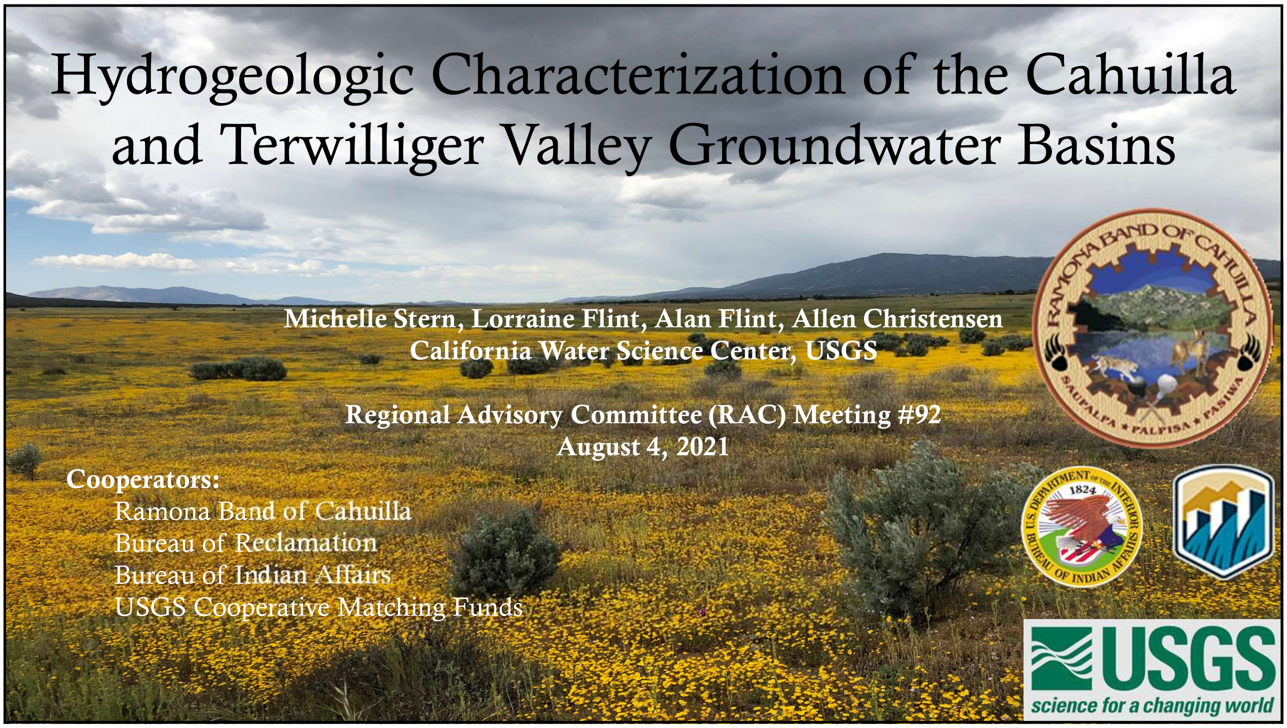

1

Presentation Overview

1. Benefits of the Project
2. Introduction
3. Conceptual Model
4. Findings
5. Limitations
6. Conclusions

2

Benefits of this Project

- Developing unbiased local estimates of natural water balance variables are an important first step to sustainably managing groundwater resources
- "You can't manage what you do not measure (or model)"
- Publication of results – open access
  - USGS Data Release of model outputs:

    https://www.sciencebase.gov/catalog/item/5ee7dc2382ce3bd58d82f010
  - Journal of the American Water Resources Association (JAWRA) publication (in press)
- Model outputs will be used to drive a local groundwater model to complete the hydrogeologic characterization of the Cahuilla and Terwilliger Valley groundwater basins

3

Water balance modeling to assess recharge patterns

- In arid and semi-arid environments annual potential evapotranspiration exceeds annual precipitation
- Excess water due to seasonal precipitation results in runoff and recharge in some years
- Recharge and runoff only occasionally occur on the valley floors due to thick alluvial deposits
- Some runoff may become recharge in losing streams

4

Recharge and Runoff

- Basin Characterization Model (BCM)
  - monthly water balance calculations
  - grid-based data at 270-meter resolution
  - calculates recharge, runoff, actual evapotranspiration, climatic water deficit, snow accumulation and melt
- Potential evapotranspiration, PET (Priestley-Taylor)
  - hourly solar radiation model, topographic shading, and cloudiness are used to calculate the energy balance and PET
  - Accumulated to monthly to drive water balance
- Snow accumulation and melt based on NWS Snow-17 Model
- Soil water storage based on soil maps (SSURGO)
- Bedrock permeability based on geology
- Climate data from meteorology stations, PRISM or future projections

