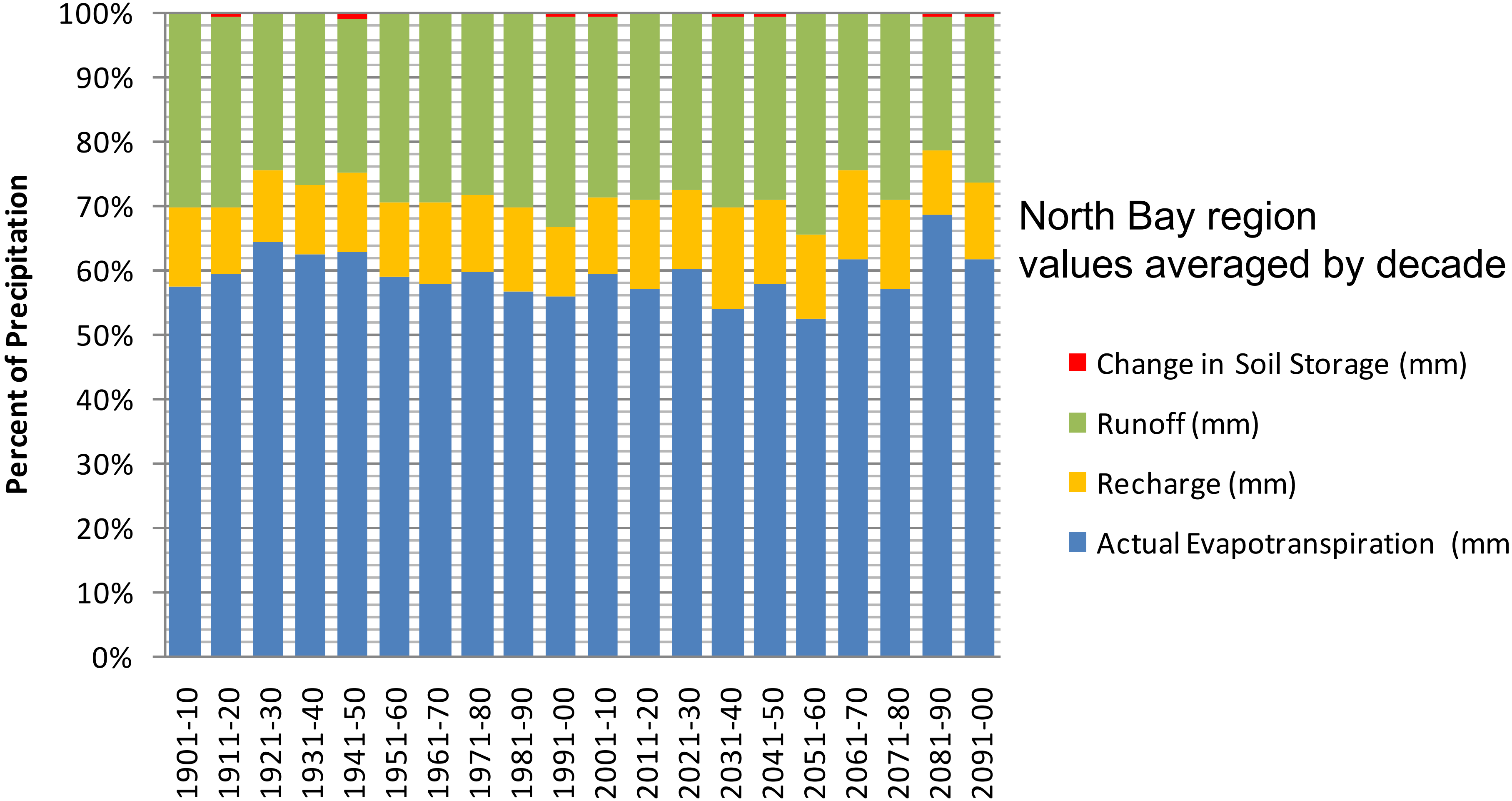


To get at important issue of available water for people and ecosystems!



