Applying Multiple Linear Regression to the Timing of Spring Migration in Hummingbirds

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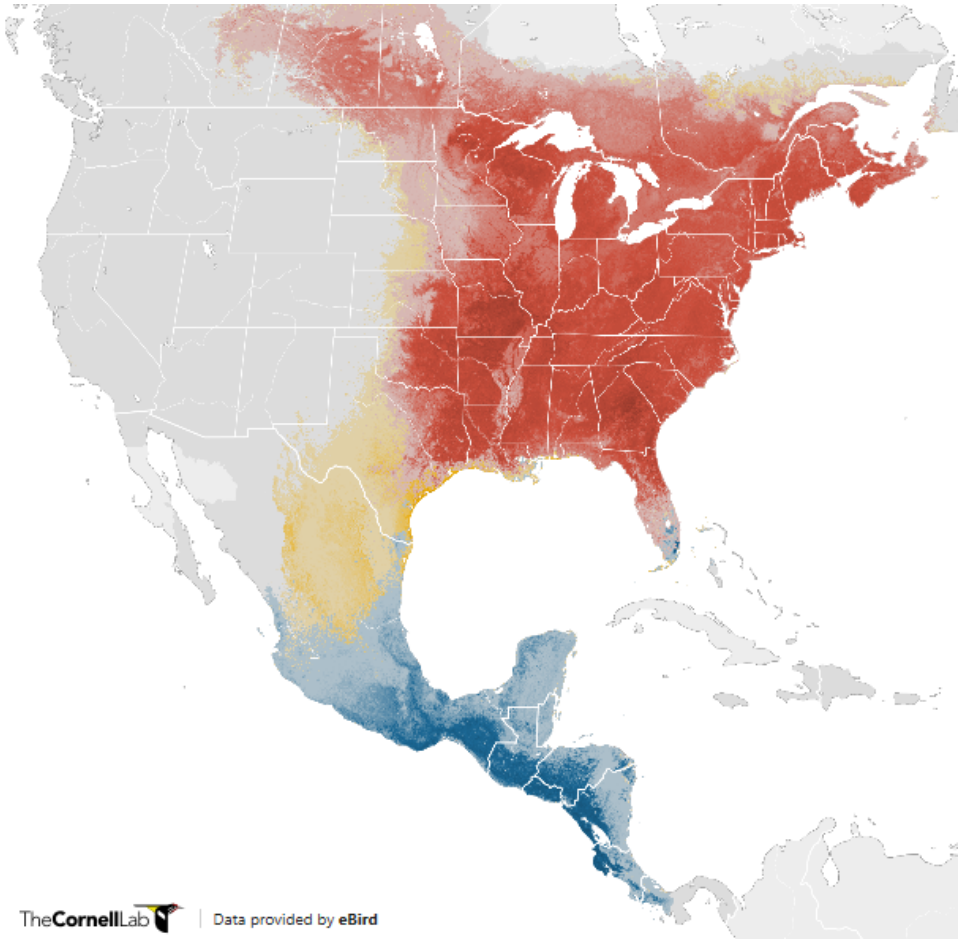
Overview

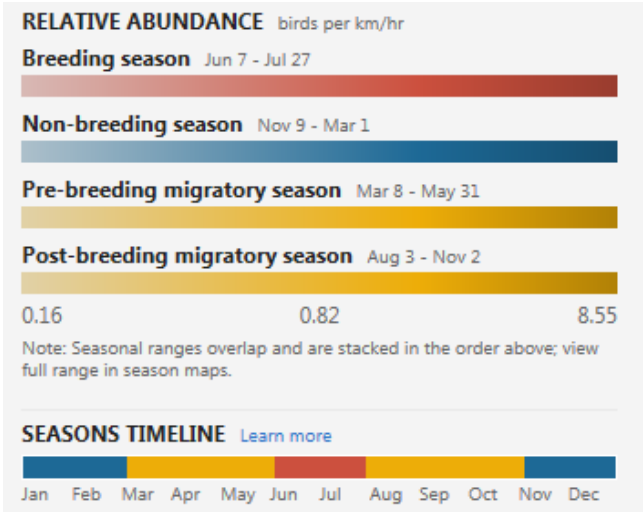
Purpose of this Research

What external cues do hummingbirds use to determine the timing of their spring migration?

Can we create a model that uses external cues to predict arrival date in a given location?

