Modeling Soil Moisture: Applying Machine-Learning to Help Utah Agriculture

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RESEARCH ON CAPITOL HILL

About Me

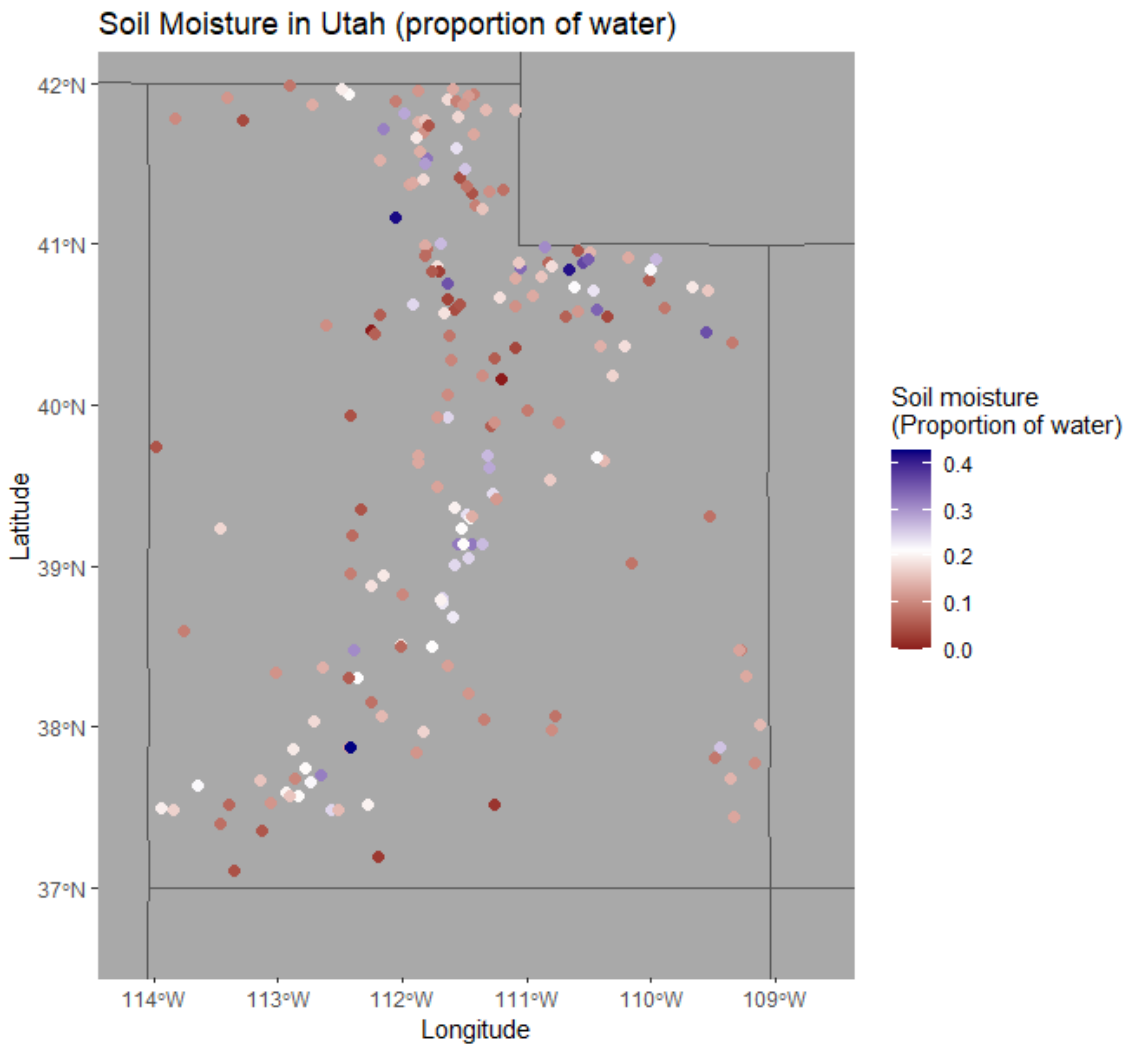
- Junior
- Mathematics and Statistics Department
- Peak Summer Research Fellow, Undergraduate Research and Creative Opportunities Grant recipient, Goldwater Scholar Nominee
- Hometown: South Jordan, UT
- Postgraduate Plans: PhD in Statistics with research in computational statistics methods

How I Got Started

- I felt like I was missing something when I was just taking classes. I reached out to all my professors in my second semester and asked what problems I could research
- I became interested in machine-learning for spatial data after hearing a pitch from my research mentor on this project and how difficult (i.e., fun) it would be!

