Importance of River Water Recharge to Selected California Groundwater Basins

Groundwater Resources Association of California
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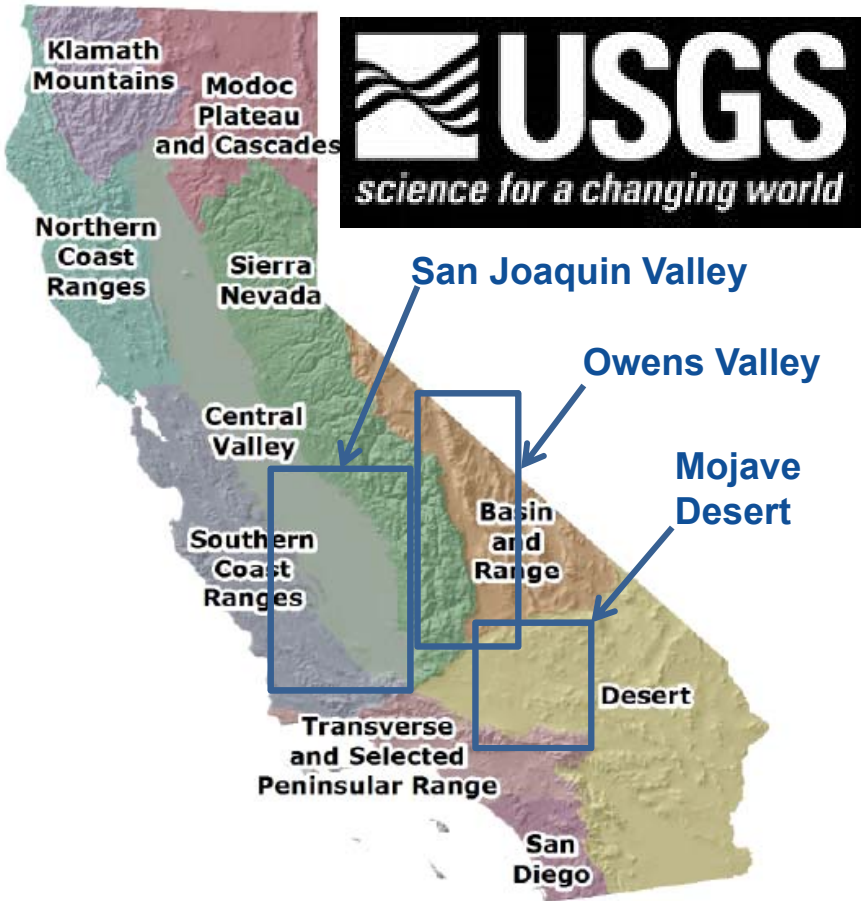
Importance of River Water Recharge

Methods and Data

- Groundwater Ambient Monitoring and Assessment (GAMA) program
- Priority Basin project:
  - Ken Belitz, Miranda Fram, Justin Kulongoski, Bryant Jurgens
- Groundwater Analyses:
  - Source:
    Stable isotopes of water
  - Recharge mechanism:
    Noble gases
  - Time-scales:
    Tritium/helium, Carbon-14



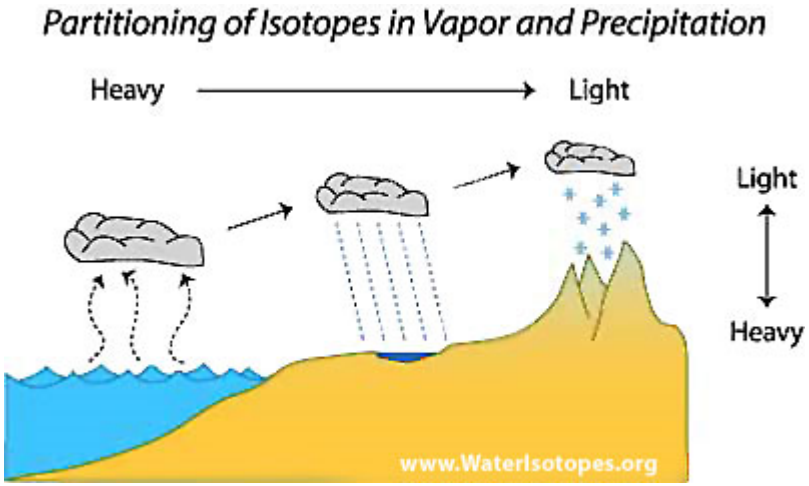
http://ca.water.usgs.gov

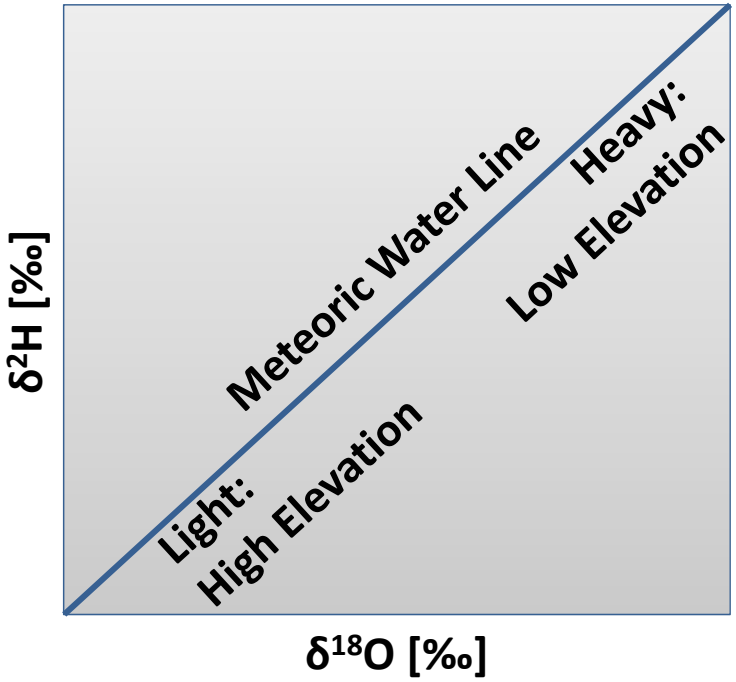
GAMA Priority Basin project produced a unique data set of isotopic signatures

Importance of River Water Recharge

Methods and Data

- Stable Isotopes of Water





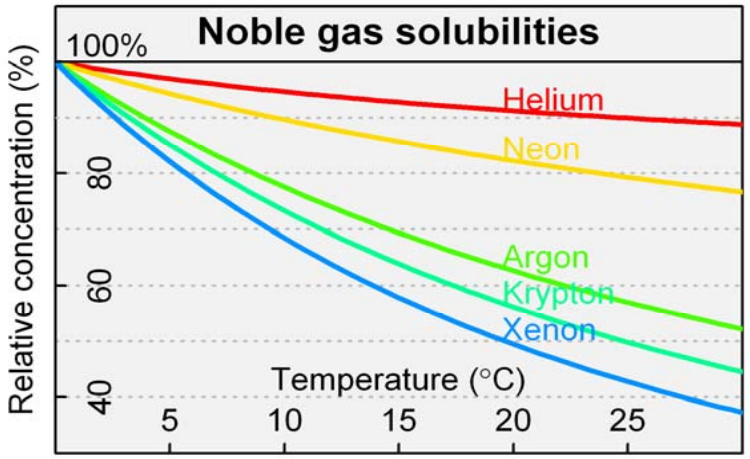
http://web.sahra.arizona.edu/programs/isotopes/oxygen.html

Stable isotope signatures of groundwater relate to the sources of the sampled water