The Ruby-throated Hummingbird





Simple Regression

- Population regression line

$$Y_i = \beta_0 + \beta_1 X_i + \epsilon_i$$

- The least squares regression

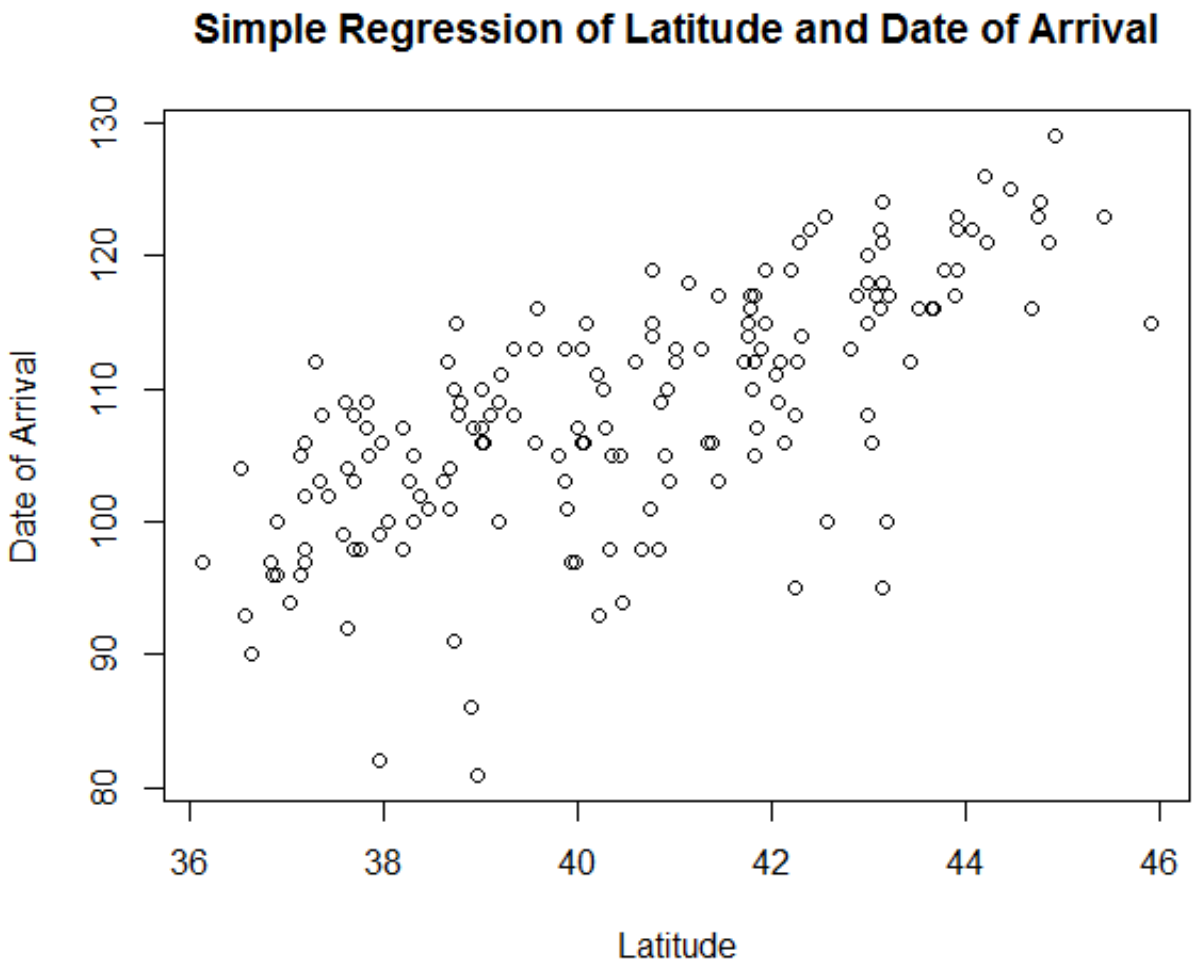
$$\hat{Y}_i = b_0 + b_1 X_i$$

estimates the population regression line