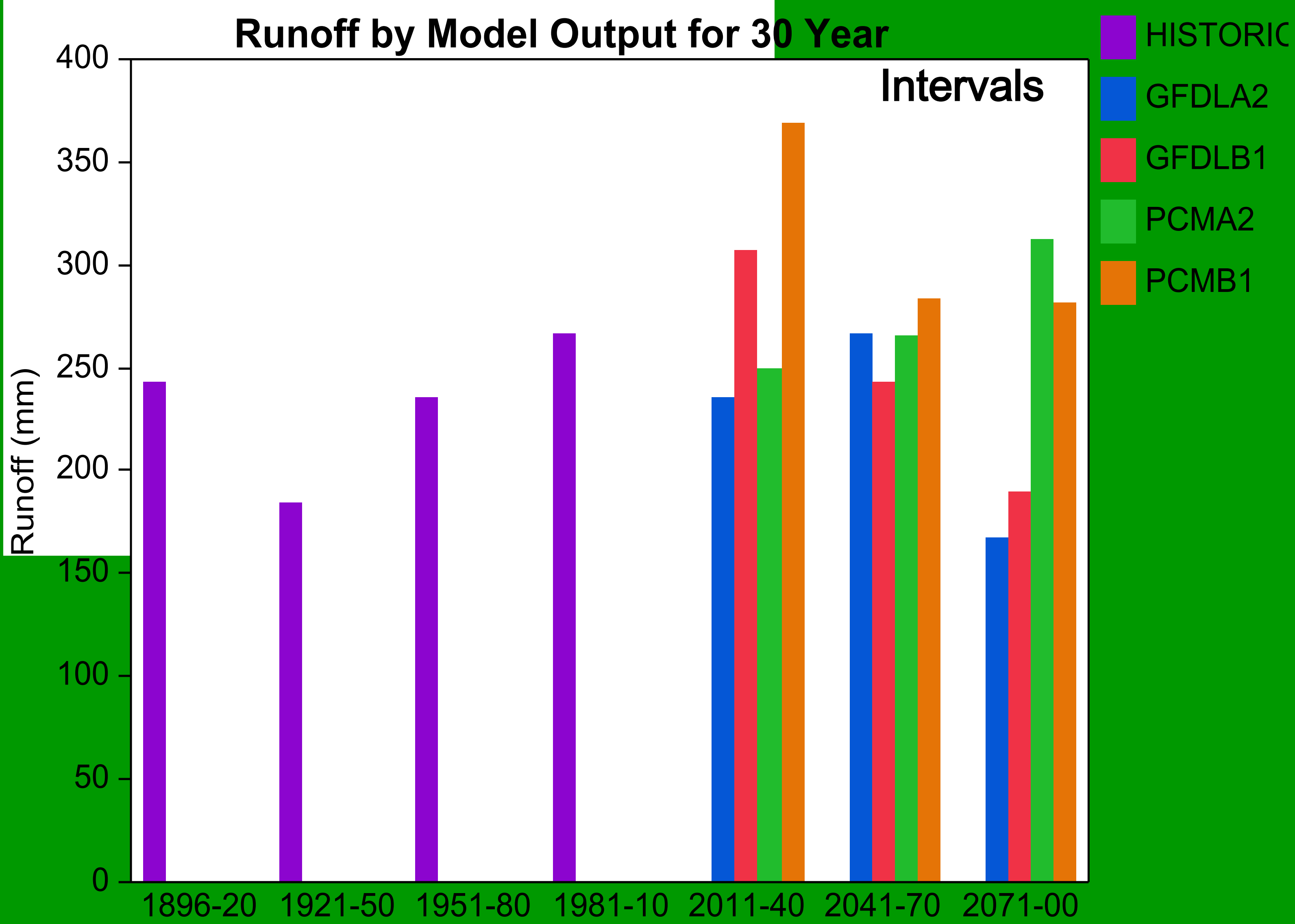
Solves the physical water and energy balance based on topography, soils, rainfall, and temp for every 270m pixel in domain—to estimate flows, recharge and soil moisture

Basin Characterization Model estimates Water Balance – based on physical interactions of heat, energy, and water



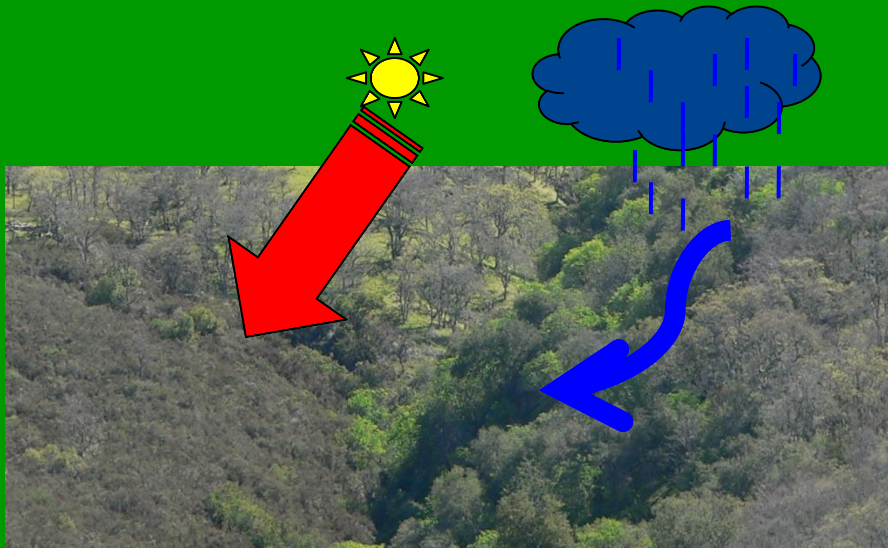
Full analysis: Spatial scale: 270 m pixels Temporal scale: monthly average values
Two centuries: 1900-2000 based on measured data, 2000-2100 modeled data

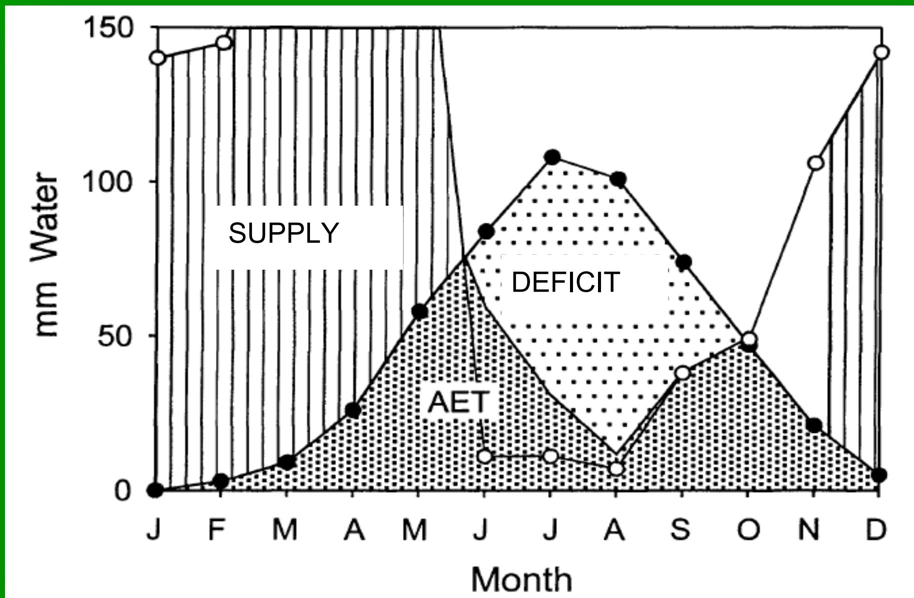
For North Bay region, approximately 40,000 points to analyze to produce decade, 30-y, 100-y averages at scale of minor and major basins and region