Importance of River Water Recharge

Methods and Data

- Noble Gas Recharge Temperature

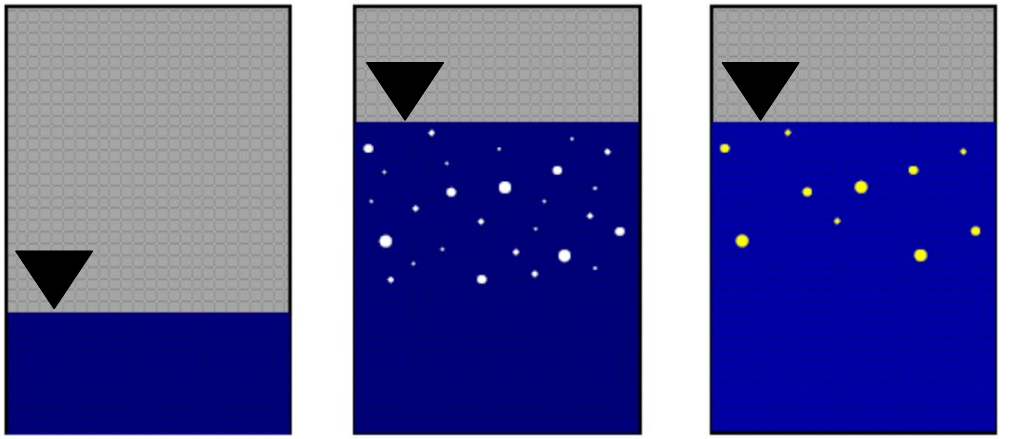


http://www.middleschoolchemistry.com/

Noble gases in groundwater provide information about recharge temperatures

Importance of River Water Recharge
Methods and Data

- Noble Gas: Excess Air

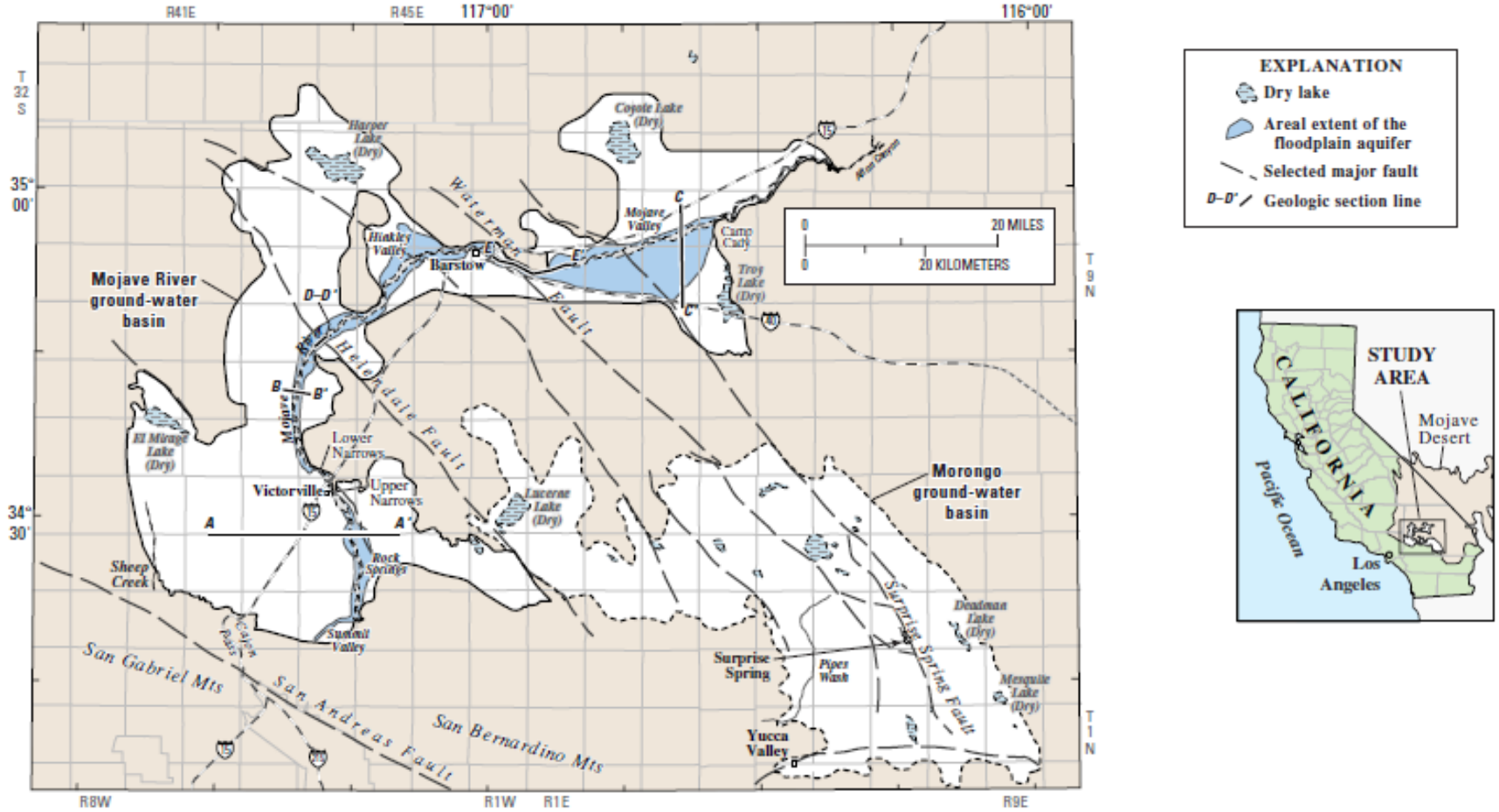


Werner Aeschbach-Hertig, U Heidelberg

Noble gases in groundwater provide information about water table fluctuations

Mojave Desert Groundwater Basin

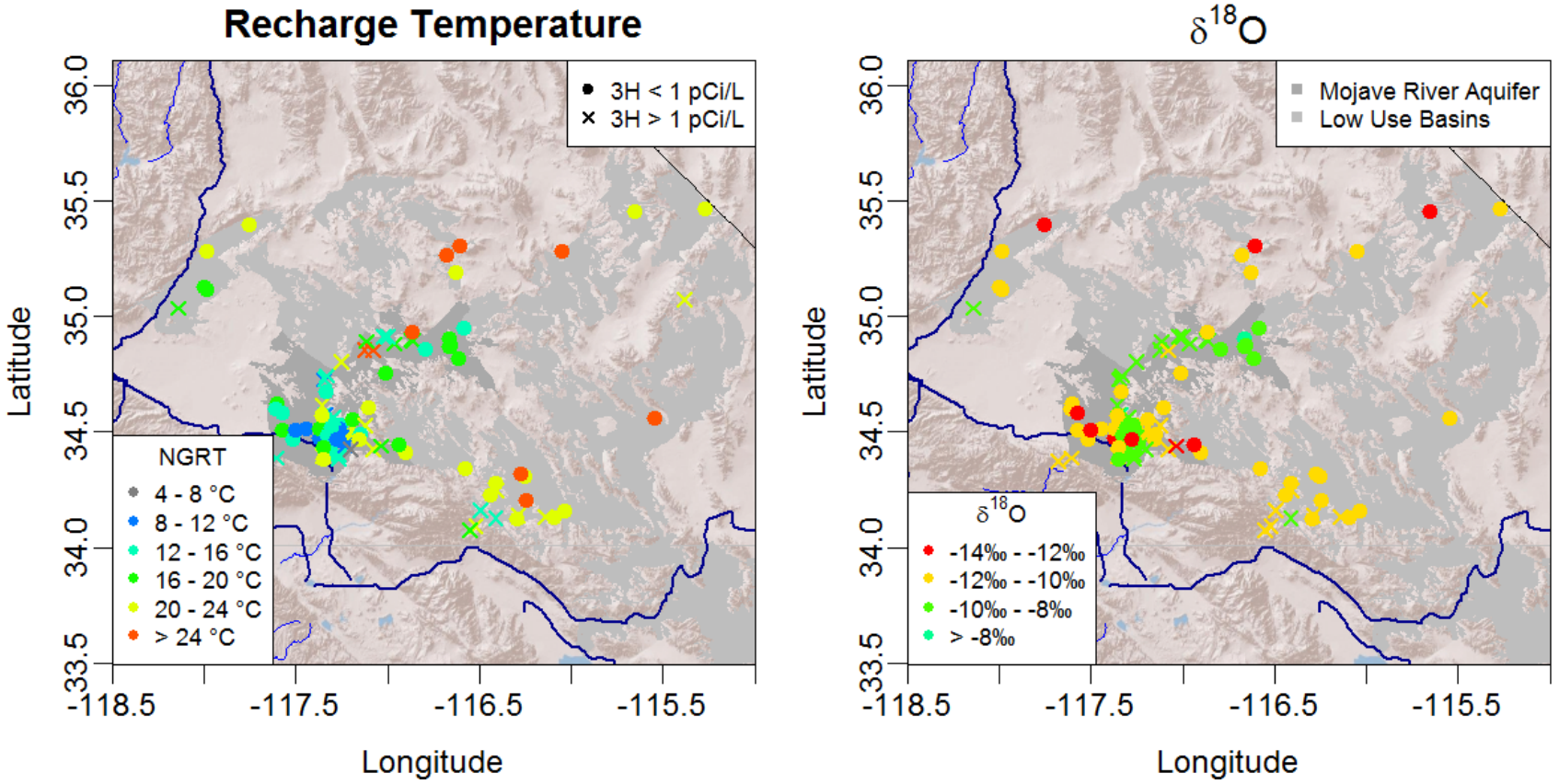
Characterization and Previous Studies