My Project

- Rewrote and modified an existing machine-learning method to model complex spatial variables such as soil moisture and ground snow load in Utah
- The model uses known training data (shown on the right) and climate maps to predict in places where we haven't directly measured the spatial variable of interest



My Results

- Preliminary research developed a novel machine-learning method called "autocart“ (autocorrelative regression trees), a model specifically intended for spatial data that feature coordinate information in the training data
- This model will shortly be available in the official R repository

1. Train a regression tree with a modified objective function

$$g = (1 - \alpha - \beta)g_{rss} + \alpha g_{ac} + \beta g_{sc}$$

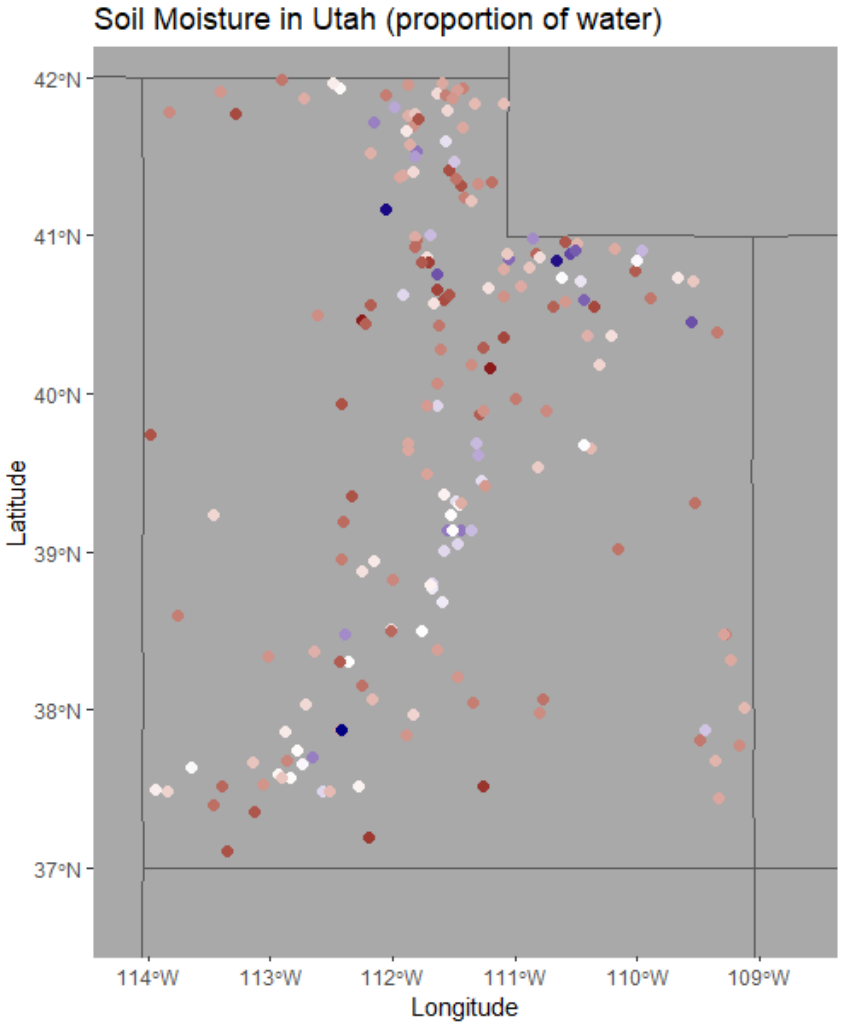
$\alpha, \beta \in [0,1]$ and $\alpha + \beta \leq 1$

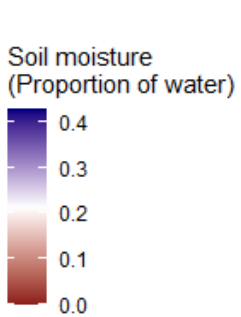
2. Make a prediction and supplement it with an interpolation of the residuals of the training observations that reside in the terminal node of the tree where the prediction occurs.