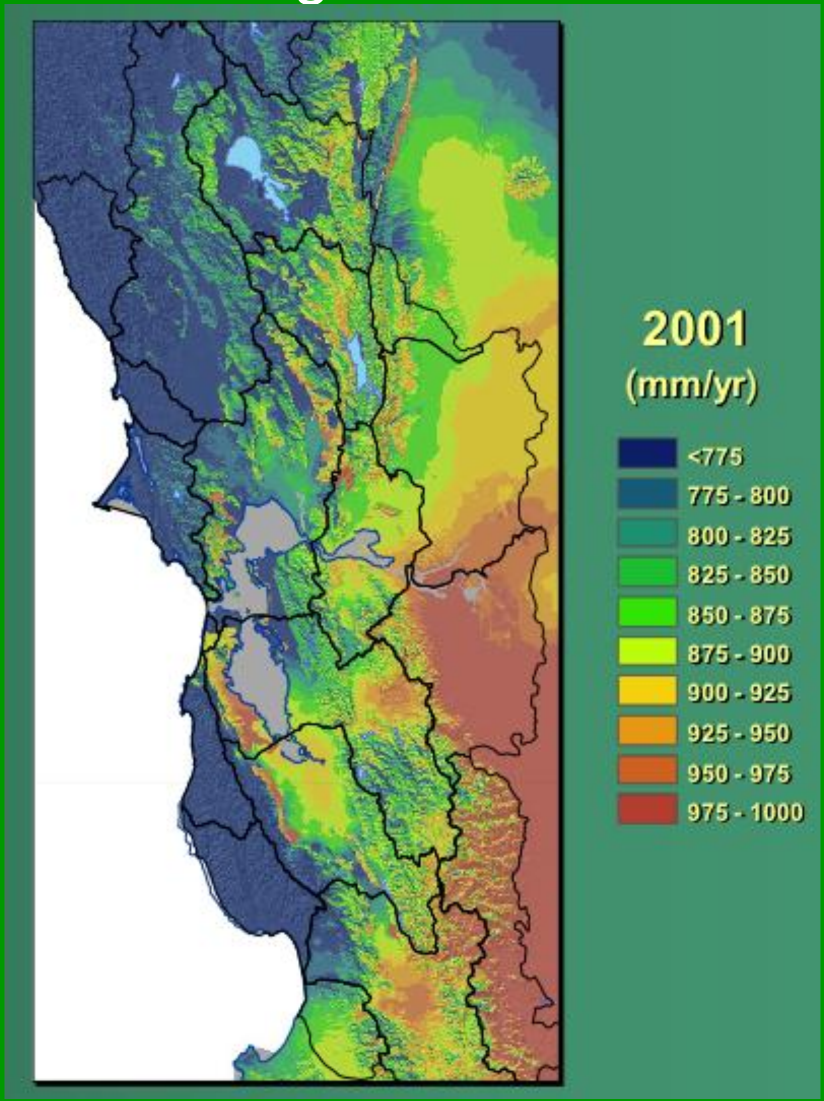


Focus on long-term trends, statistics for 30-yr intervals (monthly values), "book-end" scenarios (drier-warmer, wetter warmer), ranges from approx 20% less to 40% more than 20thC average

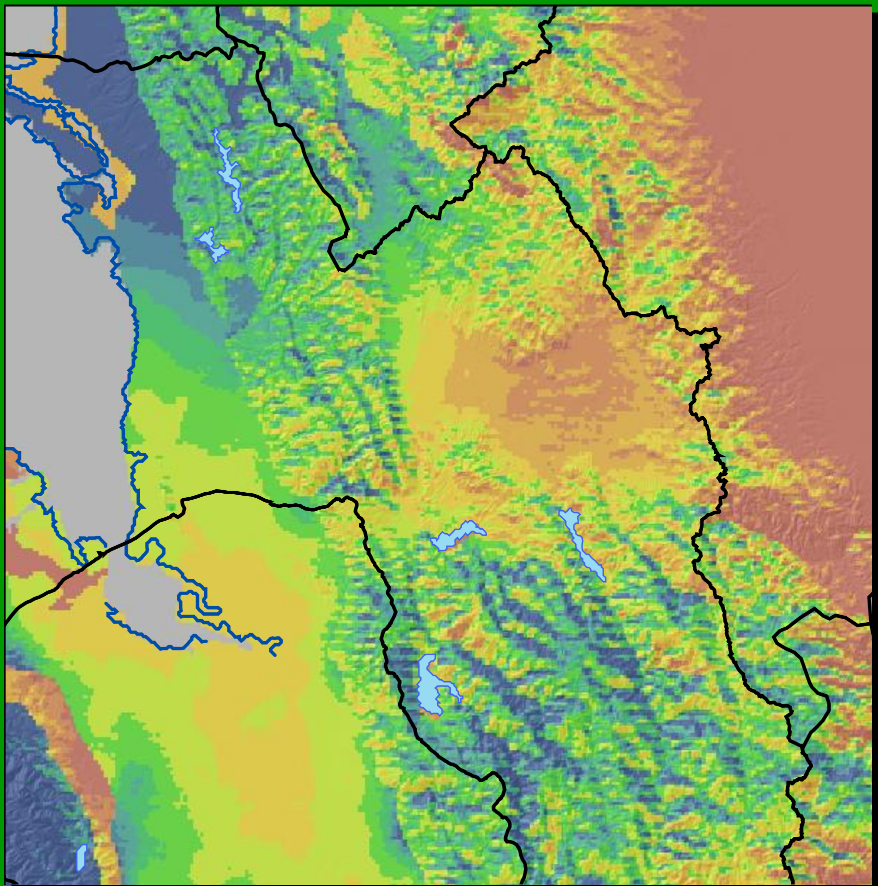
Climatic (Soil) Water Deficit:
excess evaporative demand relative to available water
estimates end of growing season "drought stress"