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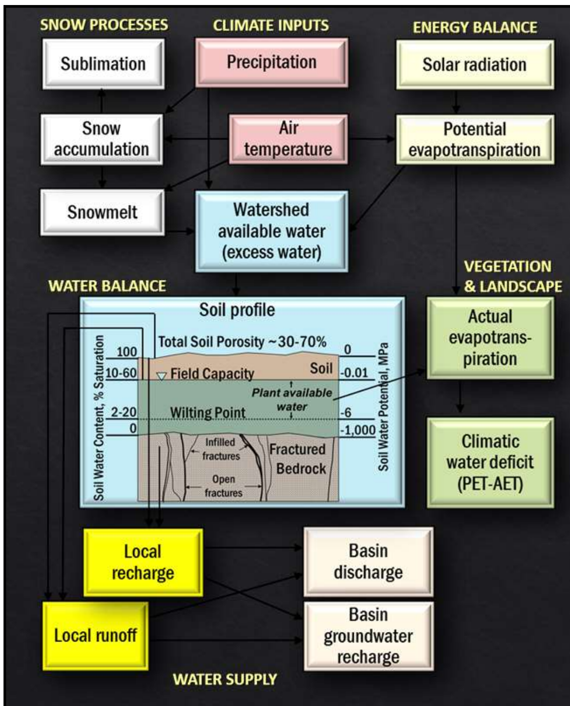
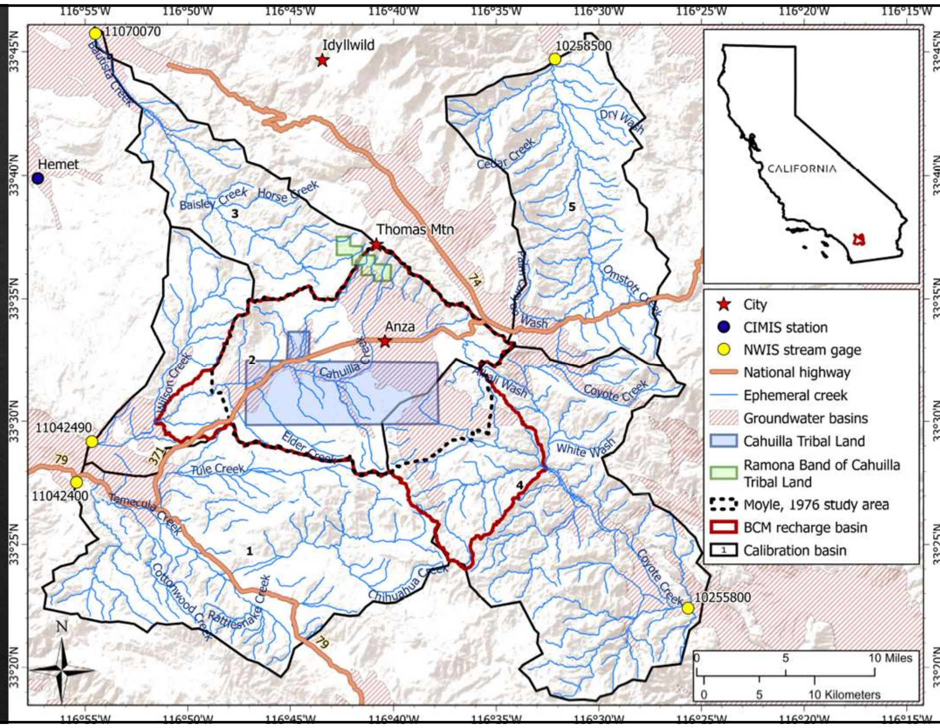


Basin Characterization Model

- A grid-based water balance model
- Uses gridded climate data downscaled to fine spatial scales (historical and future)
- Incorporates detailed soil properties and estimates of bedrock permeability
- Calculates spatially distributed water supply as recharge and runoff
- Calculates climatic water deficit as estimate of demand

