Predicting Domestic Well Failure in California with Open Data & Machine Learning

Rich Pauloo
PhD Candidate in Hydrology
University of California Davis

@richpauloo

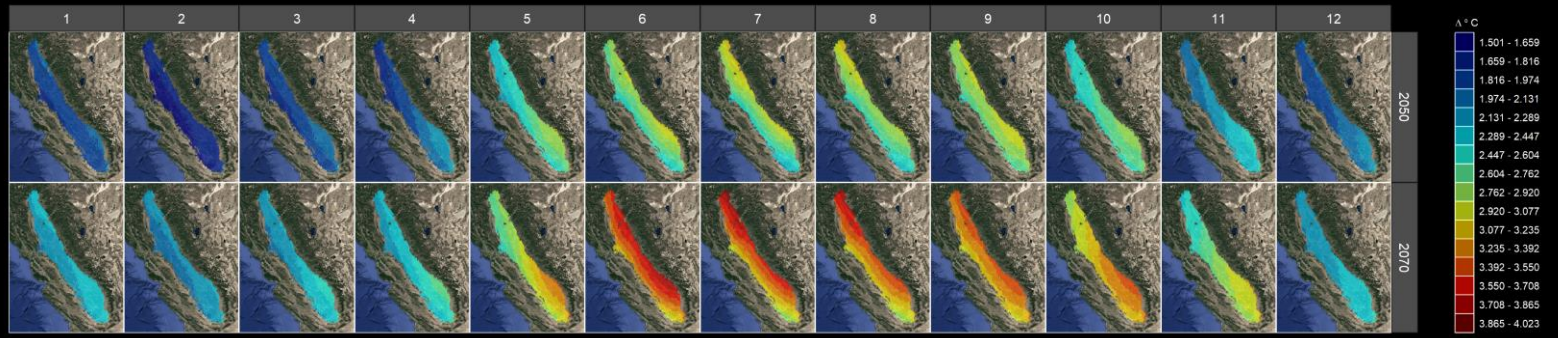
richpauloo

richpauloo.github.io

tmax

RCP 4.5

19 climate models



“A change is gonna come.”

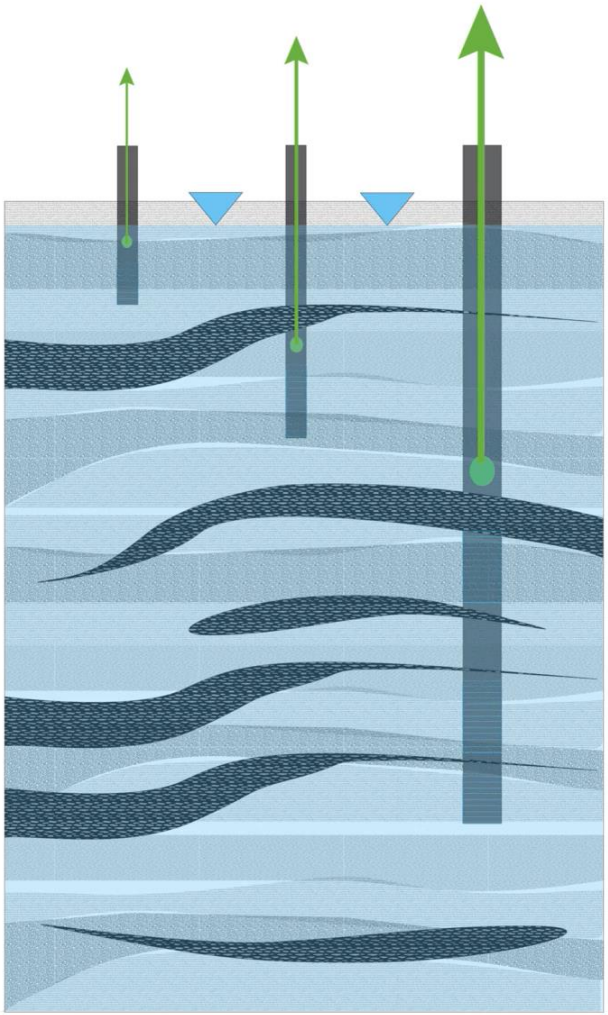
B2

- Sam Cooke

precip

RCP 4.5

19 climate models



Englebright Dam on the Yuba River, CA

Irrigation in California's Central Valley

A groundwater well

Emergency Water Tanks in the Tulare Basin, CA

QUESTIONS

1. Where did domestic wells fail during the 2012 - 2016 drought?

Donna Johnson, 70, (L) lifts pallets of donated bottled water from the back of her truck during her daily delivery run to residents whose wells have run dry, with resident Gabriel Tapia, 31, in Porterville, California October 14, 2014. Picture taken October 14, 2014. Photograph: Reuters/Lucy Nicholson