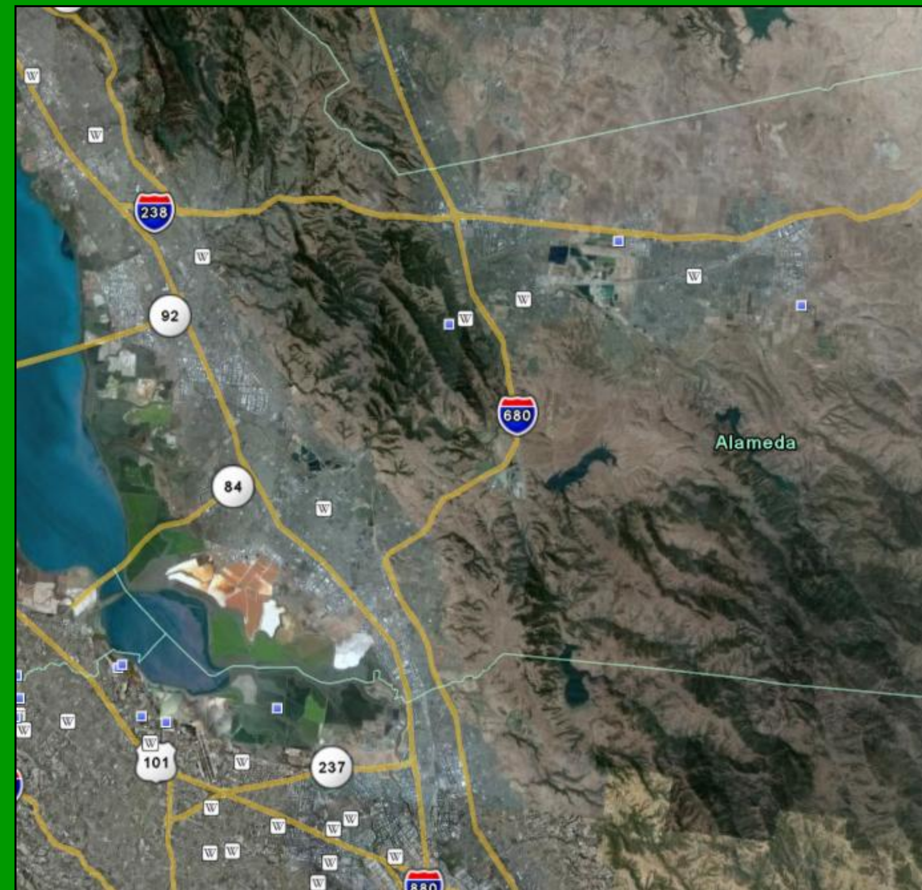




courtesy: Al and Lorrie Flint, USGS
see Stephenson 1998 J. Biogeog.