Izbicki and Michel, 2004, USGS Water-Resources Investigations Report 03-4314
Movement and Age of Ground Water in the Western Part of the Mojave Desert, Southern California, USA

Mojave Desert

Stable Isotope and Noble Gas Signatures

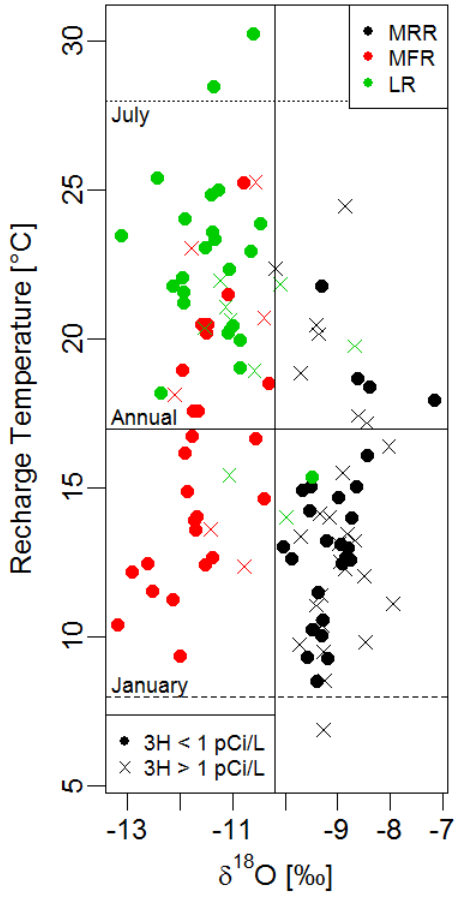


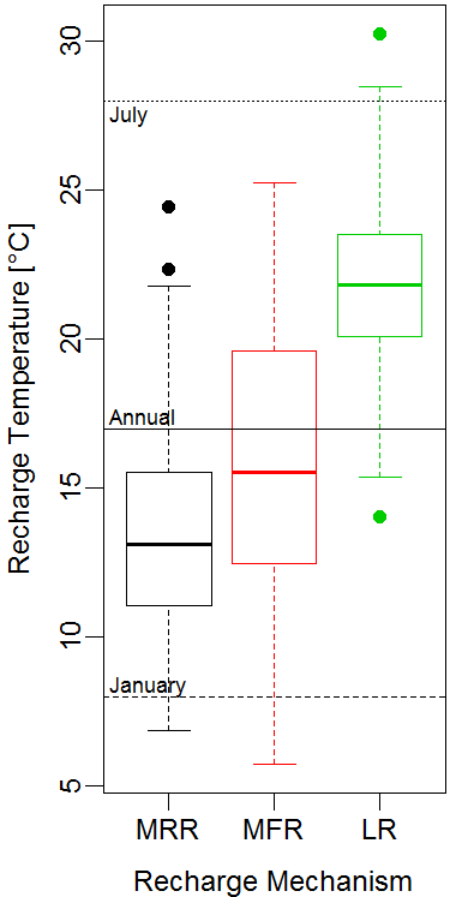
Low Noble Gas Recharge Temperatures coincide with **less depleted** $\delta^{18}O$

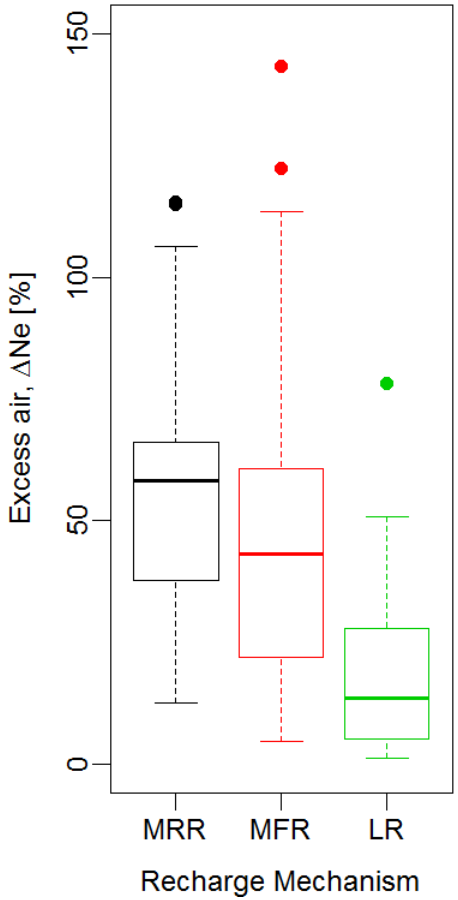
Mojave Desert

Stable Isotope and Noble Gas Signatures

- **Mojave River Recharge**
- **Mountain Front Recharge**
- **Local Precipitation Recharge**