QUESTIONS

1. Where did domestic wells fail during the 2012 - 2016 drought?

2. What areas of the Central Valley are most vulnerable to well failure in a changing climate?

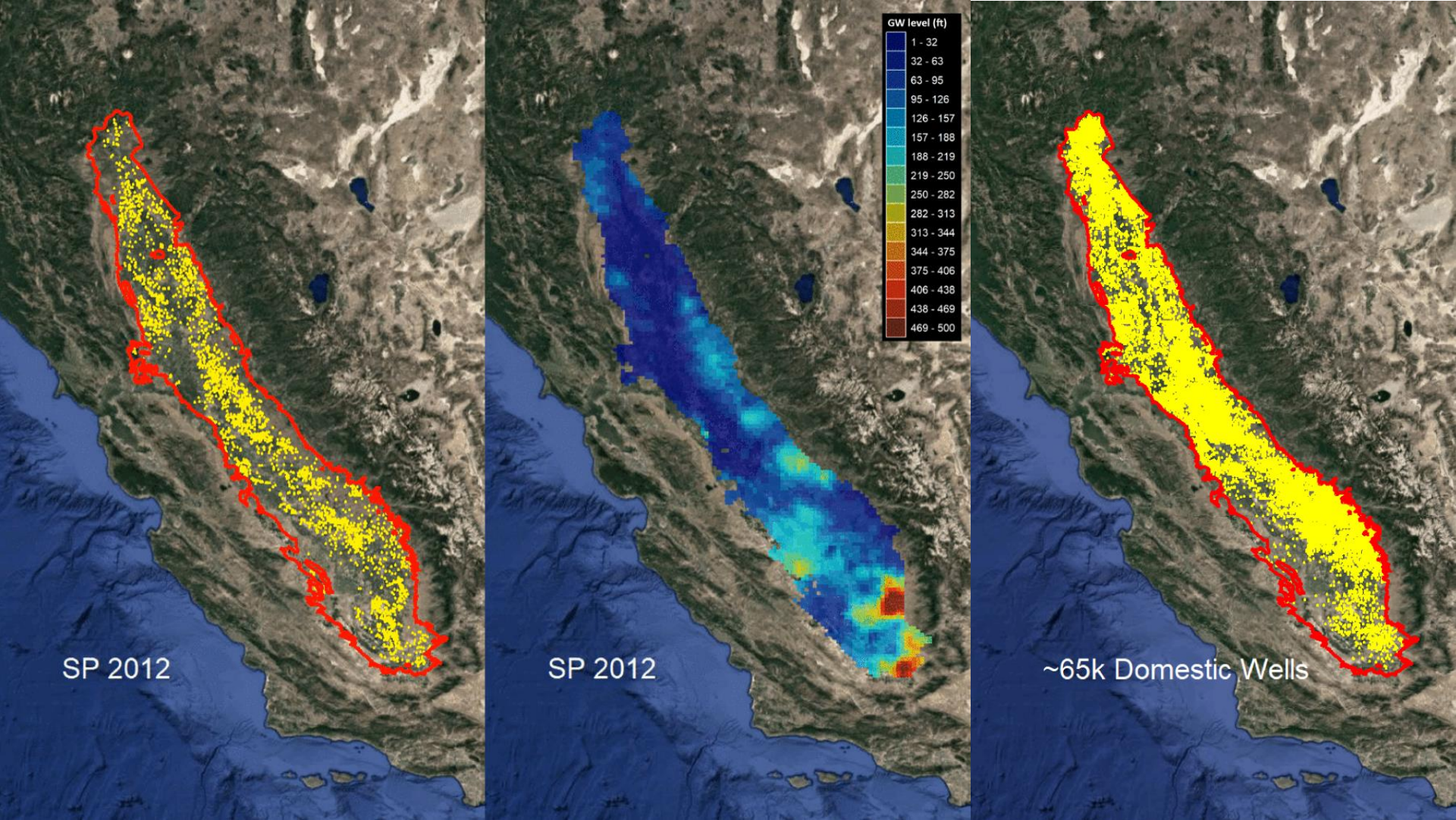
Donna Johnson, 70, (L) lifts pallets of donated bottled water from the back of her truck during her daily delivery run to residents whose wells have run dry, with resident Gabriel Tapia, 31, in Porterville, California October 14, 2014. Picture taken October 14, 2014. Photograph: Reuters/Lucy Nicholson