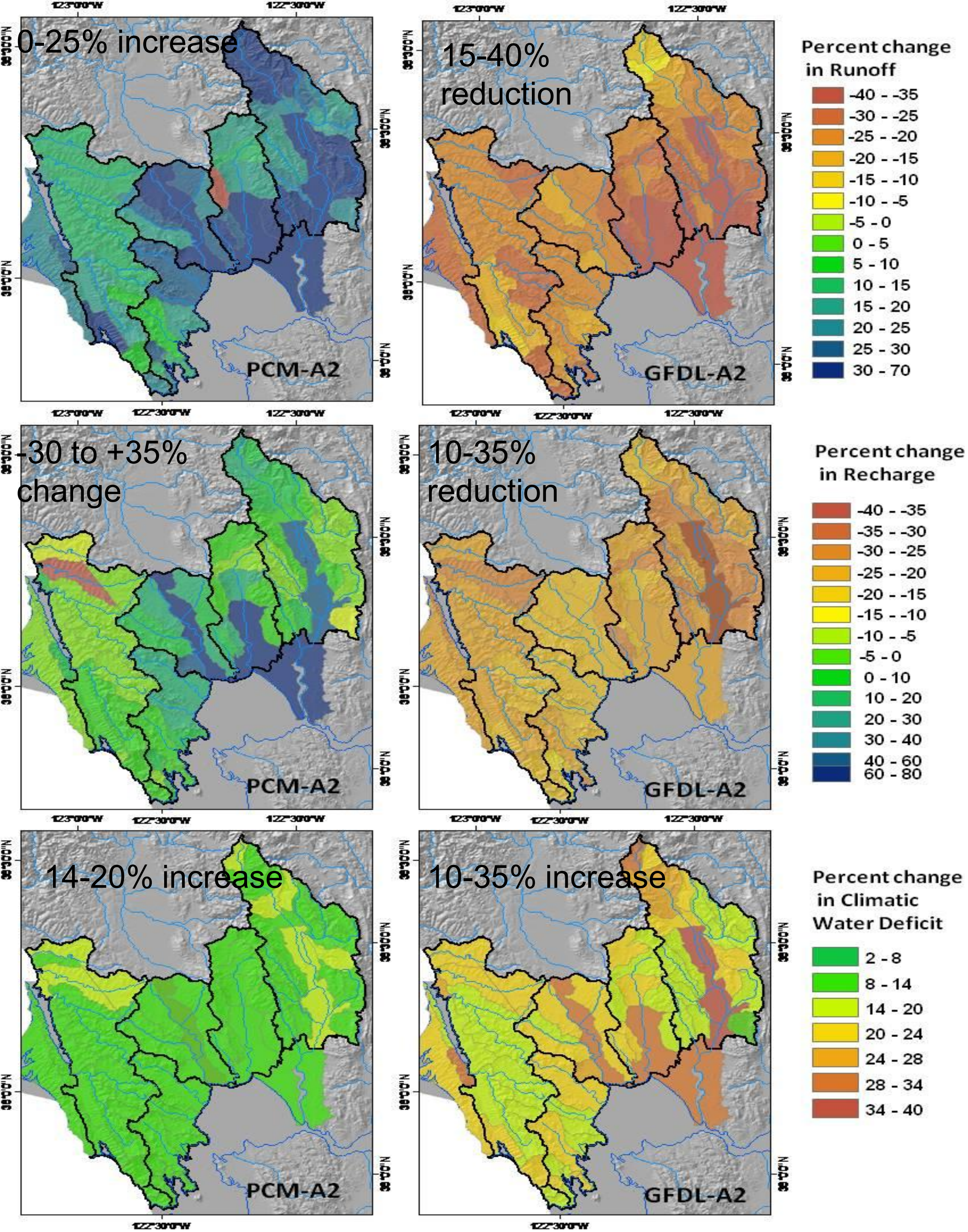


Climatic Water Deficit in South Bay



Google Earth Image of South Bay

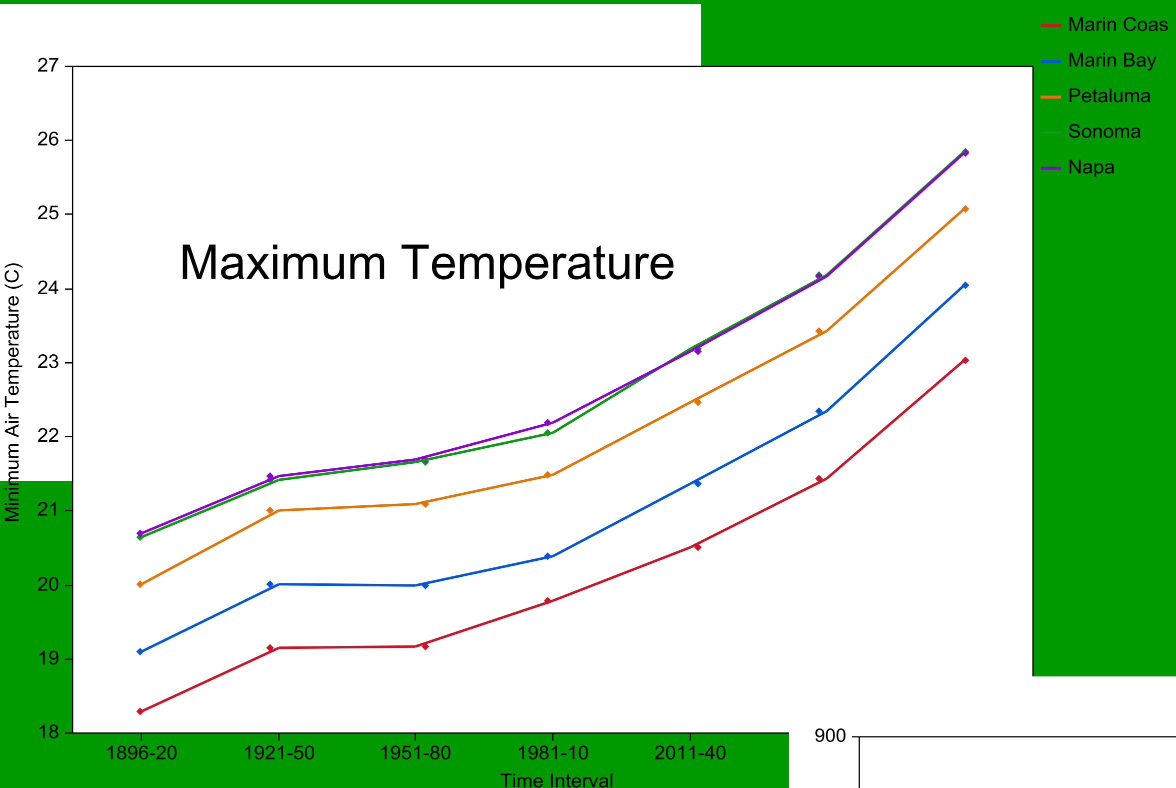
water deficit correlates to vegetation cover