6



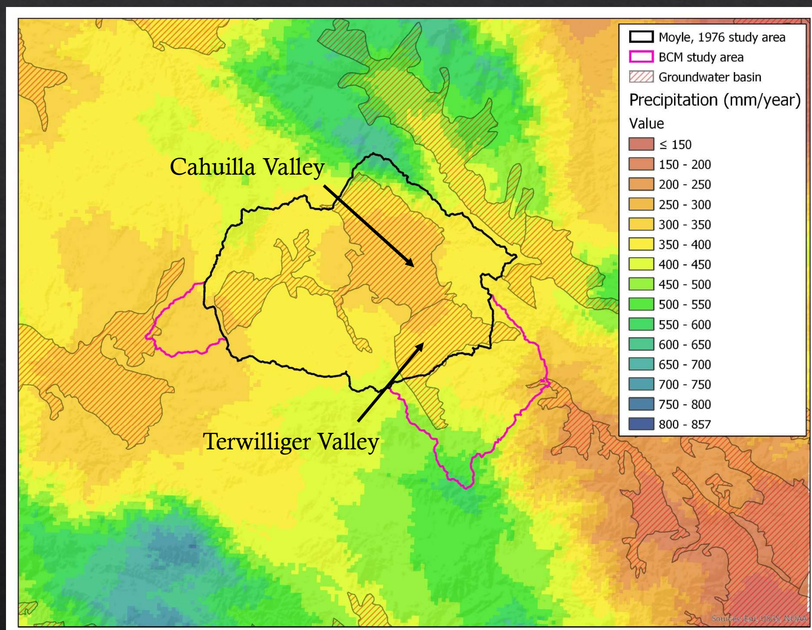
7

Model Calibration

- The BCM is calibrated or validated regionally to many sources of data, both point measurements and remote sensing, including streamflow, soil moisture, potential and actual evapotranspiration, as well as estimates of recharge on the basis of post-calibration MODFLOW models.
- Local variables used for calibration include streamflow and actual evapotranspiration to constrain the water balance
- Calibration parameters that are adjusted:
  - bedrock permeability
  - soil storage capacity
  - vegetation type k-factor (monthly percentage of total PET that is actual ET)
  - root exploration depth below soil depth
  - proportion of runoff that may become recharge (or vice versa, representing gaining and losing streams)

8

Average annual precipitation, 1981-2010



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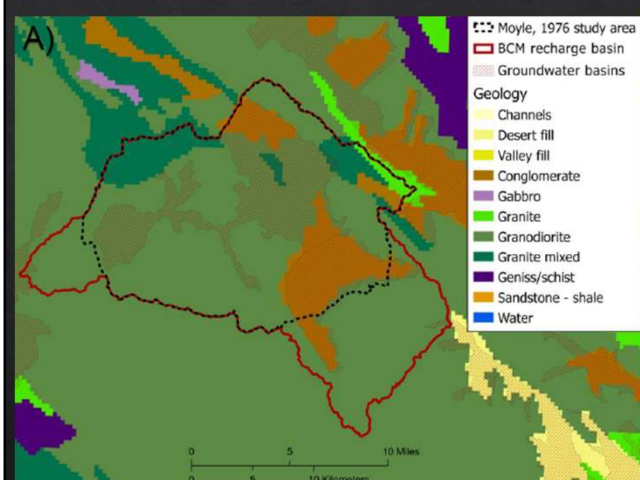