QUESTIONS

1. Where did domestic wells fail during the 2012 - 2016 drought?

2. What areas of the Central Valley are most vulnerable to well failure in a changing climate?

3. What characterizes the communities affected by well failure?


GW level (ft)
1 - 32
32 - 63
63 - 95
95 - 126
126 - 157
157 - 188
188 - 219
219 - 250
250 - 282
282 - 313
313 - 344
344 - 375
375 - 406
406 - 438
438 - 469
469 - 500
SP 2012
SP 2012
~65k Domestic Wells

Predicting Domestic Well

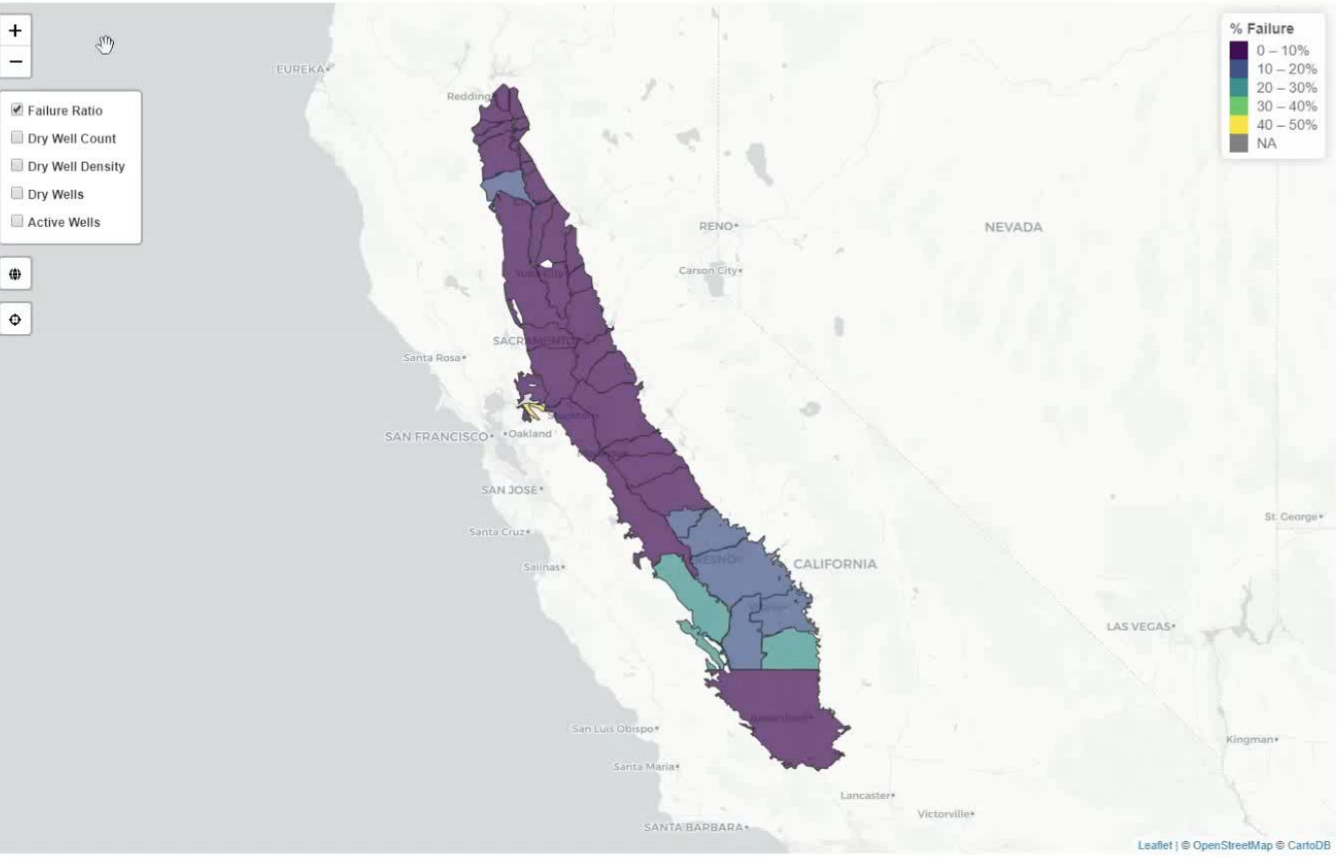
file:///C:/Users/rpauloo/Desktop/cwdc.htm

Apps | SelectorGadget | R | MODFLOW | AbstR | Deep Learning | Stats | Recomendation Eng | Python | QE | Machine Learning | MATH | NLP | Hugo | Conferences | Business | Legal Stuff | Recipes | Data | Blogs | Other bookma

redicting Domestic Well Vulnerability to Drought

Source Co

ulletin 118 Subbasin | Groundwater Sustainability Agency | Public Water Systems | Machine Learning Models | Machine Learning Predictions