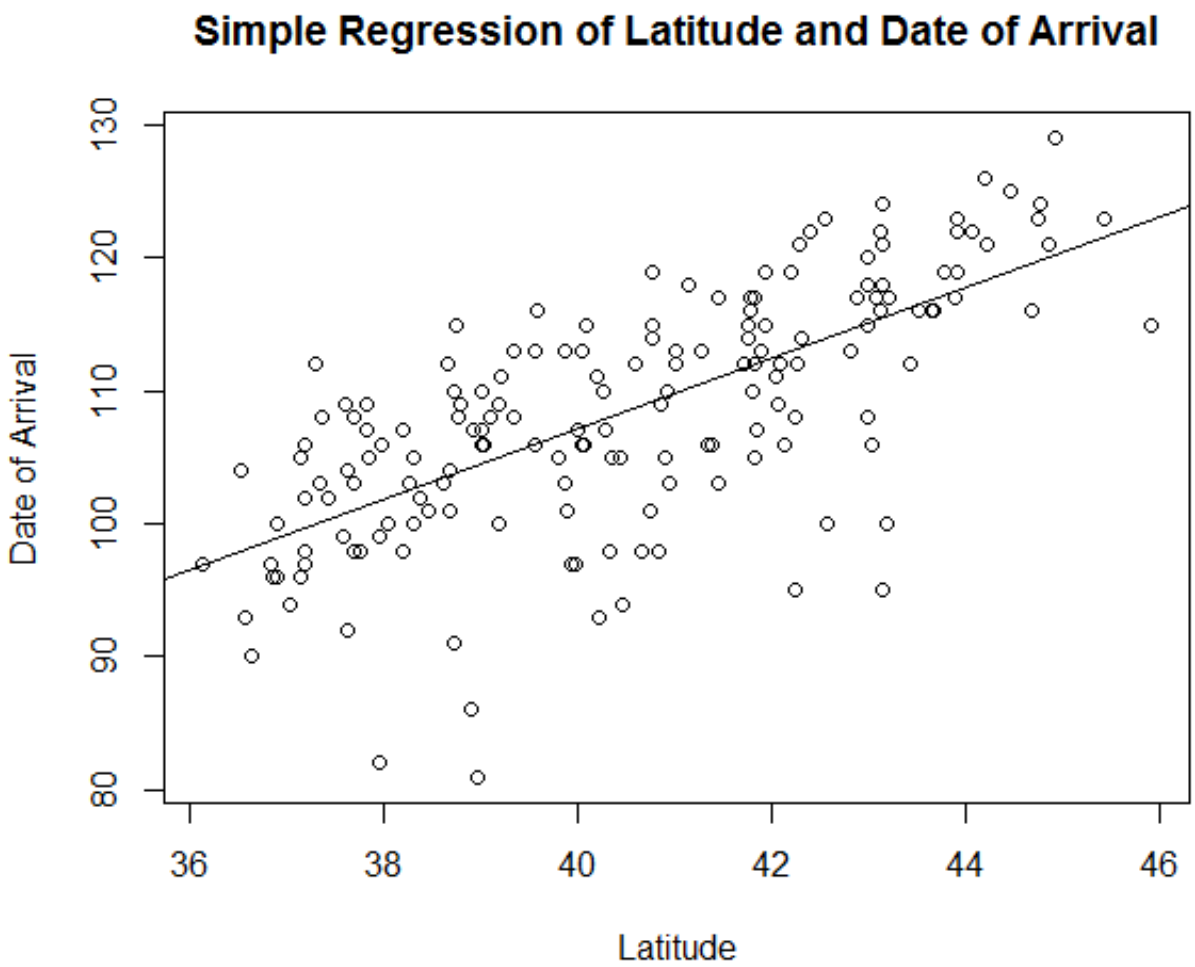
- Minimizes

$$MSE = \frac{1}{N} \sum_i \left(Y_i - \hat{Y}_i \right)^2$$

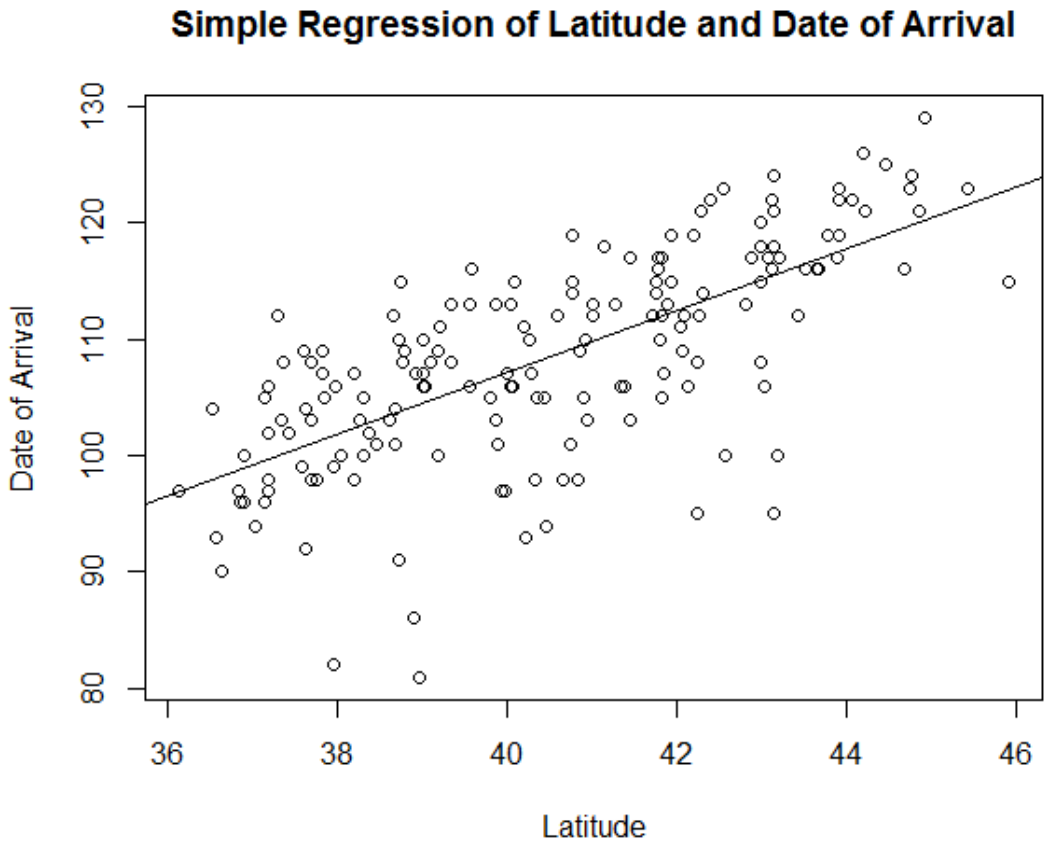
Simple Regression Example



Simple Regression Example



Simple Regression Example



$$\hat{Y}_i = 0.84 + 2.66X_i$$