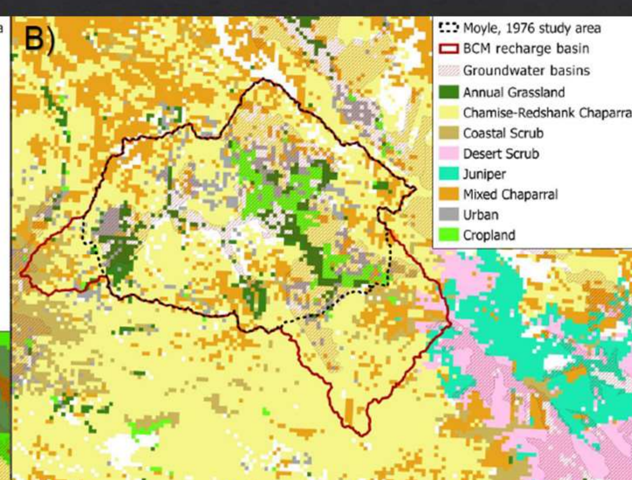

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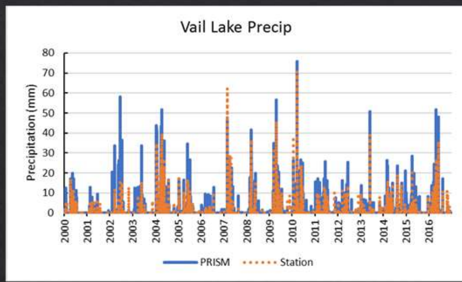
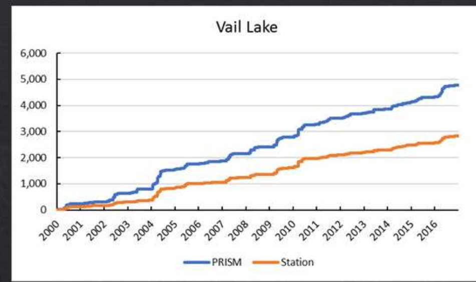
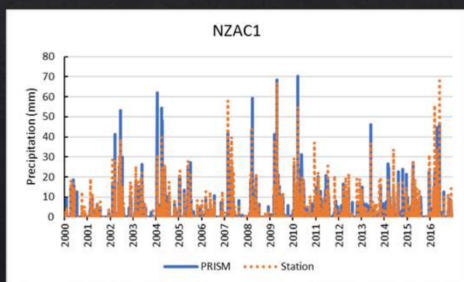
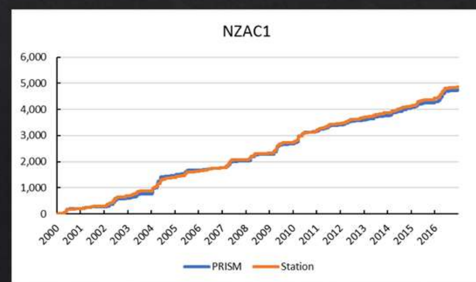




Daily precipitation (mm)

Cumulative precipitation (mm)





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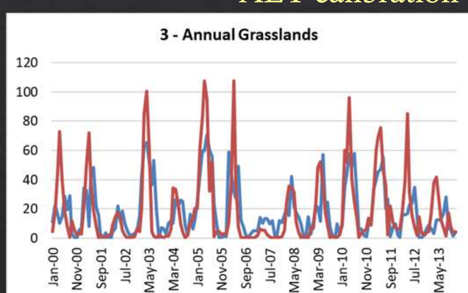
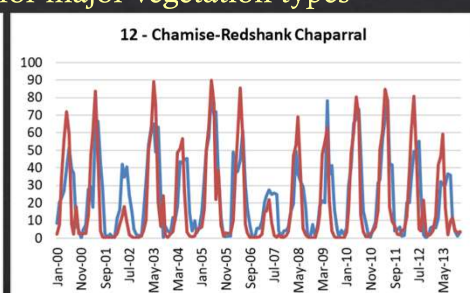
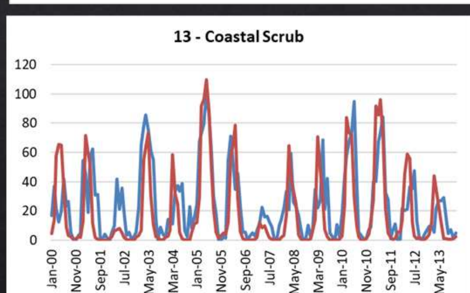
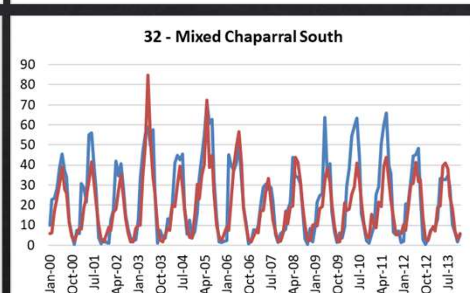
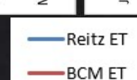
AET calibration for major vegetation types