$$\hat{Y} = \bar{y}_T + u(\boldsymbol{s})$$

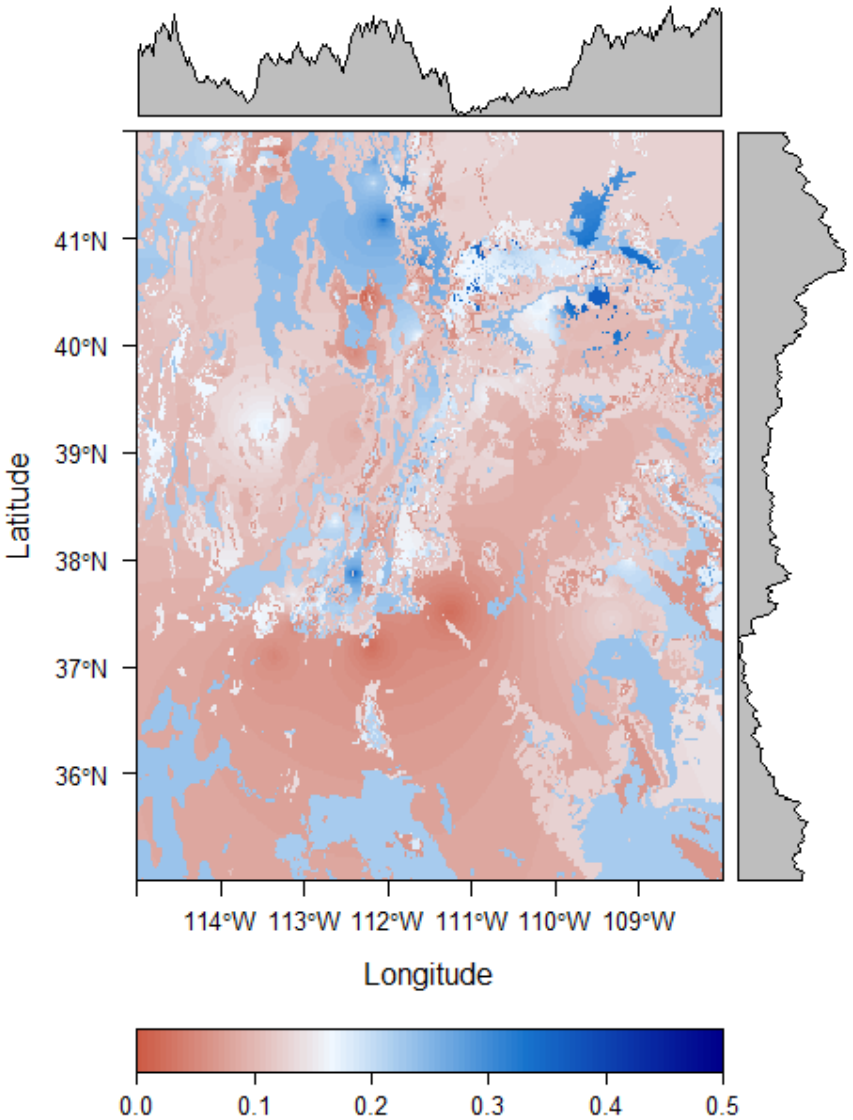
$\bar{y}_T$ is the original prediction made with the average response variable in the terminal node, and $u(\boldsymbol{s})$ is the interpolated residual.