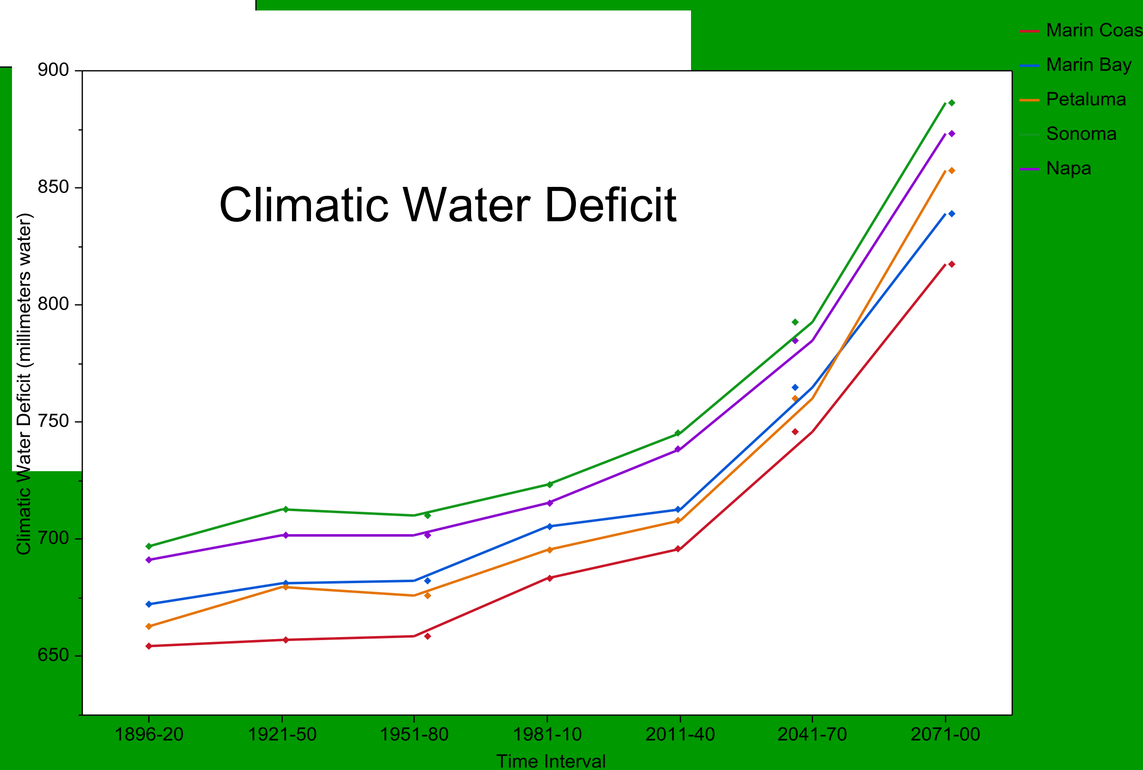


Sub-basin results display spatial diversity of climate and hydrology

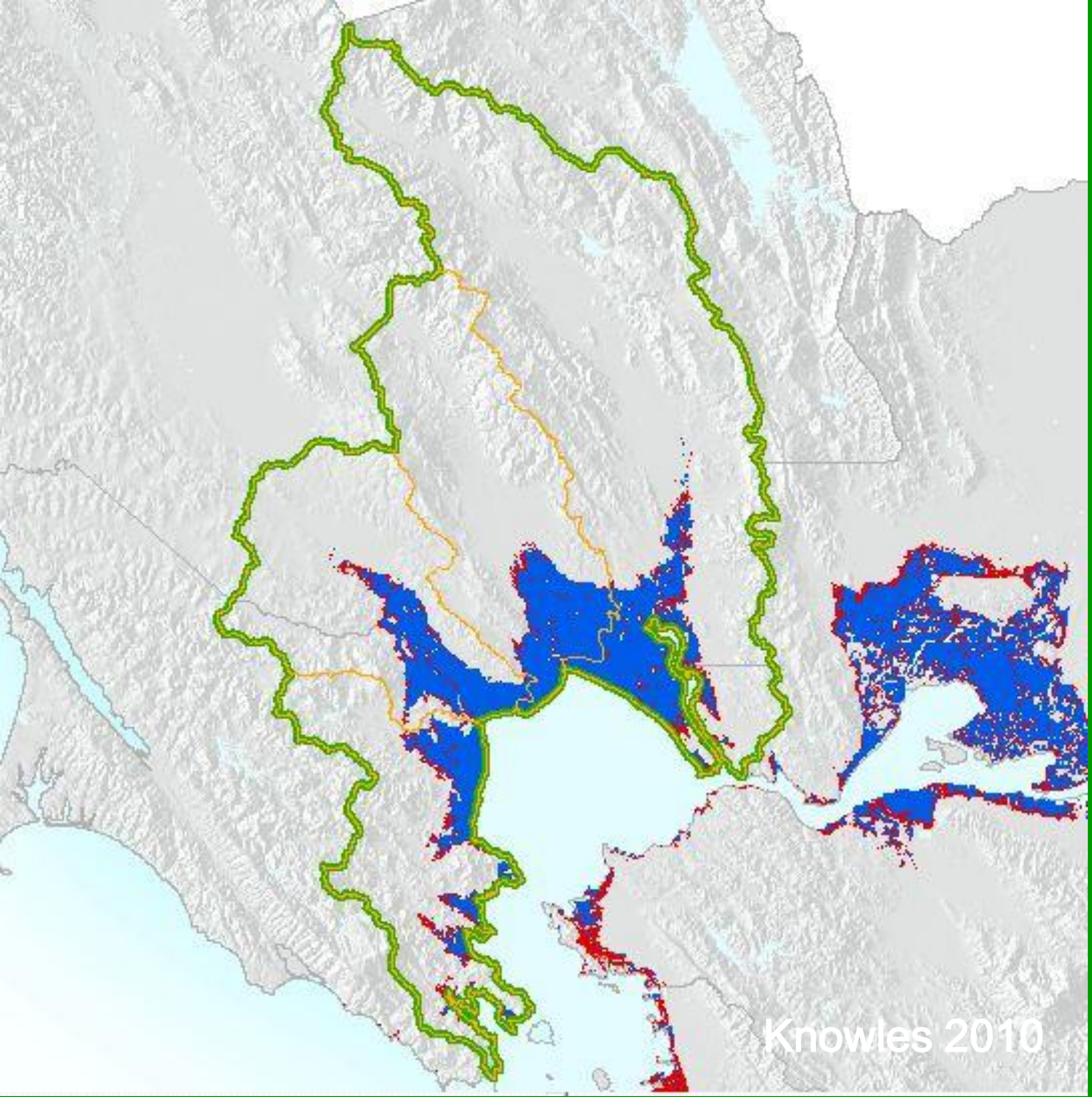
All scenarios project increases in climatic (soil) water deficit

Major Basin Comparisons: Water Deficit increase steeper than Temp





Under both warmer drier and warmer wetter scenarios, climatic water deficit increases on the order of 10-20%, or approx 75-150 mm (3-6") additional water needed to maintain vegetation cover (natural or crop)-an indicator of increasing demand