$$R^2 = 0.476$$

Multiple Regression

- Population regression line

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} + \epsilon_i,$$

- The least squares regression

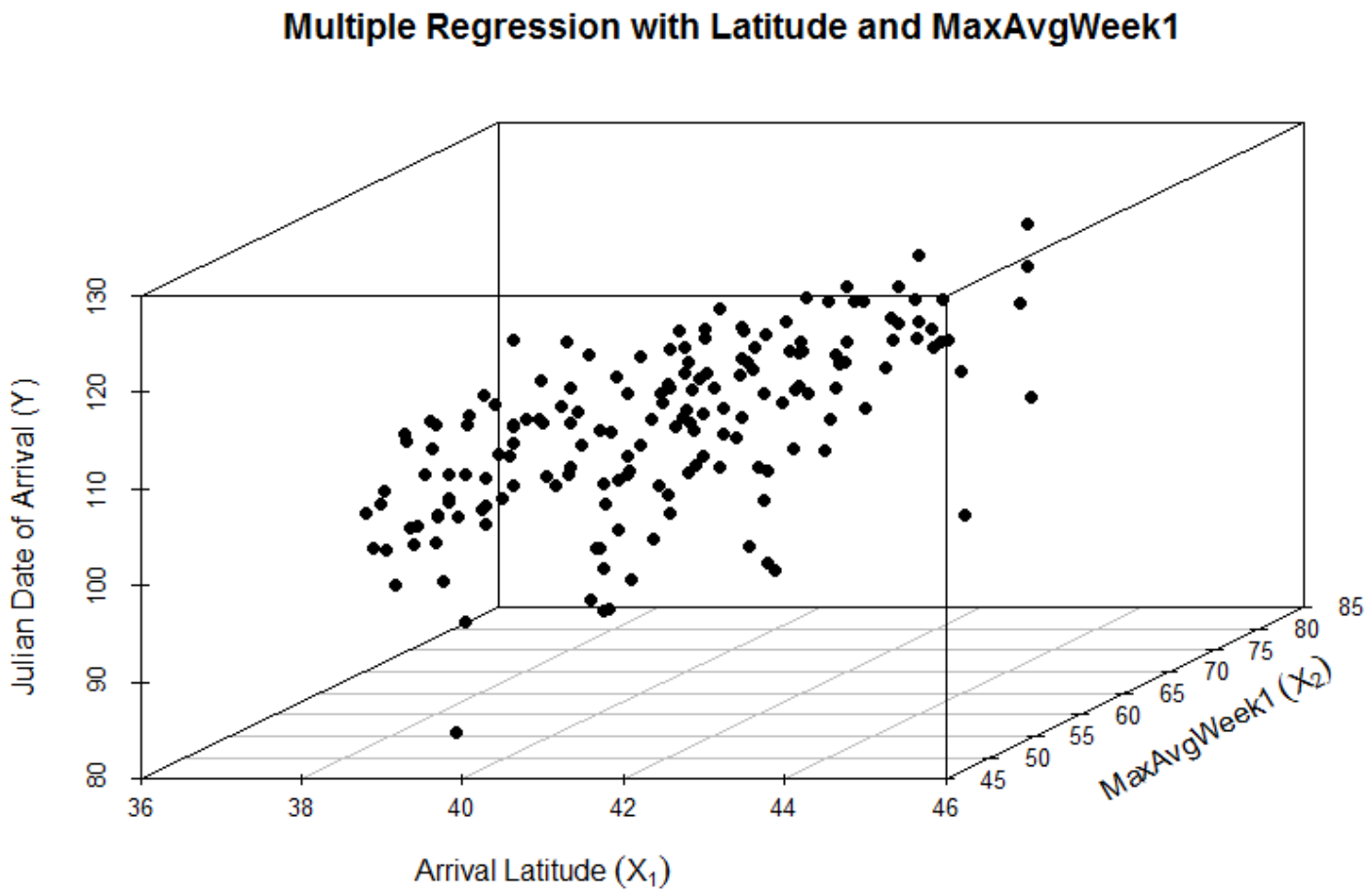
$$\hat{Y}_i = b_0 + b_1 X_{i1} + b_2 X_{i2} + \cdots + b_p X_{ip}$$