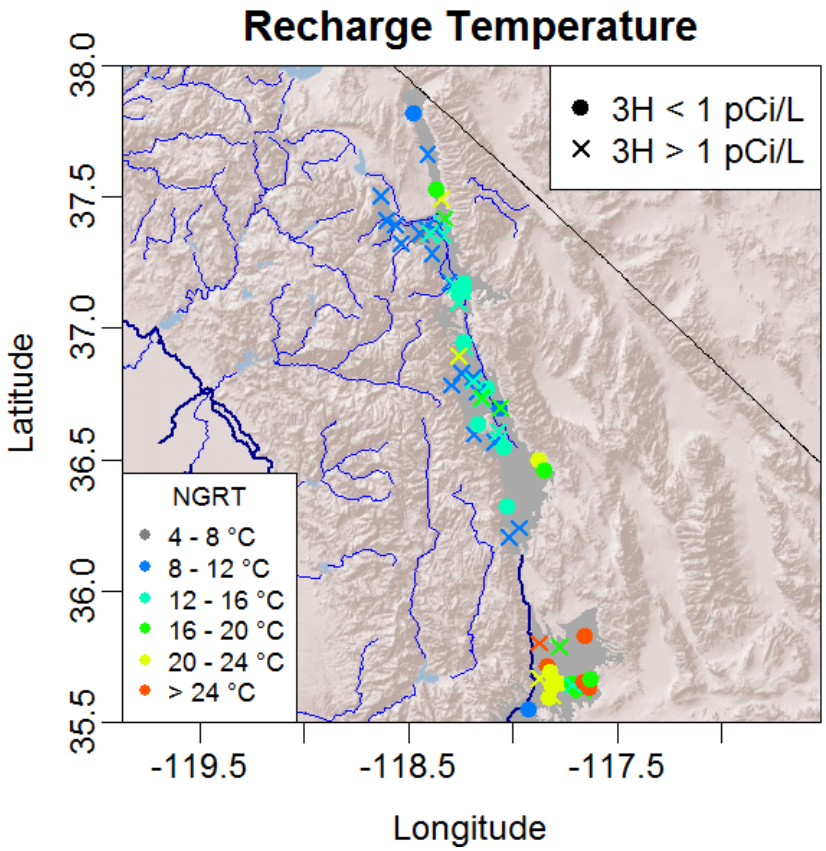


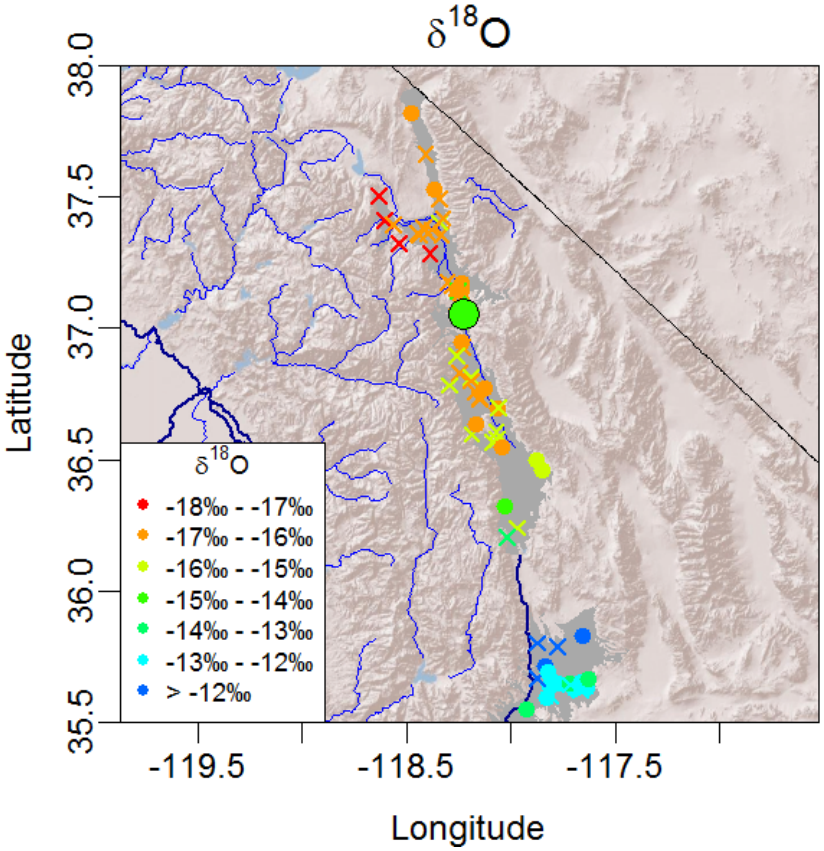




Owens Valley

Stable Isotope and Noble Gas Signatures



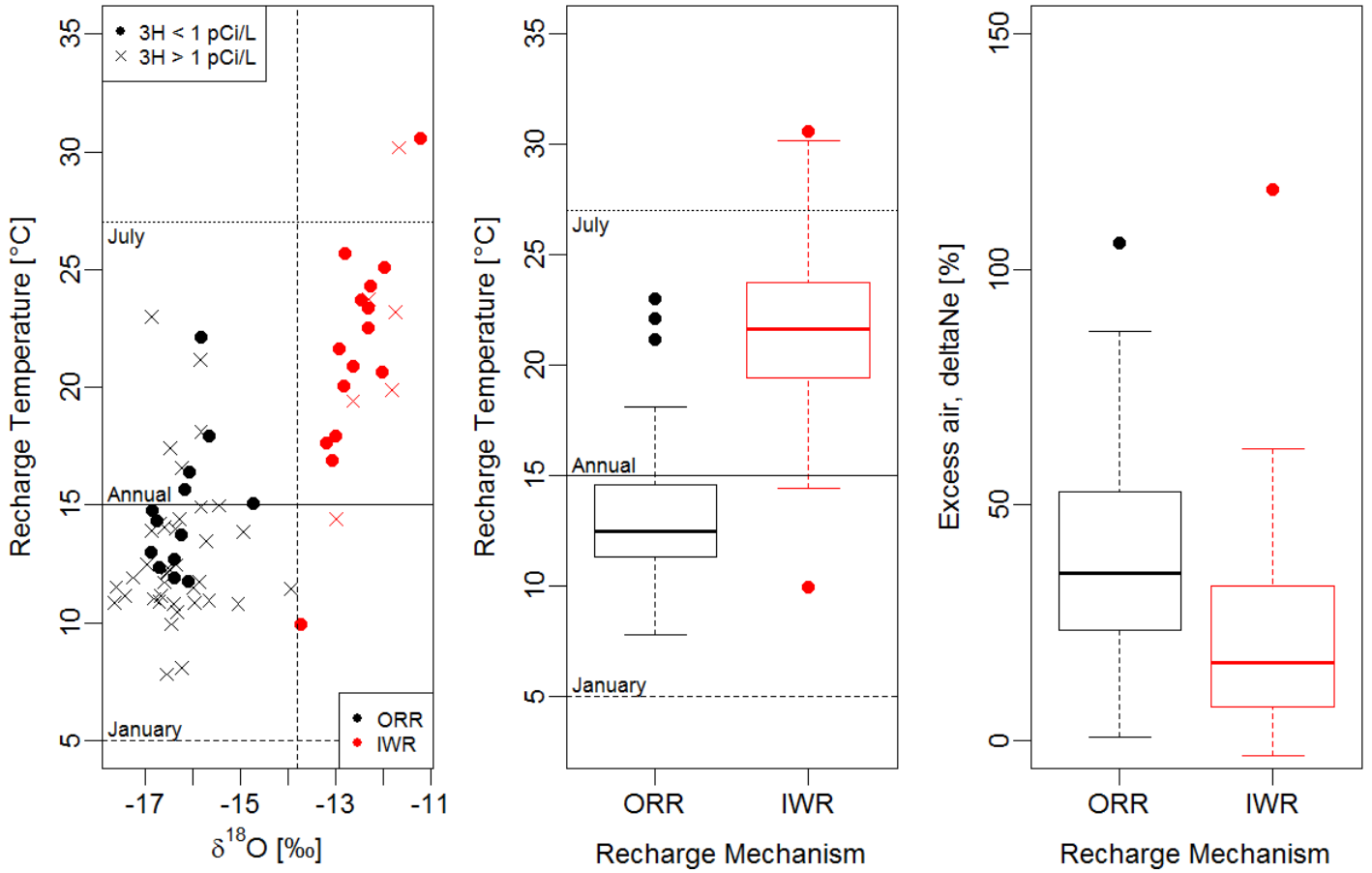


Low Noble Gas Recharge Temperatures coincide with **more depleted** $\delta^{18}O$