Example of Mapping Results – Soil Moisture in Utah





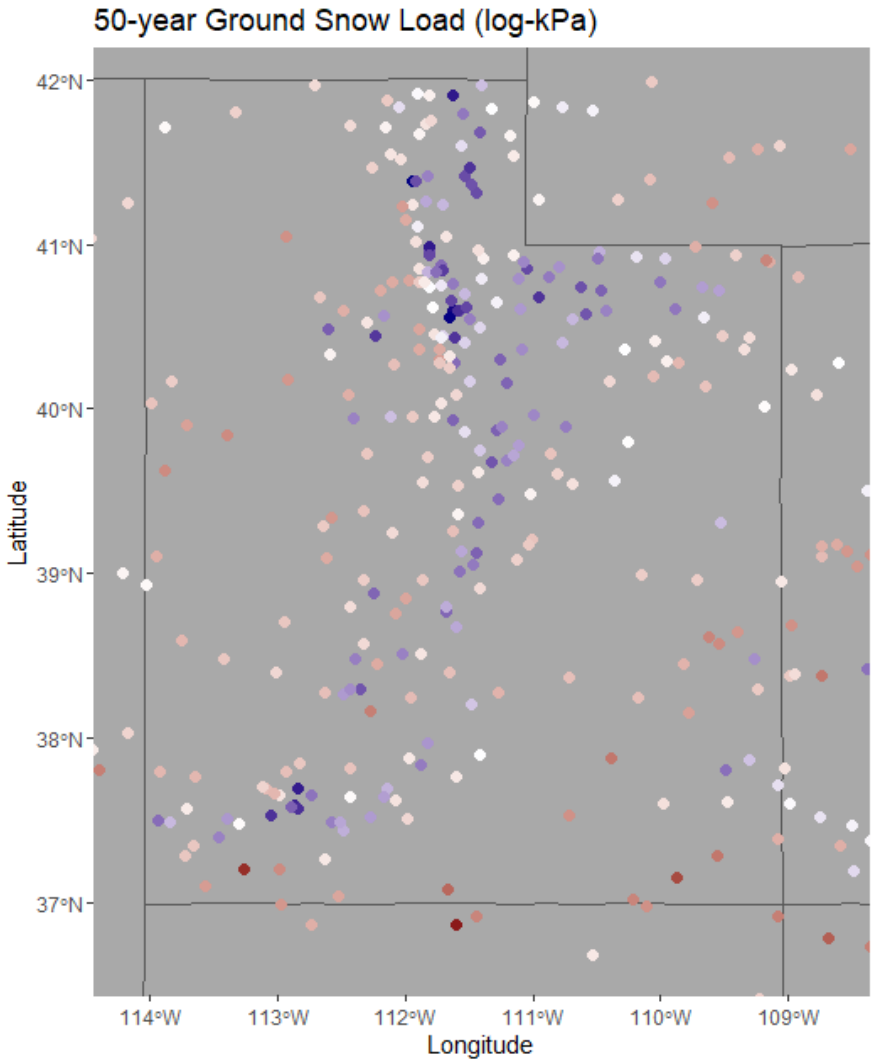
Autocart +
Climate data



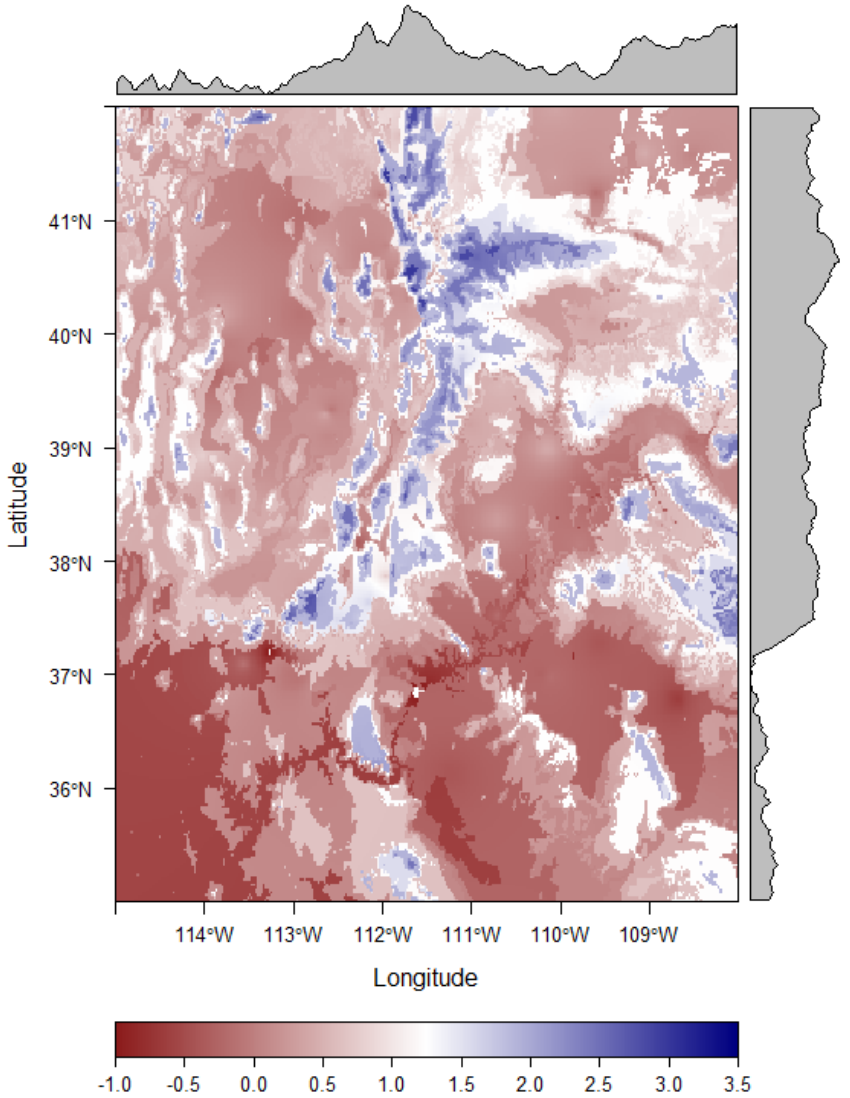
Original raw data

Predicted soil moisture (expressed as a proportion of the soil)

Examples of Mapping Results – 50-Year Utah Ground Snow Load (prediction of log-kPa)



Autocart +
Climate data



Original raw data

Predicted 50-year ground snow load (log-kPa)

Impact on Utah

- In the summer of 2021, I am being funded as a research assistant to help create high resolution forecast maps for soil moisture in Utah that will be updated daily. These maps will be interfaced to the public by the Utah Climate Center. Autocart is a strong candidate for these maps
- Knowledge of soil moisture is particularly important as droughts seem to be getting more severe in Western states and weather patterns are changing. Understanding the nature of these changes is crucial to our agricultural communities.

My Research Experience

- My research experience has been invaluable as I prepare to apply to competitive PhD programs.
- I love working with extremely difficult statistical problems that may or may not have a solution. It is much more exciting to me than working through textbook problems where known solutions exist!