  estimates the population regression line

- Minimizes

$$MSE = \frac{1}{N} \sum_i \left(Y_i - \hat{Y}_i \right)^2$$

Multiple Regression Example



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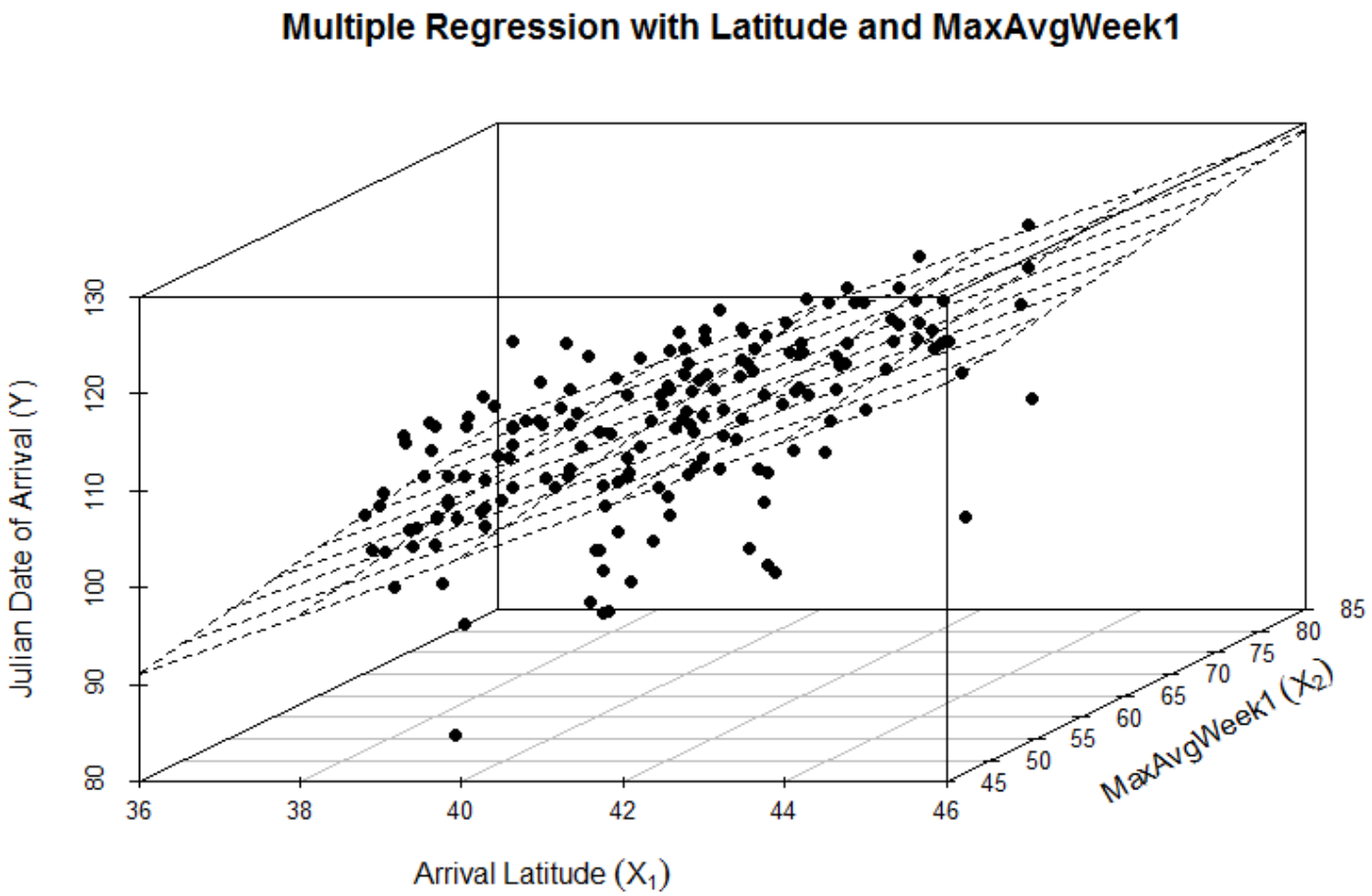