Background | Data | Model | Conclusion

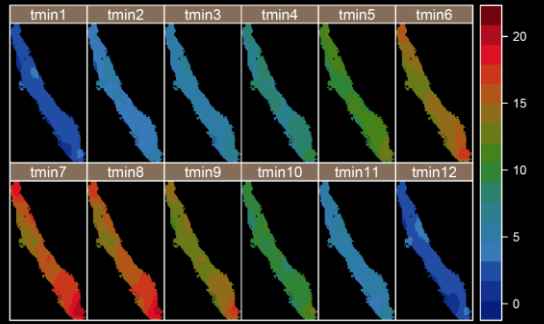
Motivation

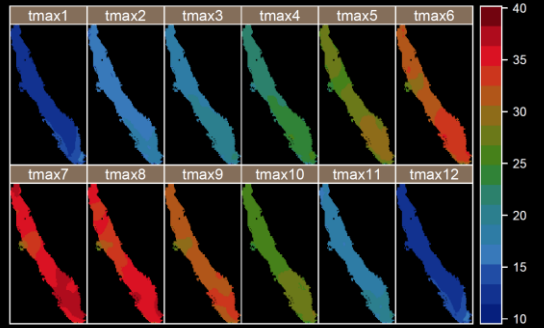
Drought and the overexploitation of aquifers threatens the reliability of domestic water fo millions of Californians. During the 2012-2016 drought thousands of domestic wells in Central Valley went dry, which drew national attention and federal intervention.

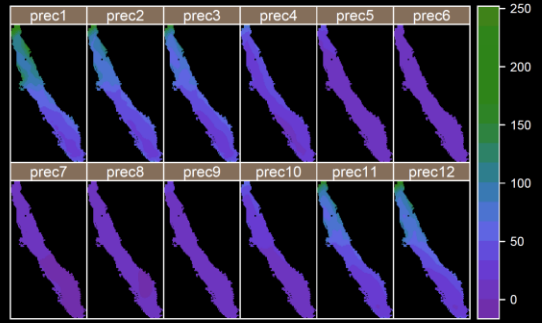
Questions

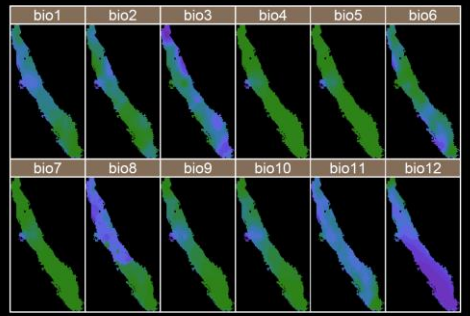
1. How will a short (1-2 yr) or long (4-5 yr) drought affect domestic well failure in California?
2. Are well failures more associated with particular social factors (i.e. - median income, ethnicity)? What policy implications does this have?
3. Can machine learning models predict domestic well failure from climatological variables, and if so, what does climate change imply for domestic well vulnerability?

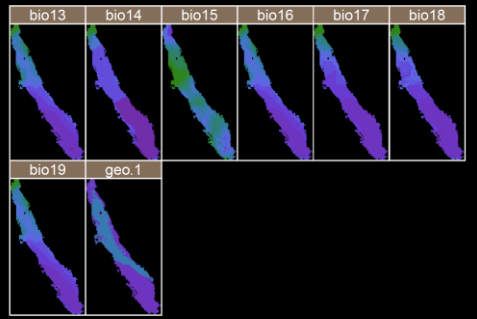
Donna Johnson, 70, (L) lifts pallets of donated bottled water from the back of her truck during her daily delivery run to residents whose wells have run dry, with resident Gabrie Tapia, 31, in Porterville, California October 14, 2014. Picture taken October 14, 2014. Photograph: Reuters/Lucy Nicholson