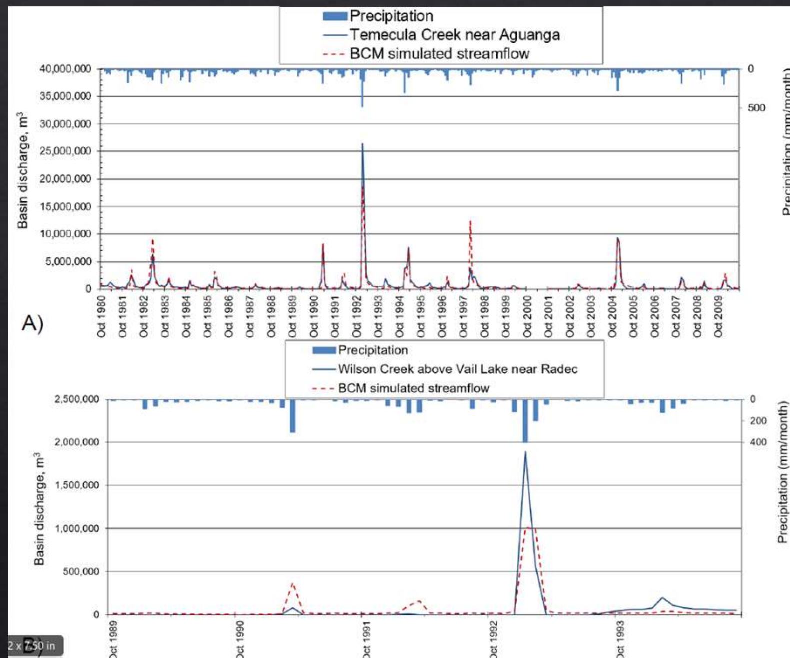




Reitz, Meredith, Senay, G.B., and Sanford, W.E., 2017, Combined remote sensing and water-balance evapotranspiration estimates (SSEBop-WB) for the conterminous United States: U.S. Geological Survey data release, https://doi.org/10.5066/F7QC02FK. https://www.sciencebase.gov/catalog/item/59d3d13ce4b05fe04cc3d278

12

ID	Gage name	Area (m^2)	R^2
1	Temecula Creek near Aguanga	340,580,773	0.81
2	Wilson Creek above Vail Lake near Radec	308,296,220	0.71
3	Bautista Creek at Mouth near Valle Vista	132,263,505	0.88
4	Coyote Creek near Borrego Springs	404,201,565	0.45
5	Palm Canyon Creek near Palm Springs	241,438,206	0.72



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Variable	Period	Point or area comparison	Source	Published estimate	This study
				mm	mm
Precipitation	1897-1947	Moyle recharge basin	Moyle, 1976	406-762	419
Precipitation	1956	Moyle recharge basin	Moyle, 1976	132	210
Precipitation	1943	Moyle recharge basin	Moyle, 1976	568	427
Precipitation	1949-1954	BCM recharge basin	CA DWR, 1956	364	337
Precipitation	1953	BCM recharge basin	CA DWR, 1956	298	298
Precipitation	1951	BCM recharge basin	CA DWR, 1956	185	261
Precipitation	1981-2010	Anza (Point)	WRCC, 2020b	300	321
Precipitation	1981-2010	Idyllwild (Point)	WRCC, 2020c	665	627
Precipitation	1981-2010	Hemet (Point)	WRCC, 2020a	297	307
Precipitation	water year 2016	Hemet (Point)	CIMIS	177	174
Precipitation	water year 2017	Hemet (Point)	CIMIS	181	364
Precipitation	water year 2018	Hemet (Point)	CIMIS	128	129
PET	water year 2016	Hemet (Point)	CIMIS	1,634	1,468
PET	water year 2017	Hemet (Point)	CIMIS	1,588	1,471
PET	water year 2018	Hemet (Point)	CIMIS	1,693	1,475
				m^3 (10^3)	m^3 (10^3)
Recharge	1973	Moyle recharge basin	Moyle, 1976	5,551	5,589
AET	Average annual 1897-1947	Moyle recharge basin	Moyle, 1976	105,463	76,846