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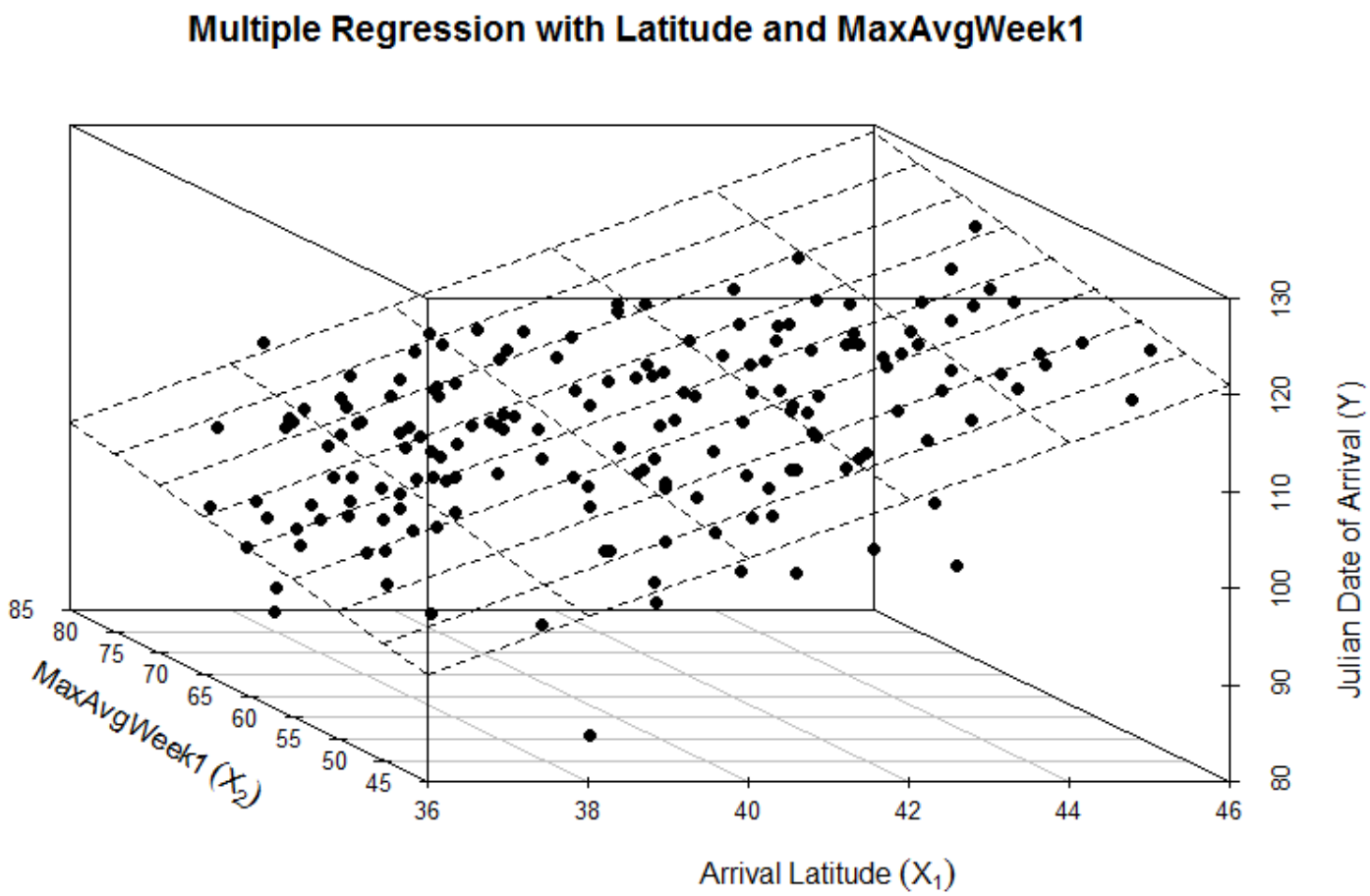
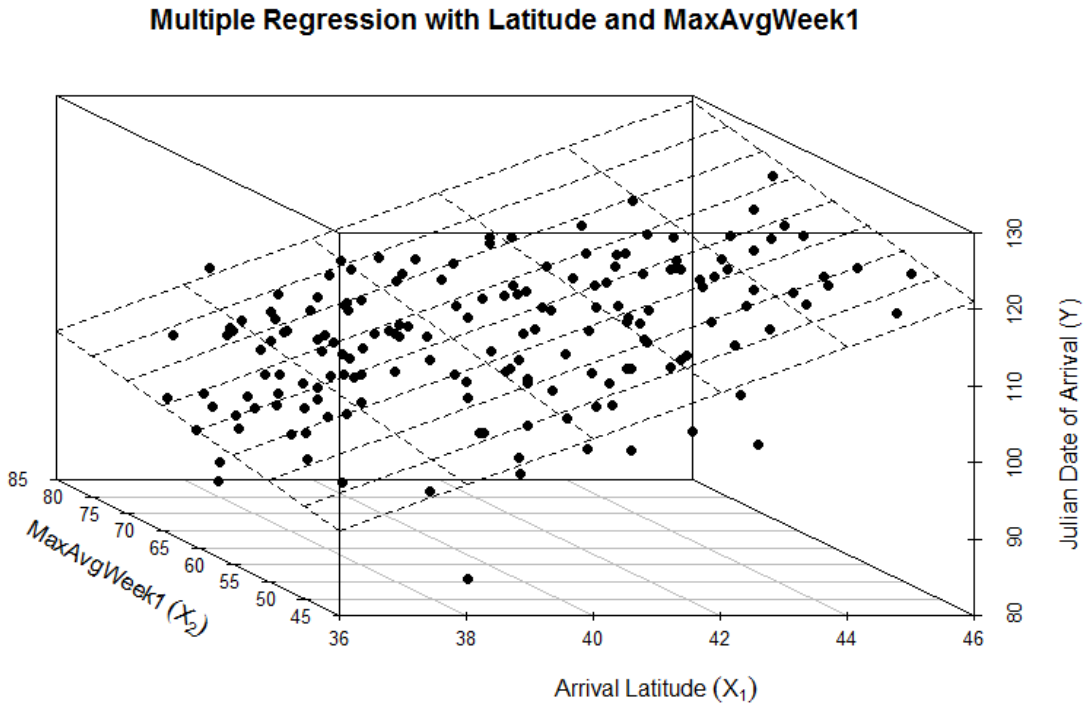


