# STOR 320 Modeling II

Lecture 16

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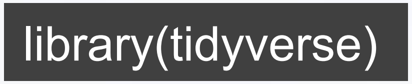
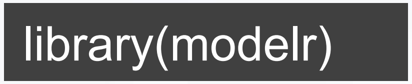
# Tutorial 10

- Instructions
  - Download Tutorial Zip
  - Unzip Folder
  - Required Packages
    - 

      ```
      library(tidyverse)
      ```
    - 

      ```
      library(modelr)
      ```
  - Open .Rmd File and Knit

- Daily Spanish River Data
  - W = Max Water Temperature
  - A = Max Air Temperature
  - L = River Identifier (31 Rivers)

# Introduction

- Questions About RMarkdown
  - What Does the Following Code Do When Knitted?

    ```
    `r length(unique(DATA$L))`
    ```

  - What Does the following Code Chunk Option Do When Knitted?

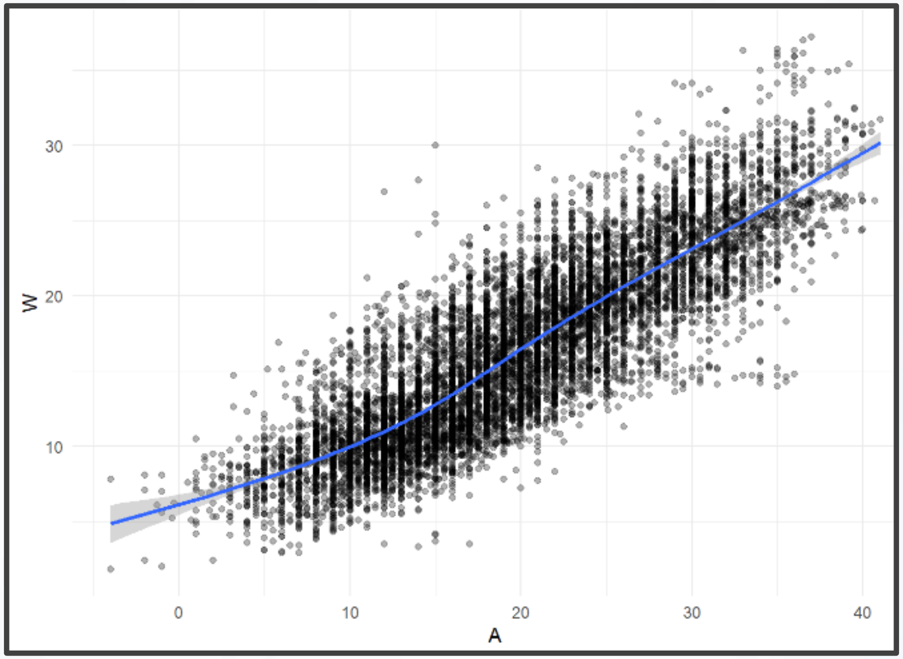
    ```
    echo=F
    ```

# Introduction

- Goal: Build a Model to Predict Max Water Temp Given Max Air Temp
  - What Do You Know About the Relationship of These Variables?
  - Who Would Care About this Relationship?
  - Why Would Someone Want to Predict the Max Water Temp?
  - Why Would this Model Be Useful?

# Part 1: Examining the Relationship

- Run Chunk 1
  - What Do You Notice About the Overall Relationship?