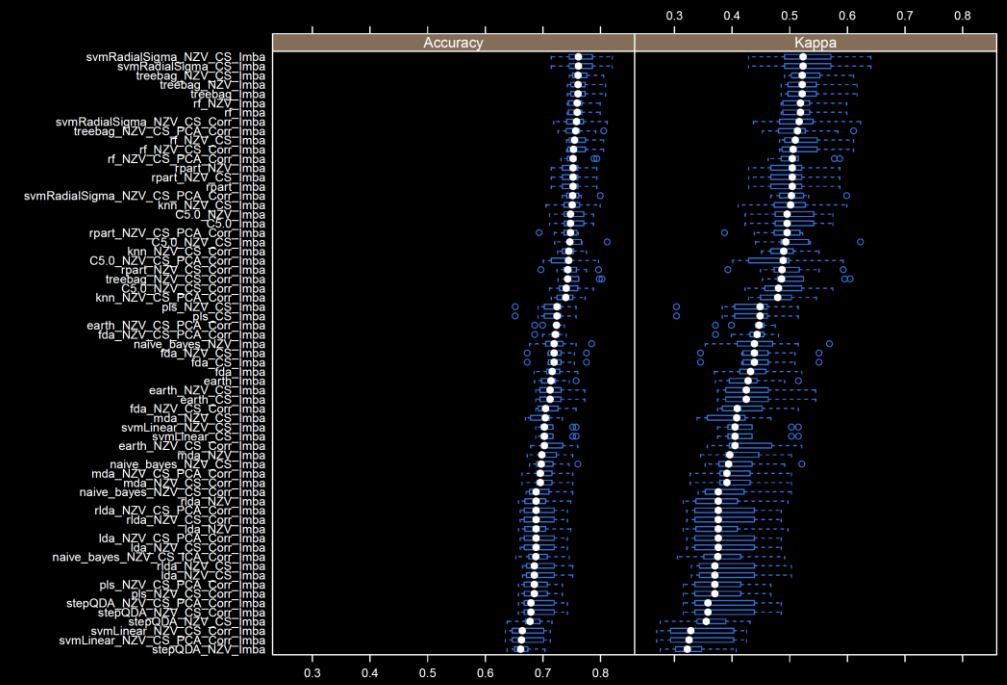

tmin1
tmin2
tmin3
tmin4
tmin5
tmin6
tmin7
tmin8
tmin9
tmin10
tmin11
tmin12
20
15
10
5
0

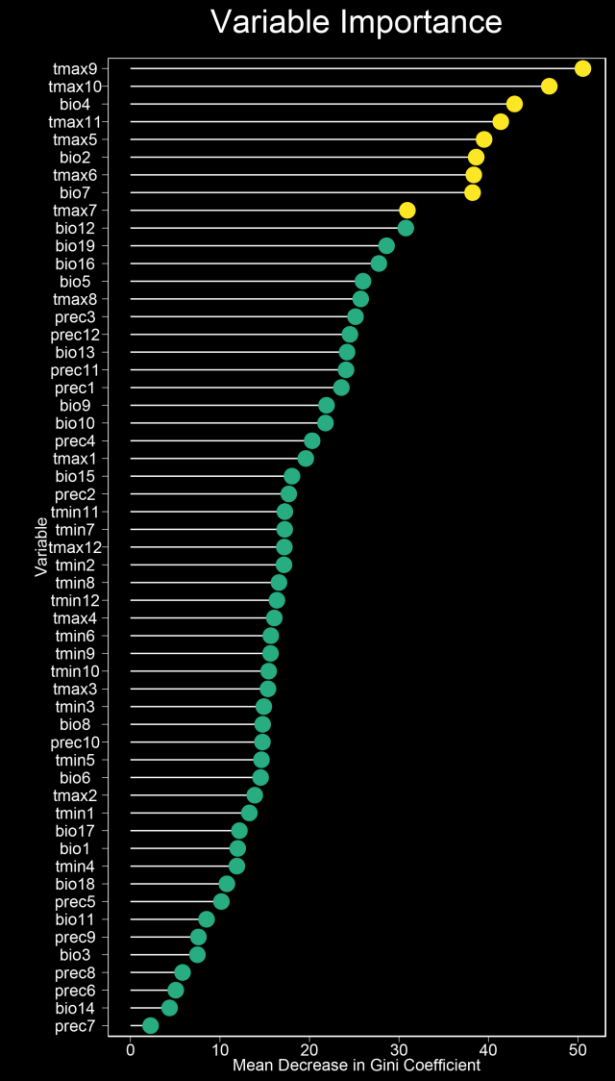

tmax1
tmax2
tmax3
tmax4
tmax5
tmax6
tmax7
tmax8
tmax9
tmax10
tmax11
tmax12
40
35
30
25
20
15
10


prec1
prec2
prec3
prec4
prec5
prec6
prec7
prec8
prec9
prec10
prec11
prec12
250
200
150
100
50
0