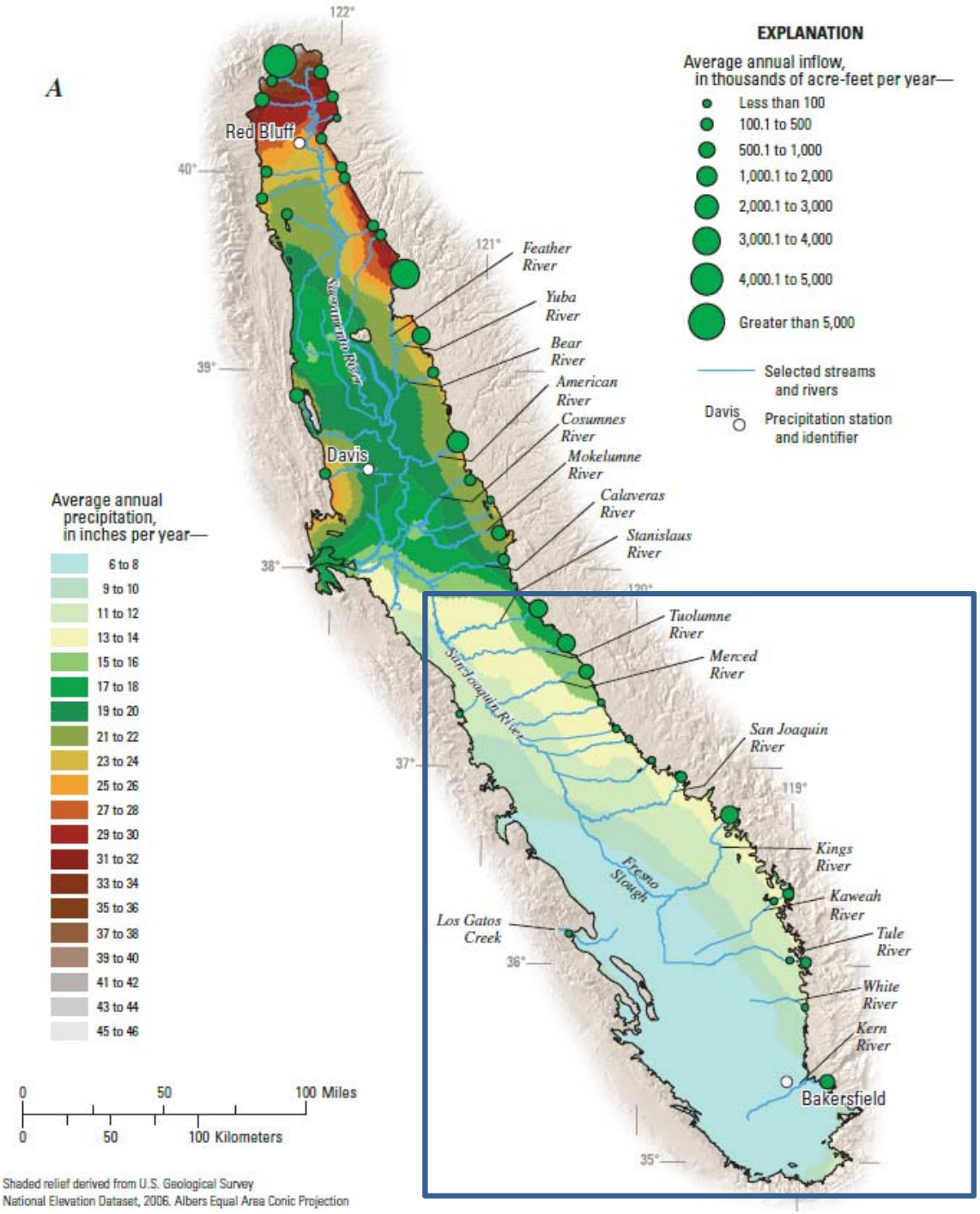
Owens Valley

Stable Isotope and Noble Gas Signatures

- Owens River Recharge
- Indian Wells Recharge



San Joaquin Valley

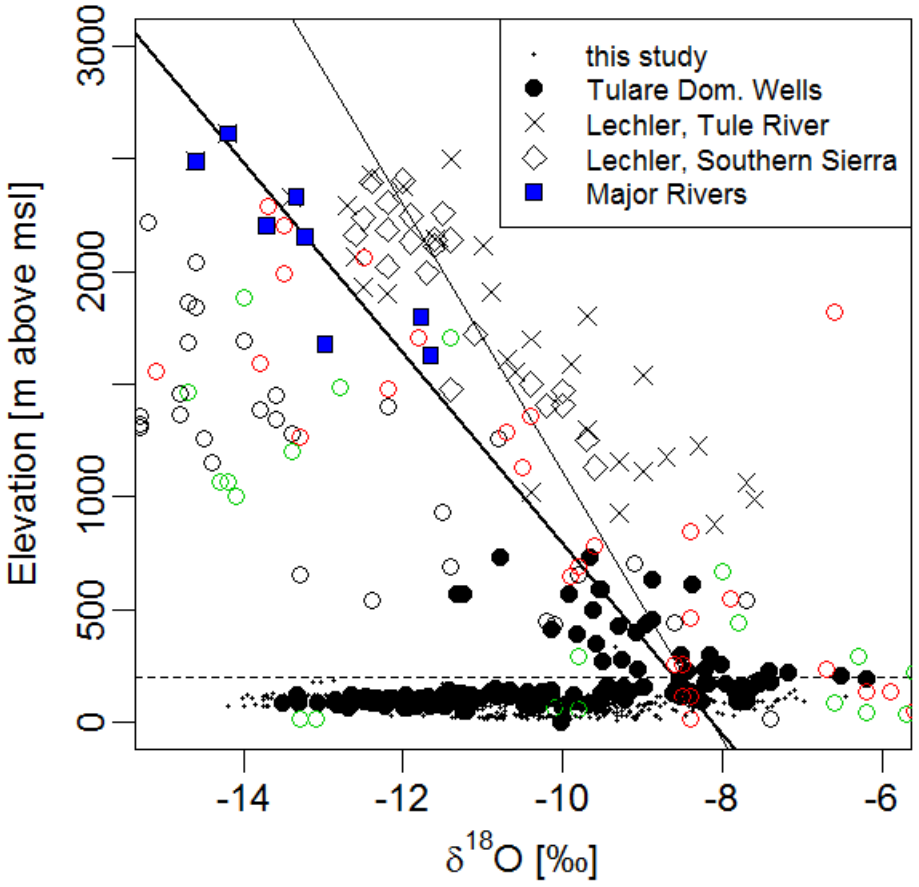


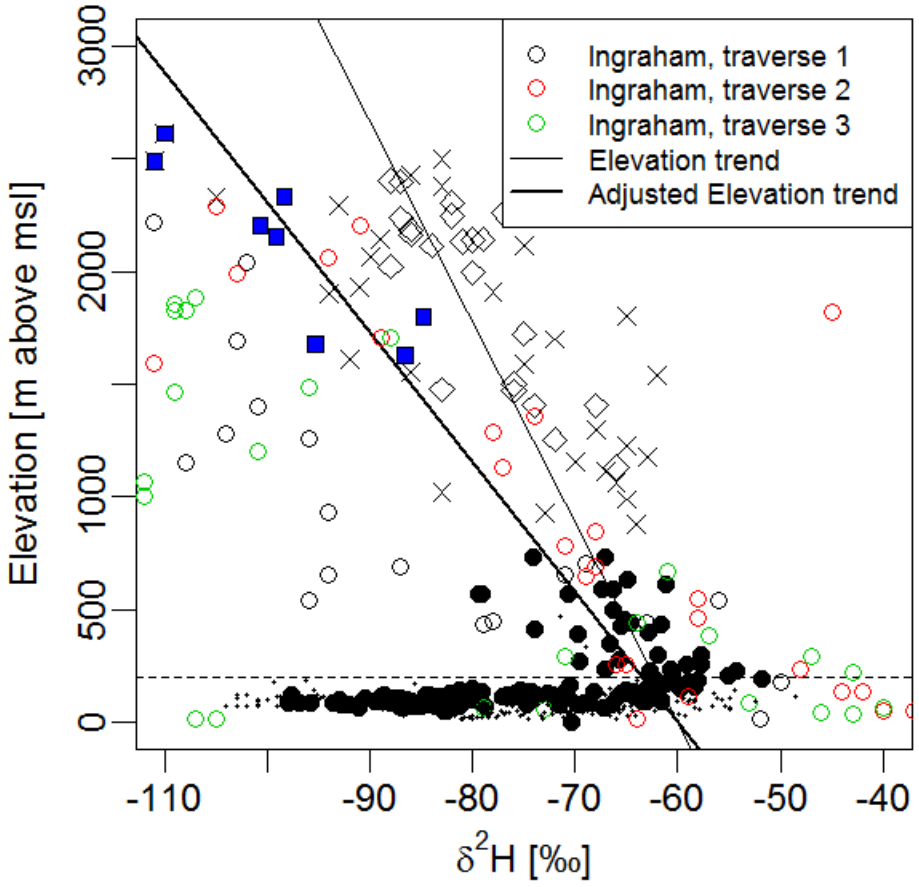
Faunt, 2009, USGS Professional Paper 1766: Groundwater Availability of the Central Valley Aquifer, California

San Joaquin Valley

Stable Isotope Signatures – Elevation Profile

$\delta^{18}O$ [‰] = 8.2 - 2.35 × elevation [km]





River Water $\delta^{18}O$ signature is controlled by catchment elevation

San Joaquin Valley

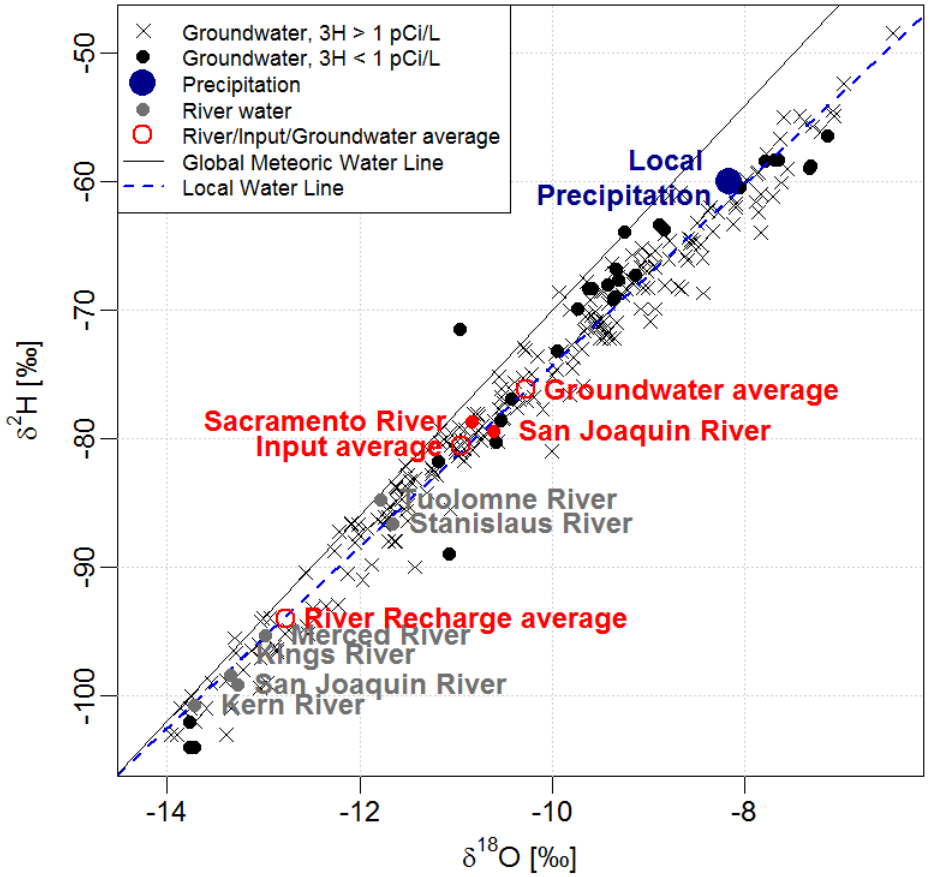
River Source Elevations, Stable Isotope Signatures and Inflow

Source	Elevation	$\delta^{18}O$ [‰]		Inflow	Proportion	
	m	observed	trend	[km^3/a]	of rivers	of total
Stanislaus	1628	-11.7	-12.0	1.3	15%	
Tuolumne	1801	-11.8	-12.4	2.1	22%	
Merced	1677	-13.0	-12.1	1.2	13%	
Fresno				0.1	1%	
San Joaquin	2155	-13.2	-13.2	0.6	6%	
Kings	2332	-13.3	-13.6	2.3	25%	
Kaweah	1845		-12.5	0.6	6%	
Tule				0.2	2%	
Kern	2204	-13.7	-13.3	0.9	10%	
Rivers		**-12.7**	**-12.8**	**9.2**	100%	**56%**
Local Precipitation		**-8.2**	**-8.2**	**6.0**		**37%**
State Water Project		**-10.8**	**-10.8**	**1.2**		**7%**
Total Inflow		**-10.9**	**-10.9**	**16.4**		**100%**

Contributions and stable isotope signature of sources of recharge in the San Joaquin Valley.