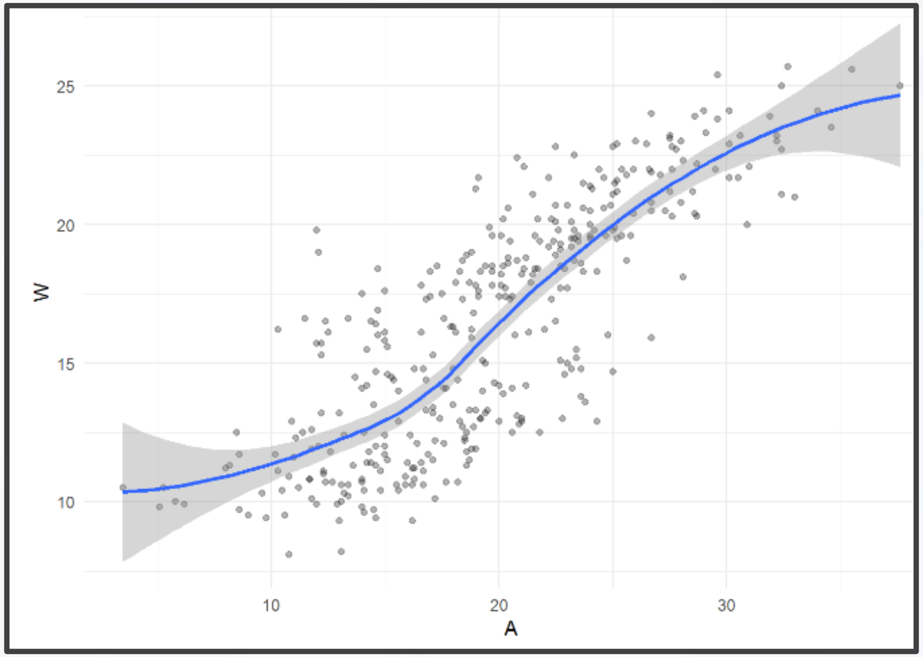


  - Do You Think This Relationship is the Same for All Locations?
  - Why?

message=F

# Part 1: Examining the Relationship

- Run Chunk 2
  - Location is a Numeric Variable
  - What Do You Notice About the Relationship for L==103?



  - What do You Notice Now?

# Part 1: Examining the Relationship

- Chunk 2 Modified
  - Modify Chunk 2 to Create a Function Called WAPlot.func With 1 Argument Location
  - Function Usage: You Specify the Location as an Integer and the Function Outputs a Figure of the Relationship
  - Use Your Function For Three Different Locations
  - Knit the Document to Observe and Compare