Multiple Regression Example



$$\hat{Y}_i = -25.84 + 2.99X_{i1} + 0.21X_{i2}$$

$$R^2 = 0.495 \qquad R^2_{\text{adjusted}} = 0.489$$

How do you create a model?

- Many different methods
- Stepwise Regression
  - Adding and removing variables based on if they significantly contribute to the model

The Model

$$\hat{Y}_i = -41.39 + 3.17X_{i1} + 0.32X_{i2} + 0.14X_{i3}$$

where

X_{i1} = Arrival Latitude

X_{i2} = Average Minimum Temperature in the Week before Arrival Week

X_{i3} = Average Maximum Temperature in Arrival Week

The Model

$$\hat{Y}_i = -41.39 + 3.17X_{i1} + 0.32X_{i2} + 0.14X_{i3}$$

where

X_{i1} = Arrival Latitude

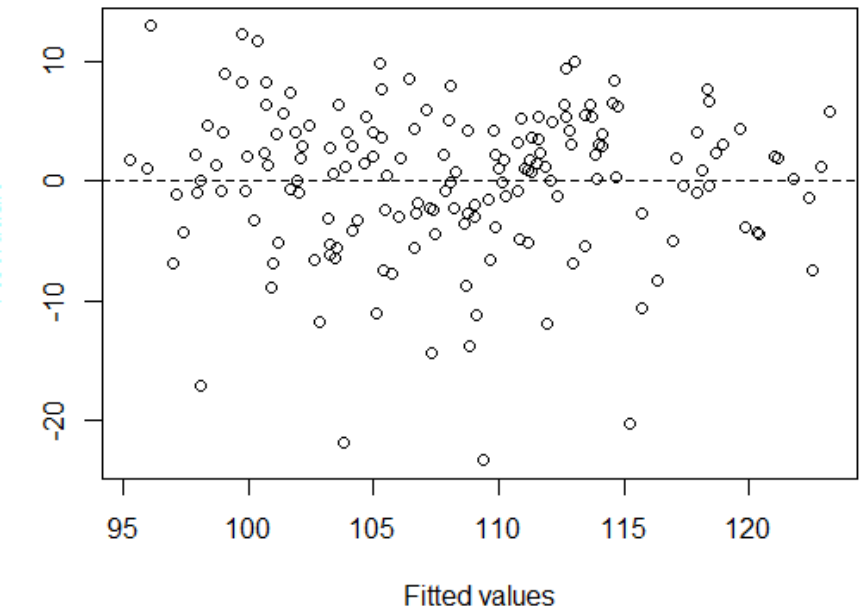
X_{i2} = Average Minimum Temperature in the Week before Arrival Week

X_{i3} = Average Maximum Temperature in Arrival Week

$$R^2 = 0.542 \qquad R^2_{\text{adjusted}} = 0.534$$

Assumptions of Multiple Regression

1. The errors, ϵ_i, are independent.
2. The errors, ϵ_i are normally distributed.
3. The errors, ϵ_i have equal variances.



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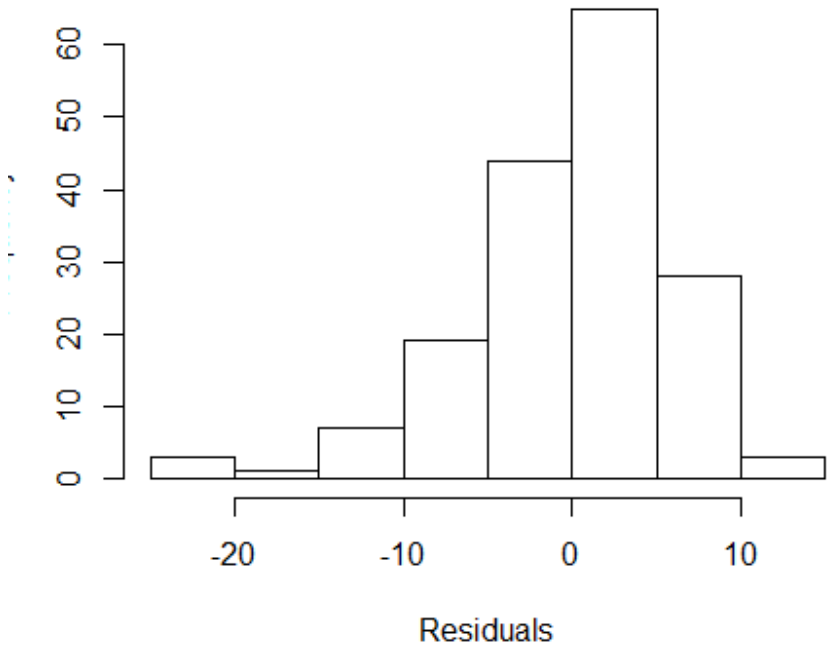

Future Research Directions

- Data transformations
- Build multiple models using different methods and compare them
- Add variable(s) for conditions in Central America

Sampling of Sources

- eBird. 2012. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Available: http://www.ebird.org. (Accessed: Mar. 2018).
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- Myers, J. L., and A. D. Well. 2003. Research Design and Statistical Analysis.Mahwah (NJ): Lawrence Erlbaum Associates
- The Penn State University. 2018. STAT 501 Online Course: Regression Methods.
- Wherry, R. J. 1931. "A new formula for predicting the shrinkage of the coefficient of multiple correlation." *The annals of mathematical statistics 2*(4), 440-457.

Thank You!