San Joaquin Valley

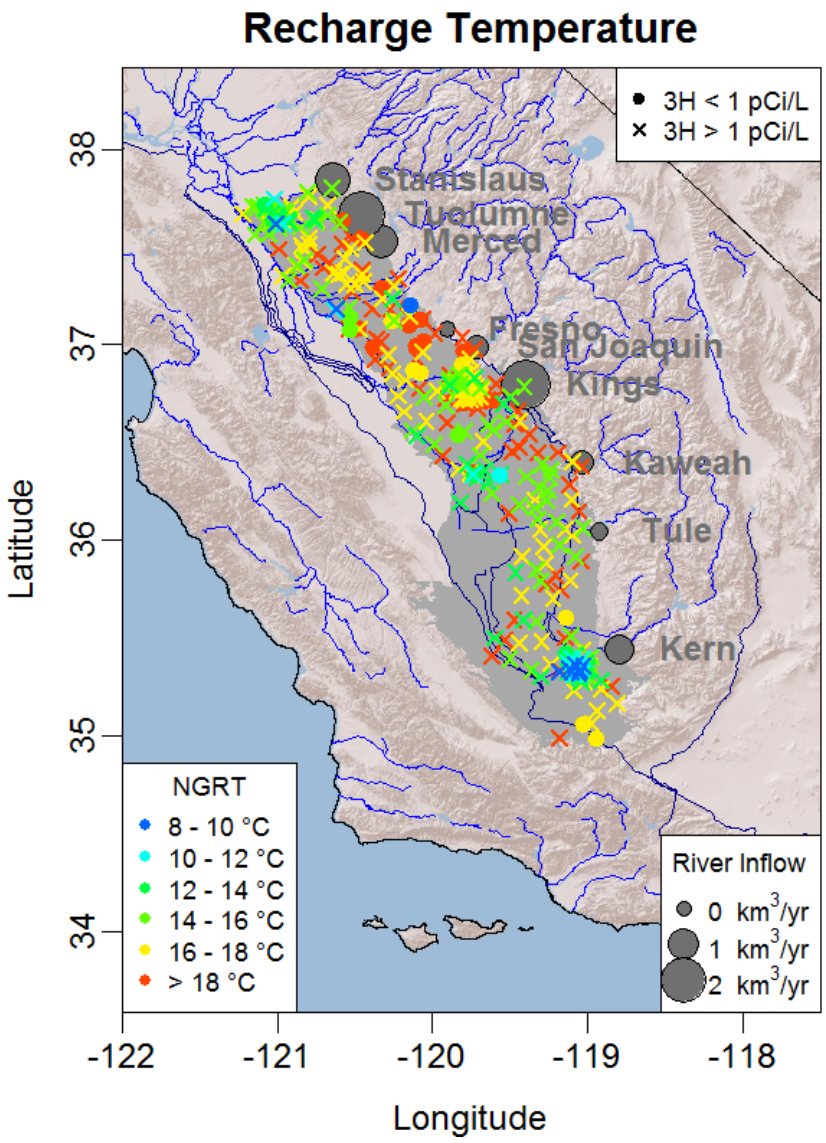
Stable Isotope Signatures – Local Water Line