# Part 1: Examining the Relationship

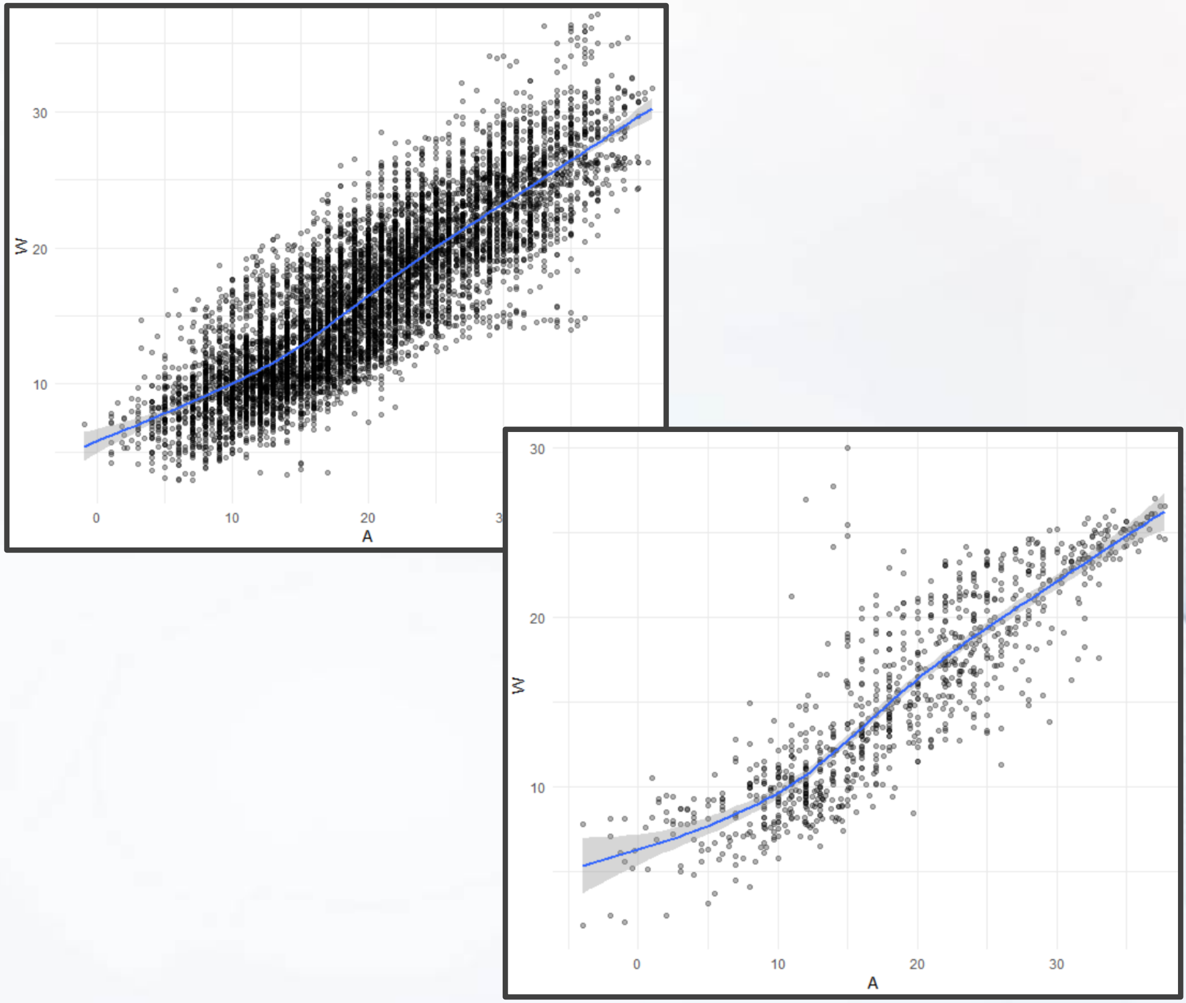
- Chunk 2 Discussion
  - What are the Differences in the Relationship Between W and A for the Various Locations?
  - Why do You Think These Differences Exist?
  - How do You Suggest We Handle the Differences?

# Part 1: Examining the Relationship

- Chunk 3
  - Randomly Samples 3 Locations
  - Plant Your Seed and Run Code
  - Usage:
    - anti_join()
    - semi_join()
  - Why Don't We Handpick the Three Locations?

# Part 1: Examining the Relationship

- Run Chunk 4
  - Train Plot
  - Test Plot



# Part 2: Linear Model

- Linear Model

  - Simplest Relationship that is Easily Explained

  - For every 1 Degree Change in A, W changes by *b* Degrees

  - When A=0 Degrees, the Expected Water Temperature is *a* Degrees

# Part 2: Linear Model

- Run Chunk 1
    - Fits Linear Model to Train Data
    - What is Your Intercept?
    - What is Your Slope?

- Run Chunk 2
    - Saves Predictions to Train/Test

```
add_predictions(MODEL,var=“NAME”)
```