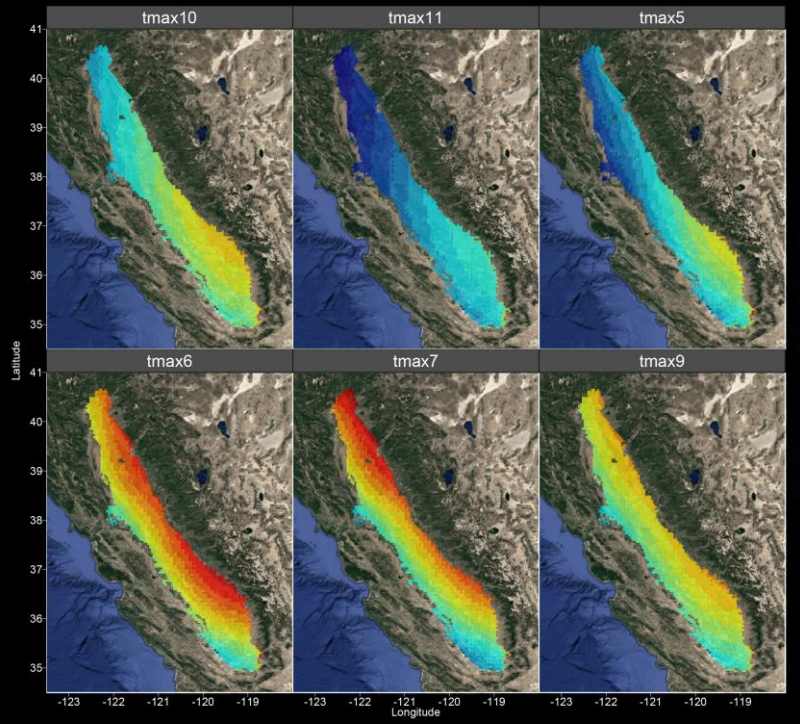

bio1
bio2
bio3
bio4
bio5
bio6
bio7
bio8
bio9
bio10
bio11
bio12

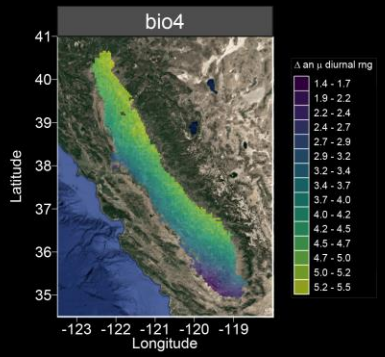

bio13
bio14
bio15
bio16
bio17
bio18
bio19
geo.1

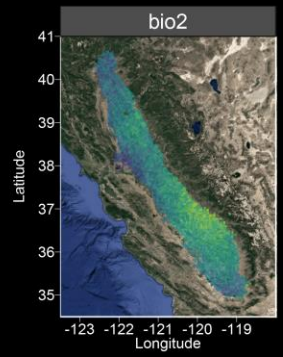

Accuracy
Kappa
0.3
0.4
0.5
0.6
0.7
0.8
svmRadialSigma_NZV_CS_Imba
svmRadialSigma_CS_Imba
treebag_NZV_CS_Imba
treebag_NZV_Imba
treebag_Imba
rf_NZV_Imba
rf_Imba
svmRadialSigma_NZV_CS_Corr_Imba
treebag_NZV_CS_PCA_Corr_Imba
rf_NZV_CS_Corr_Imba
rf_NZV_CS_Imba
rf_NZV_CS_PCA_Corr_Imba
rpart_NZV_Imba
rpart_NZV_CS_Imba
rpart_Imba
svmRadialSigma_NZV_CS_PCA_Corr_Imba
knn_NZV_CS_Imba
C5.0_NZV_Imba
C5.0_Imba
rpart_NZV_CS_PCA_Corr_Imba
C5.0_NZV_CS_Imba
knn_NZV_CS_Corr_Imba
C5.0_NZV_CS_PCA_Corr_Imba
rpart_NZV_CS_Corr_Imba
treebag_NZV_CS_Corr_Imba
C5.0_NZV_CS_Corr_Imba
knn_NZV_CS_PCA_Corr_Imba
pls_NZV_CS_Imba
pls_CS_Imba
earth_NZV_CS_PCA_Corr_Imba
fda_NZV_CS_PCA_Corr_Imba
naive_Bayes_NZV_Imba
fda_NZV_CS_Imba
fda_CS_Imba
fda_Imba
earth_Imba
earth_NZV_CS_Imba
earth_CS_Imba
fda_NZV_CS_Corr_Imba
mda_NZV_CS_Imba
svmLinear_NZV_CS_Imba
svmLinear_CS_Imba
earth_NZV_CS_Corr_Imba
mda_NZV_Imba
naive_bayes_NZV_CS_Imba
mda_NZV_CS_PCA_Corr_Imba
mda_NZV_CS_Corr_Imba
naive_bayes_NZV_CS_Corr_Imba
rda_NZV_Imba
rlda_NZV_CS_PCA_Corr_Imba
rlda_NZV_CS_Corr_Imba
lda_NZV_Imba
lda_NZV_CS_PCA_Corr_Imba
lda_NZV_CS_Corr_Imba
naive_bayes_NZV_CS_PCA_Corr_Imba
rda_NZV_CS_Imba
lda_NZV_CS_Imba
pls_NZV_CS_PCA_Corr_Imba
pls_NZV_CS_Corr_Imba
stepQDA_NZV_CS_PCA_Corr_Imba
stepQDA_NZV_CS_Corr_Imba
stepQDA_NZV_CS_Imba
svmLinear_NZV_CS_Corr_Imba
svmLinear_NZV_CS_PCA_Corr_Imba
stepQDA_NZV_Imba