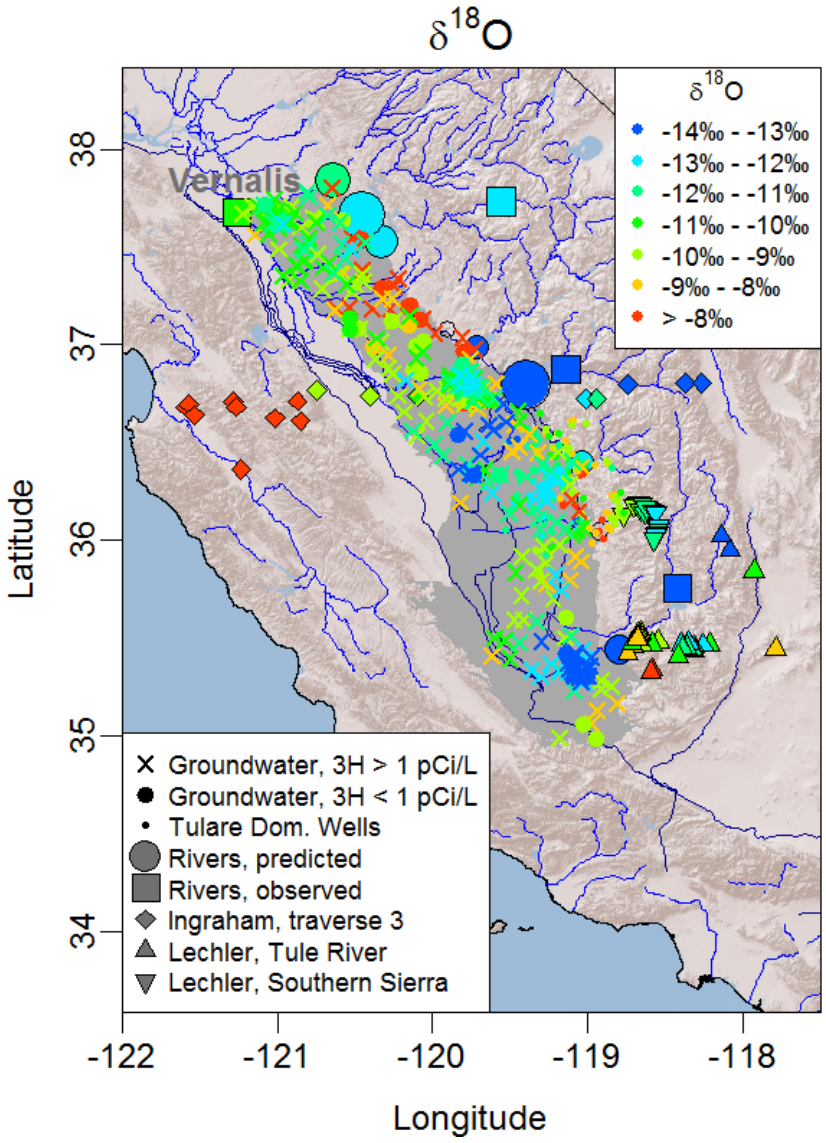


River Water and Local Precipitation have distinct stable isotope signatures

San Joaquin Valley

Stable Isotope and Noble Gas Signatures

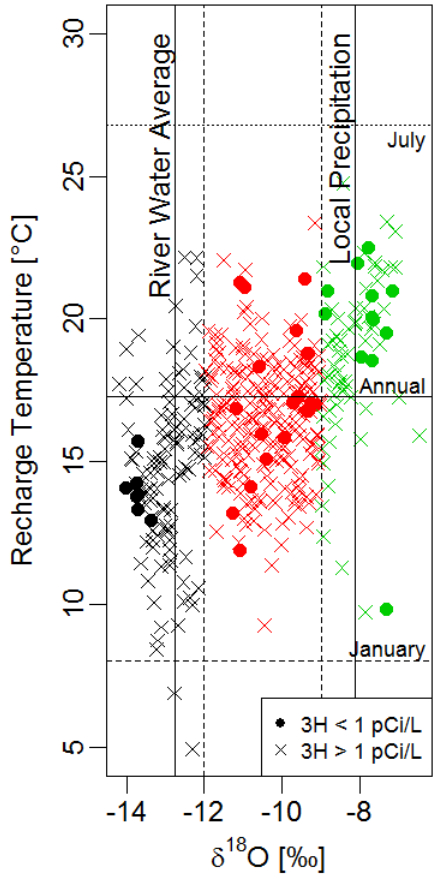


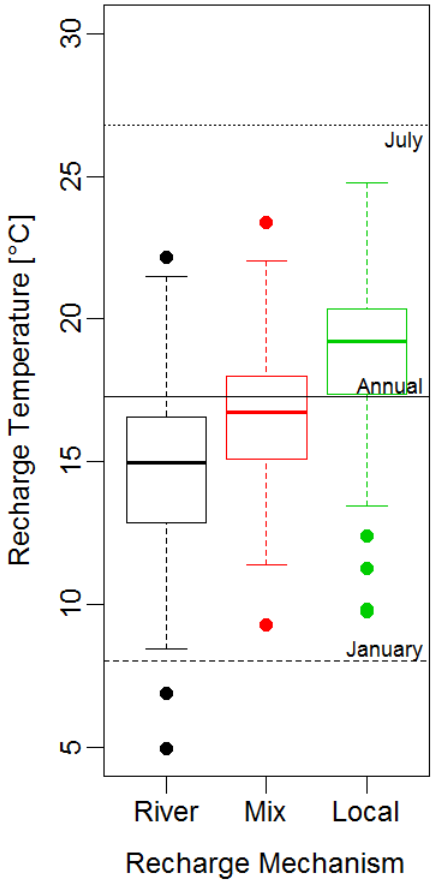


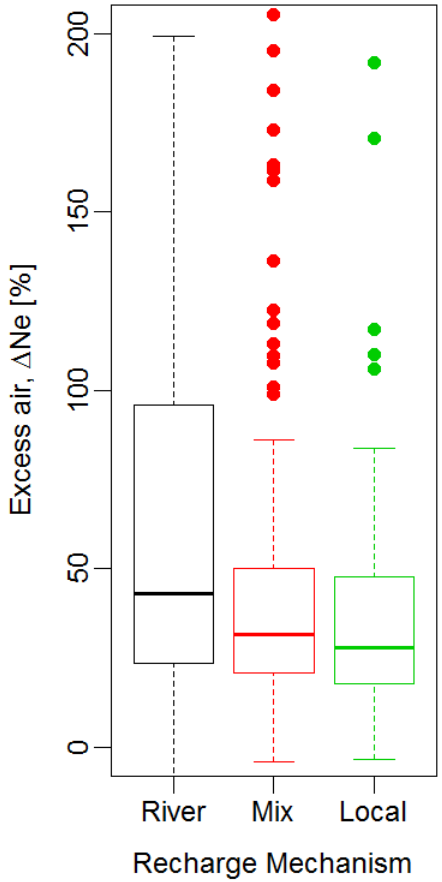
San Joaquin Valley

Stable Isotope and Noble Gas Signatures

- River Water Recharge
- Mixed Recharge
- Local Precipitation Recharge







River water recharges under cooler conditions than local precipitation

San Joaquin Valley

Proportion River Water Recharge Calculation

$$\text{Proportion River Water Recharge} = (\delta^{18}O_{GWmean} - \delta^{18}O_{LPR}) / (\delta^{18}O_{RWR} - \delta^{18}O_{LPR})$$

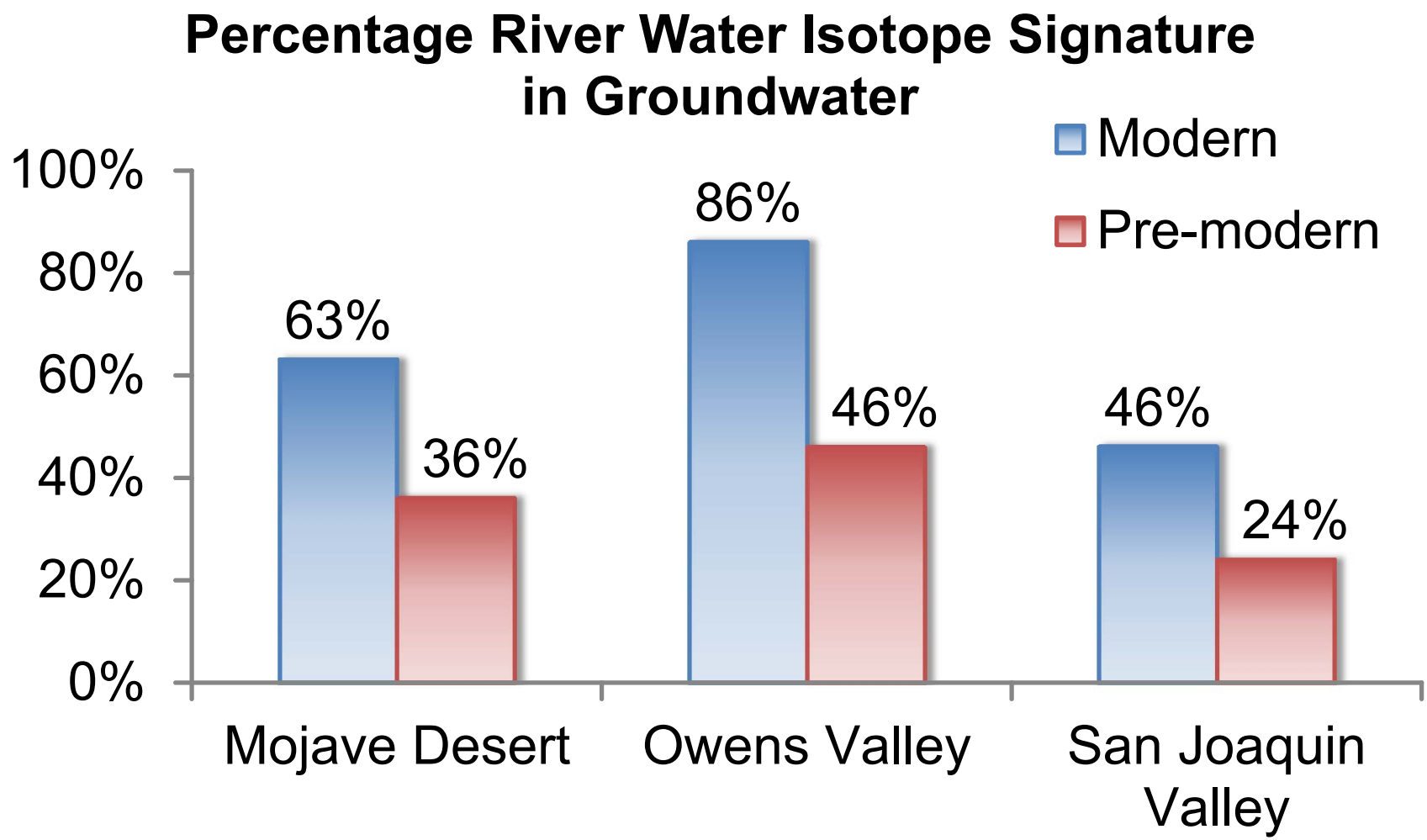
$$\text{Proportion Local Precipitation Recharge} = (\delta^{18}O_{GWmean} - \delta^{18}O_{RWR}) / (\delta^{18}O_{LPR} - \delta^{18}O_{RWR})$$

Data Selection	$\delta^{18}O$ mean	Proportion River Water Recharge	Proportion Local Precipitation Recharge
Priority Basin samples	-10.15 ‰	43%	57%
- Pre-modern samples	-9.25 ‰	**24%**	76%
- Modern samples	-10.26 ‰	**46%**	54%
San Joaquin at Vernalis	-10.60 ‰	53%	47%
River Water Recharge Signature	-12.80 ‰	0%	100%
Local Precipitation Recharge Signature	-8.20 ‰	100%	0%
Average Input Signature	-10.90 ‰	59%	41%

Table 2: Isotopic signatures of selected data subsets and calculated proportions of River Water Recharge and Local Precipitation Recharge

Mean $\delta^{18}O$ signatures of modern and pre-modern groundwater samples indicate increase in proportion river water recharge from 24% to 46%

Importance of River Water Recharge



Conclusions

- Isotopic and Noble Gas signatures reflect source and mechanism of recharge
  - River Water Recharge or Local Precipitation Recharge
  - Valuable constraints for numerical flow models
- River water recharge: (compared to local precipitation recharge)
  - Lower temperatures
  - Larger water table fluctuations
- Importance of river water recharge has nearly doubled
  - Corresponds to total increase of recharge of 40%
  - Caused by river water irrigation return flows?
- Mountain front recharge and local precipitation contribute to recharge of desert groundwater basins
  - Geological features focus scarce desert precipitation and promote infiltration
- Groundwater banking of seasonal surface water flows: natural and promising method for increasing the resilience of water supply systems.
  - Surface storage is limited: cold river recharge temperatures resulting from fast recharge

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