[1]CIMIS Hemet station, https://cimis.water.ca.gov/

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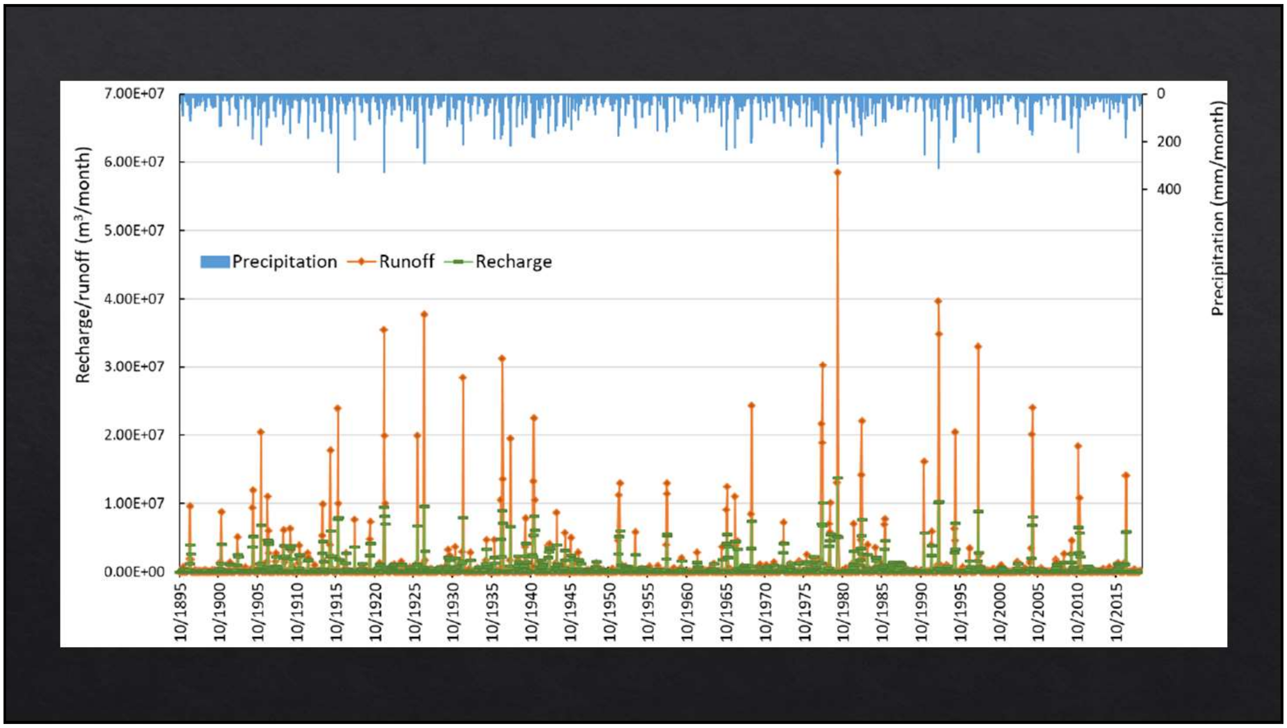

7.00E+07
6.00E+07
5.00E+07
4.00E+07
3.00E+07
2.00E+07
1.00E+07
0.00E+00
Recharge/runoff (m3/month)
0
200
400
Precipitation (mm/month)
Precipitation
Runoff
Recharge
10/1895
10/1900
10/1905
10/1910
10/1915
10/1920
10/1925
10/1930
10/1935
10/1940
10/1945
10/1950
10/1955
10/1960
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10/2010
10/2015