Sea Level Rise Estimates for NBWA Jurisdiction

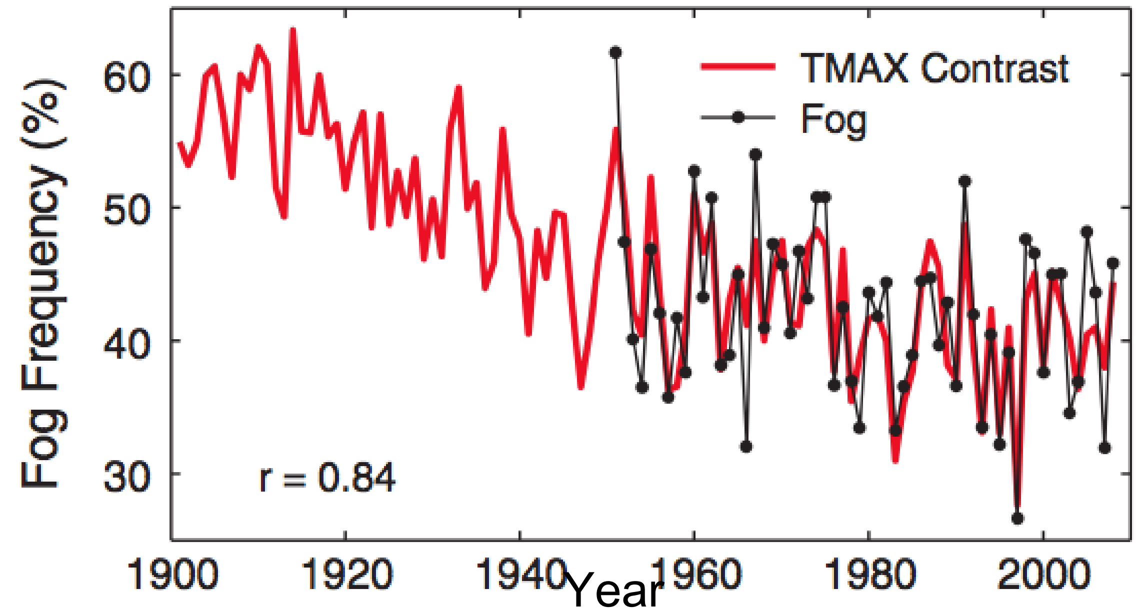
blue areas vulnerable to inundation at present under worst case scenario (100-yr storm, levee failure)

red additional areas prone to inundation with 150 cm (4.9’) of sea level rise (NBWA jurisdiction outlined in green)

Protection Status	Marin Bay	Napa River	Petaluma River	Sonoma Creek	Total
Not Protected	9,285	8,483	7,174	15,337	40,279
Protected	5,833	16,036	8,760	2,361	32,991
Total	**15,118**	**24,520**	**15,934**	**17,698**	**73,270**