- Run Chunk 3
    - Saves Residuals to Train/Test

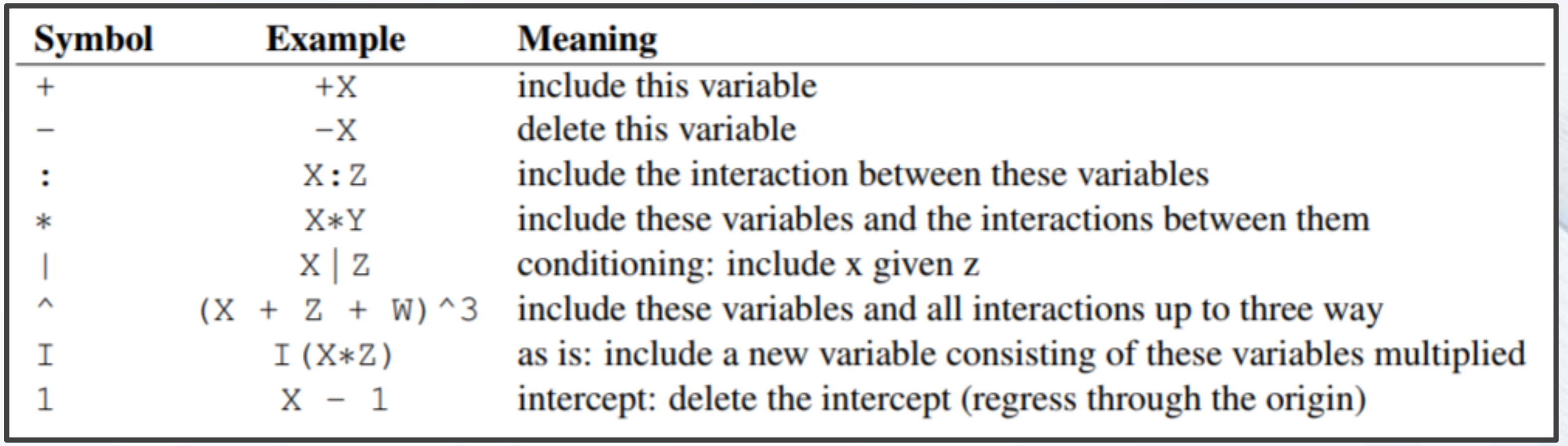
```
add_residuals(MODEL,var=“NAME”)
```

# Part 3: Polynomial Model

- Polynomial Model
  - “Feature Engineering”
  - Generalized Additive Model
  - Geom_smooth() Fits a GAM when Fitting a Curve
  - Useful for Approximating Nonlinear Relationships
  - Dependent on Degree “k”
  - Goal: Choose Best “k”

# Part 3: Polynomial Model

- Formula Object in R
  - Special Notation
  - Helpful Table:



| Symbol | Example | Meaning |
|---|---|---|
| + | +X | include this variable |
| − | −X | delete this variable |
| : | X:Z | include the interaction between these variables |
| * | X*Y | include these variables and the interactions between them |
| \| | X\|Z | conditioning: include x given z |
| ^ | (X + Z + W)^3 | include these variables and all interactions up to three way |
| I | I(X*Z) | as is: include a new variable consisting of these variables multiplied |
| 1 | X - 1 | intercept: delete the intercept (regress through the origin) |

  - We will Use the I() Function to Create New Variables Based Off Variables We Have

# Part 3: Polynomial Model

- Run Chunk 1

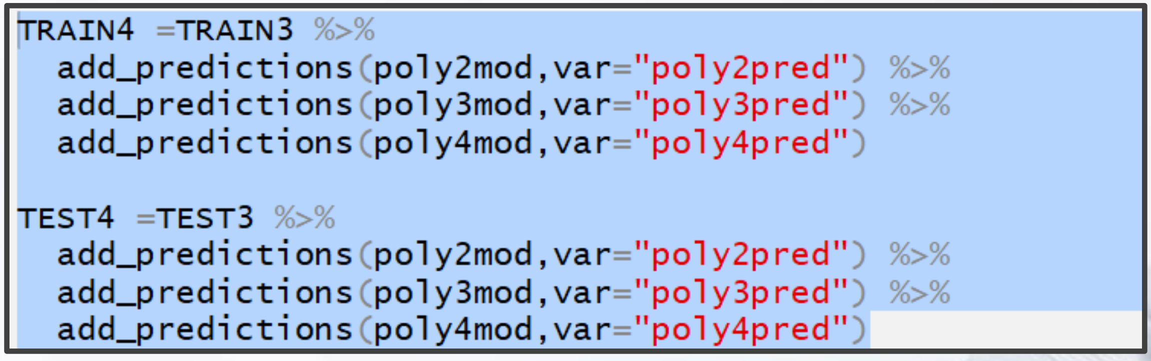
  - Fits 2nd Degree Polynomial
  - Fits 3rd Degree Polynomial
  - Fits 4th Degree Polynomial