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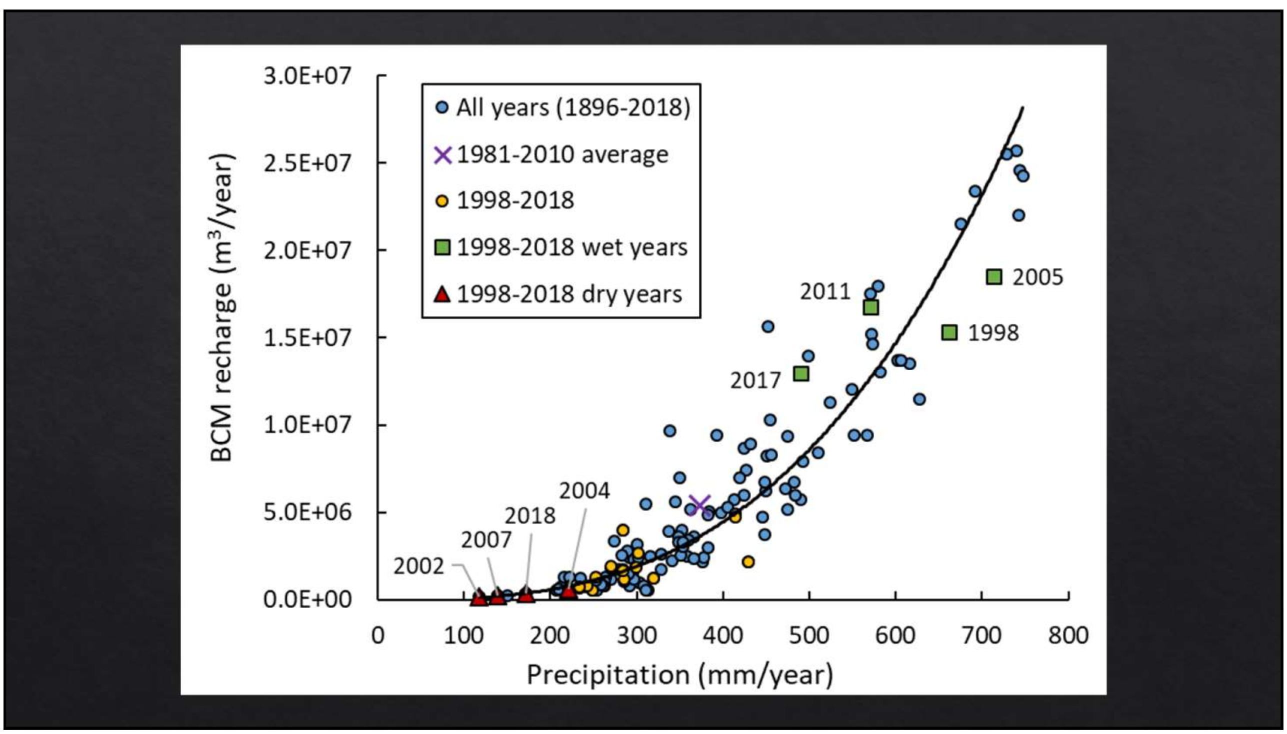
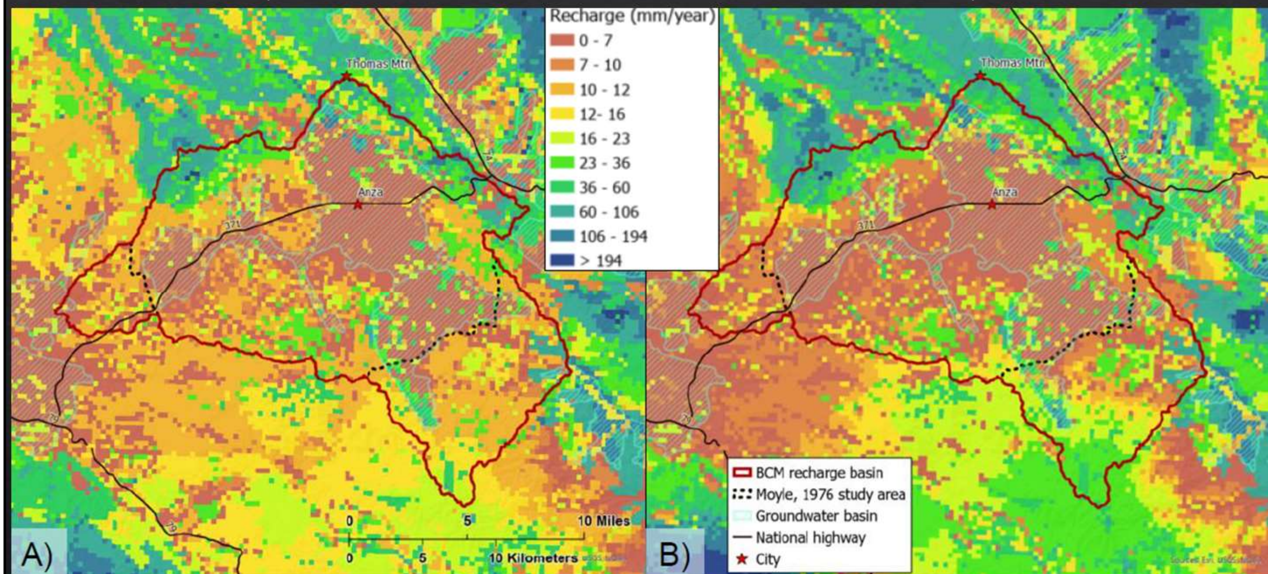


All years (1896-2018)
1981-2010 average
1998-2018
1998-2018 wet years
1998-2018 dry years
BCM recharge (m3/year)
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
2011
2005
1998
2017
2004
2018
2007
2002
0
100
200
300
400
500
600
700
800
Precipitation (mm/year)

16

Water years 2011-2018 | Water years 1981-2010



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Limitations

- Uncertainty exists in all components including climate data, streamflow measurements, other calibration data, model parameterization, and model outputs.
- The BCM calculates natural net infiltration and should not be interpreted as direct recharge to the aquifer.
- To understand how much water makes it through the unsaturated zone and to the aquifer and how it is distributed requires a groundwater model like MODFLOW