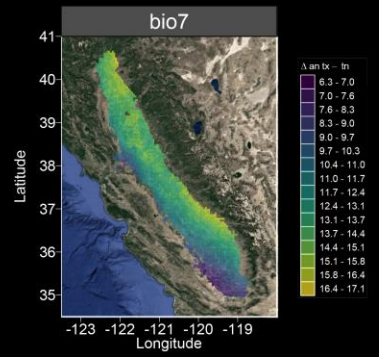


2070, RCP 4.5 (avg. of 19 models) - current

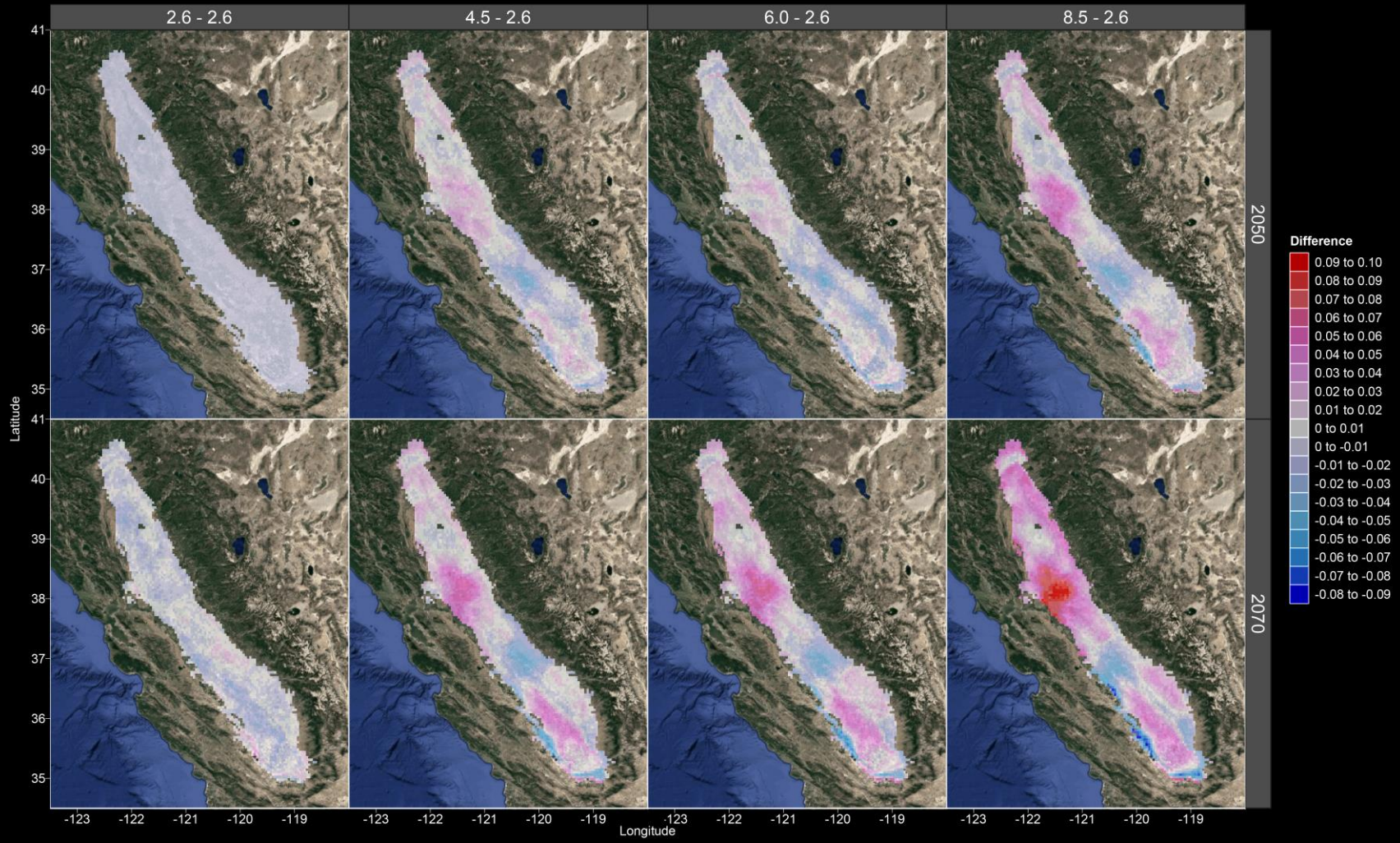








Difference in Domestic Well Failure Probability from 2050, RCP 2.6



TAKEAWAYS

> *climate change and drought threaten water security in the California and the Western US*