The Million$ Mystery Variable
for the Bay Area:
Fog frequency

Measured 2000-2010
Modis satellite imagery



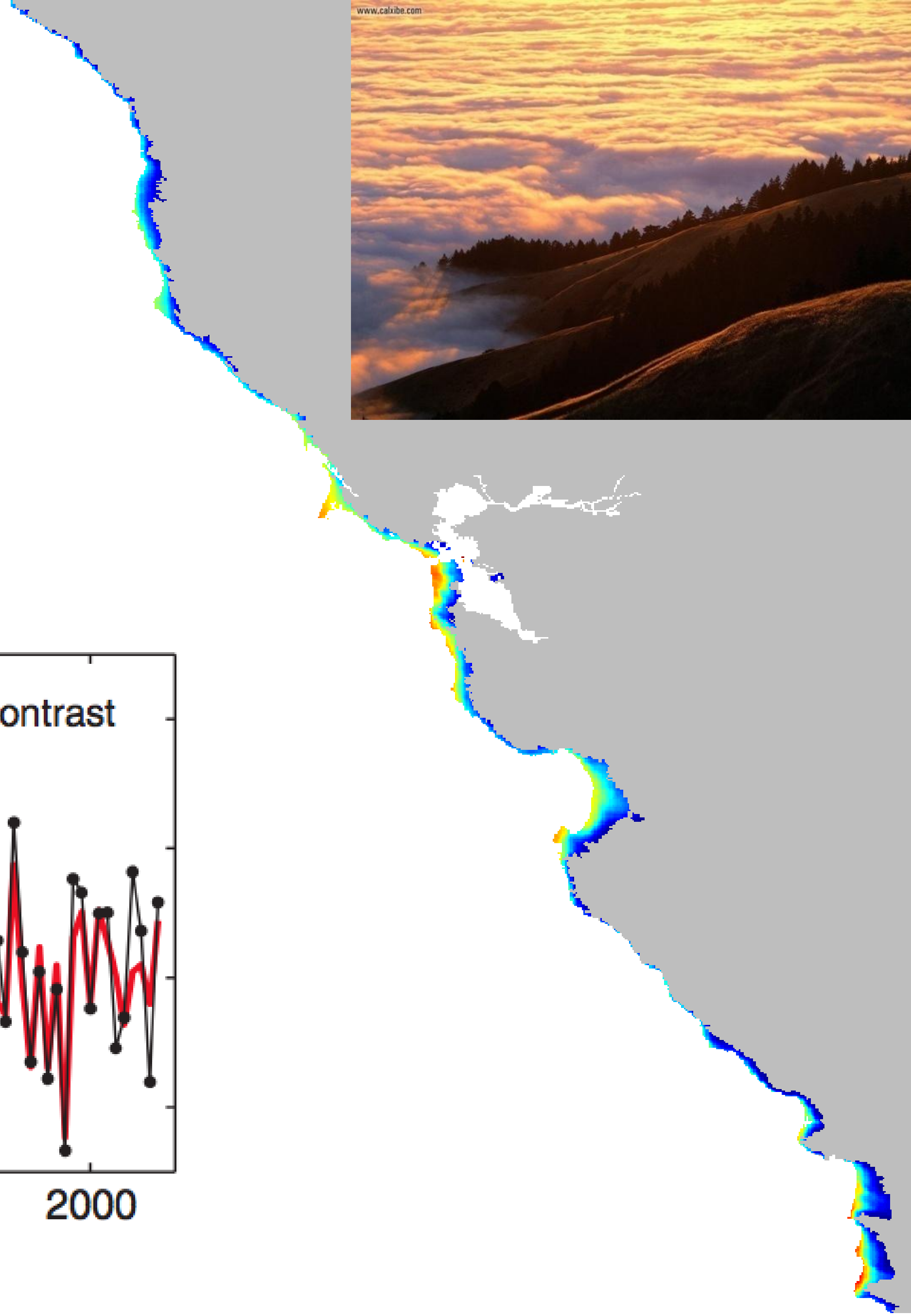
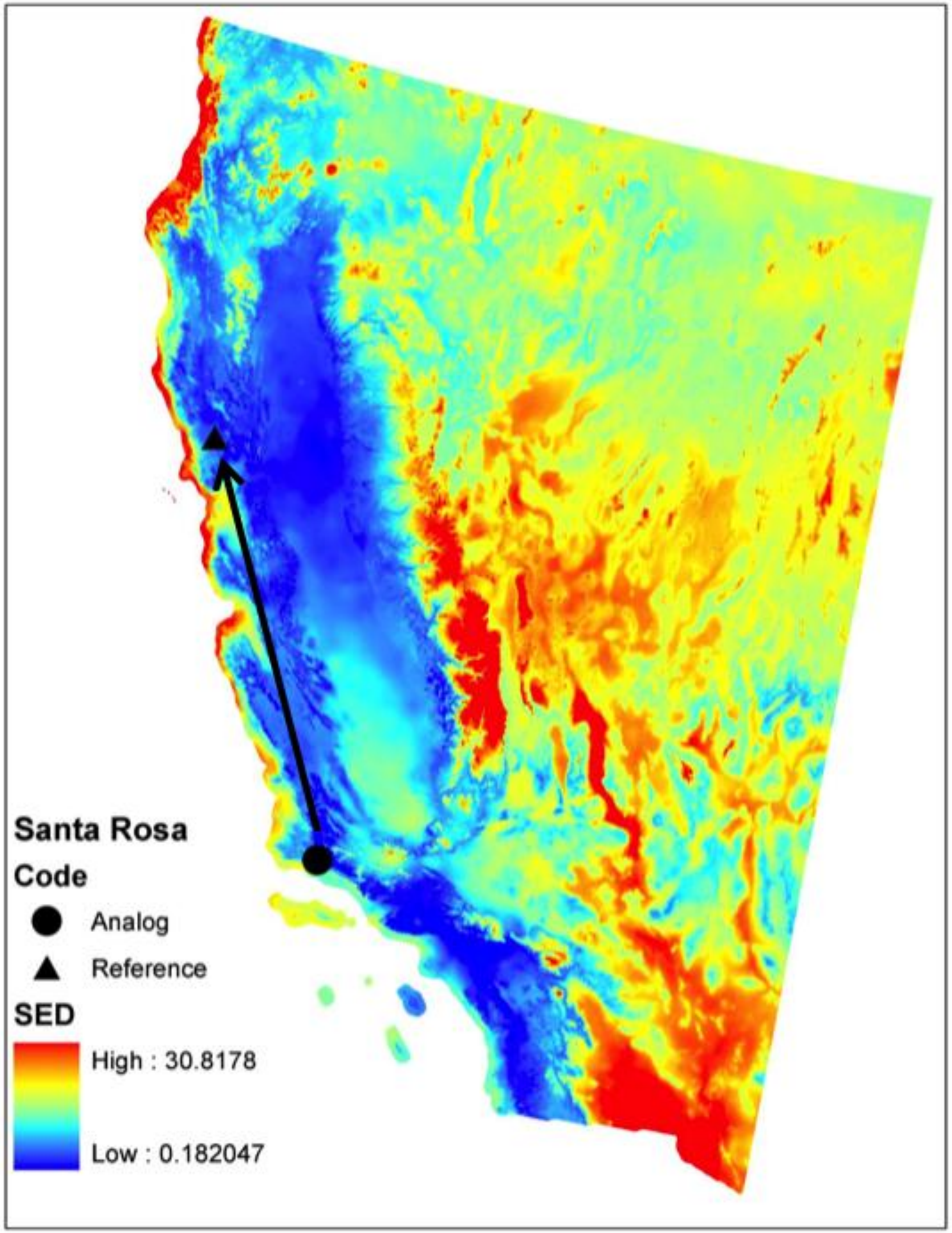


figure: Johnstone and Dawson 2010 PNAS

map: Loarie and Johnstone unpubl.



Climate Analogs: where in CA has the climate now we anticipate for Santa Rosa for 2100?

Santa Barbara!

Courtesy Sam Veloz, PRBO Conservation Science

Implications for watershed managers

Findings

Physically-reasonable scenarios project both increased and/or decreased precipitation

All scenarios suggest more variable precipitation, runoff and recharge

Recharge is less sensitive to fluctuations in precipitation than runoff

All scenarios suggest increased summer aridity and higher PET rates, which in turn are likely to increase demand

No-regrets adaptation measures

Water efficiency/conservation

Diversify water portfolio

Increased and distributed storage

Groundwater recharge/conjunctive use—greater resilience than surface sources

Prepare for more frequent “extreme events” both floods and droughts

Protect and restore stream corridors, floodplains, estuarine marsh to “buffer” climate effects via “green infrastructure”

Take home message(s)

The future is expected to be warmer and drier (in terms of increased summer aridity)

(regardless of whether the North Bay experiences more or less rain as a result of climate change)

the uncertainty is about how fast these changes will occur

in order to adapt effectively we need to start measuring patterns of change now

Pepperwood PRESERVE

Inspiring conservation through science

monitoring

coupling climate-ecosystem measurements

advancing real-time monitoring in So Co and across Bay Area

sharing data via CA-LCC Climate Commons

creating a network of practitioners

disseminating lessons learned

cost-effective means of measuring climate in concert with biotic “vital signs”

North Bay Climate Adaptation Initiative Objectives

- Decrease uncertainty to acceptable levels by estimating potential changes to climate, hydrology, and ecosystems based on the best science available at the watershed (local) scale.
- Provide managers in the North Bay with information, methods, and guidance needed to address challenges of climate change on natural systems.
- Support a Sonoma County effort for climate adaptation to implement preventative measures that reduce the impact of climate change on resources of concern
- Inform Sonoma County planning and policy processes to integrate climate adaptation strategies in local decision-making