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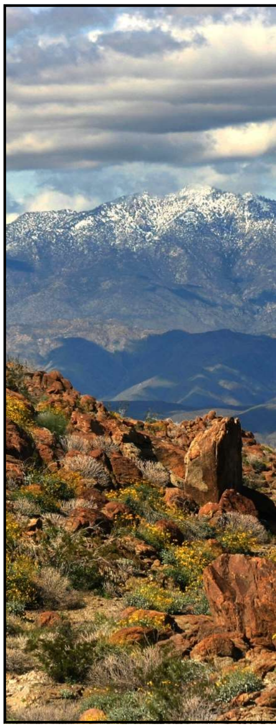

Conclusions

- Water balance modeling can be used to characterize hydrologic conditions, including recharge, in the Anza region.
- Average annual recharge in the Anza region that may contribute to the groundwater basin is about 4,500 acre-feet per year
- However, recharge doesn't occur every year, and in some years can exceed 10,000 acre-feet
- Watersheds surrounding the Anza groundwater basin contribute water, either by surface or subsurface processes, to the basin.
- The BCM has been locally calibrated and can be used to provide time series of historical boundary conditions to a groundwater model and evaluate impacts of future climate conditions on recharge in the region
- Future work could include running climate scenario and land use changes.

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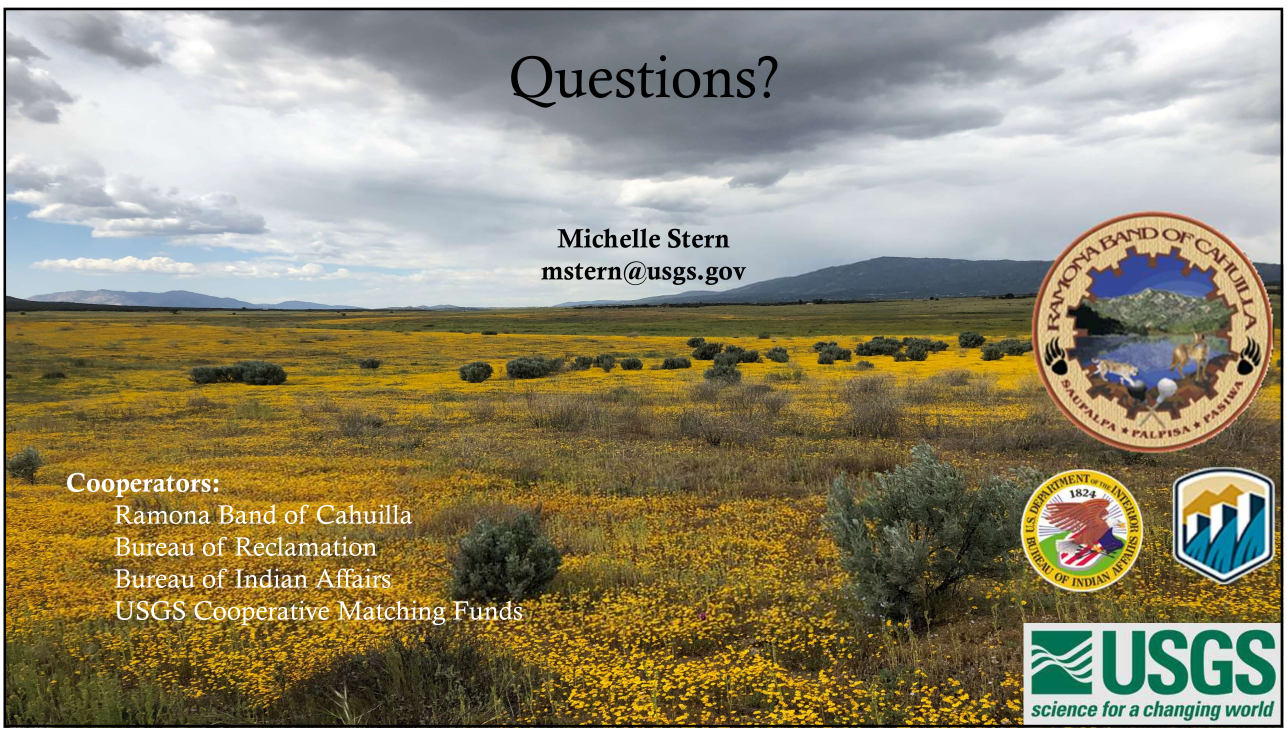

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