> *shallow domestic wells are more vulnernable than deep public and agricultural wells*

> *machine learning models suggest that [climate change induced] higher max temperatures and temperature range fluctuations intensify well failure*

FUTURE DIRECTIONS

> *investigate the socioeconomic and ethnic disparaties of domestic well failure*

> *web dashboard/mobile app: enter location, view probabilities of well failure & nearest water system*

> *inform sustainable groundwater management and policy*

ACKNOWLEDGMENTS

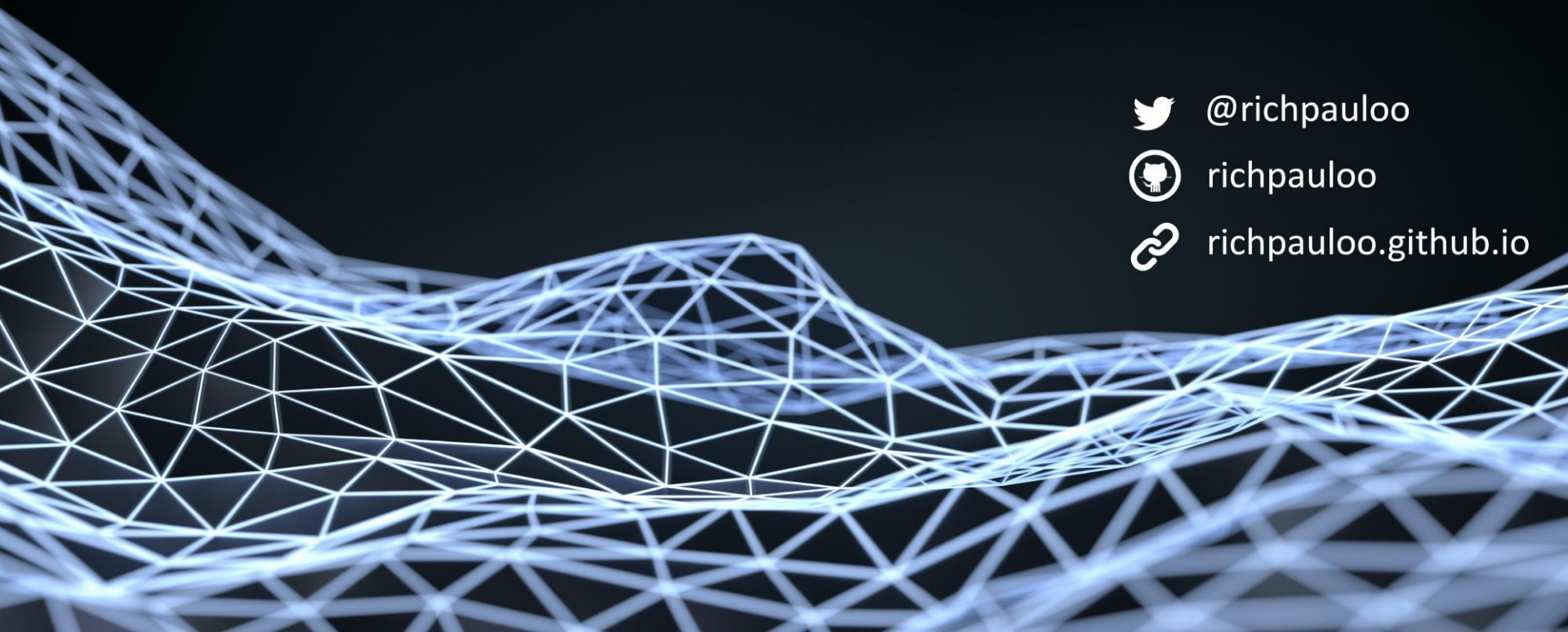
> *Alvar Escriva-Bou, Amanda Fencl, Hervé Guillon, Leo Qiu*

> *California Department of Water Resources*

> *West Big Data Hub*

> *NASA Hyperwall and AGU*

Thank You.



@richpauloo

richpauloo

richpauloo.github.io