- Run Chunk 2

  - Obtains Predictions Under the Different Polynomial Models

# Part 3: Polynomial Model

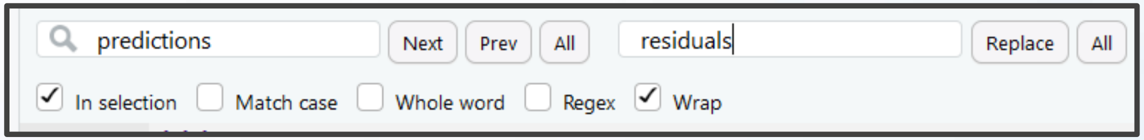
- Chunk 3
  - Code Needs Modification
  - Highlight Code



```
TRAIN4 =TRAIN3 %>%
  add_predictions(poly2mod,var="poly2pred") %>%
  add_predictions(poly3mod,var="poly3pred") %>%
  add_predictions(poly4mod,var="poly4pred")

TEST4 =TEST3 %>%
  add_predictions(poly2mod,var="poly2pred") %>%
  add_predictions(poly3mod,var="poly3pred") %>%
  add_predictions(poly4mod,var="poly4pred")
```

  - TRAIN3 -> TRAIN4 and etc.
  - Use Ctrl+F (Find and Replace)
    - ‘predictions’ -> ‘residuals’
    - ‘pred’ -> ‘res’



predictions

residuals

☑ In selection ☐ Match case ☐ Whole word ☐ Regex ☑ Wrap

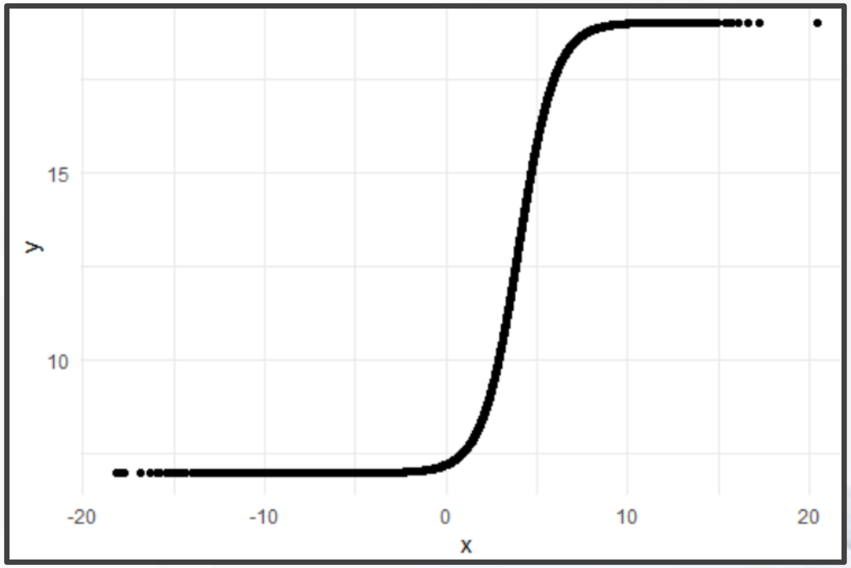
  - Run Chunk 3 After Modifying

# Part 4: Logistic Model

- Logistic Model
  - "Smart" Model Based On Physical Relationship Between A and W
  - Four Parameters
    - Controls the Shape of the Relationship
    - $a$ and $b$
    - $c$ and $d$
  - What Shape Do You Think This Function Makes?
    - Idea: Precalculus

# Part 4: Logistic Model

- Run Chunk 1
  - Plant that Seed
  - Example Model



  - Parameter Investigation
    - What Does 7 Represent?
    - What Does 12 Represent?
    - What Does 4 Represent?
    - What Does 1 Represent?

# Part 4: Logistic Model

- Run Chunk 2
  - Creation of Modeling Function
  - Creation of MSE Function Specific to this Model
- Run Chunk 3
  - Use optim() Function With Smart Starting Values Based on Understanding of The Model
  - Finds Estimates Based on Minimization of MSE

# Part 4: Logistic Model

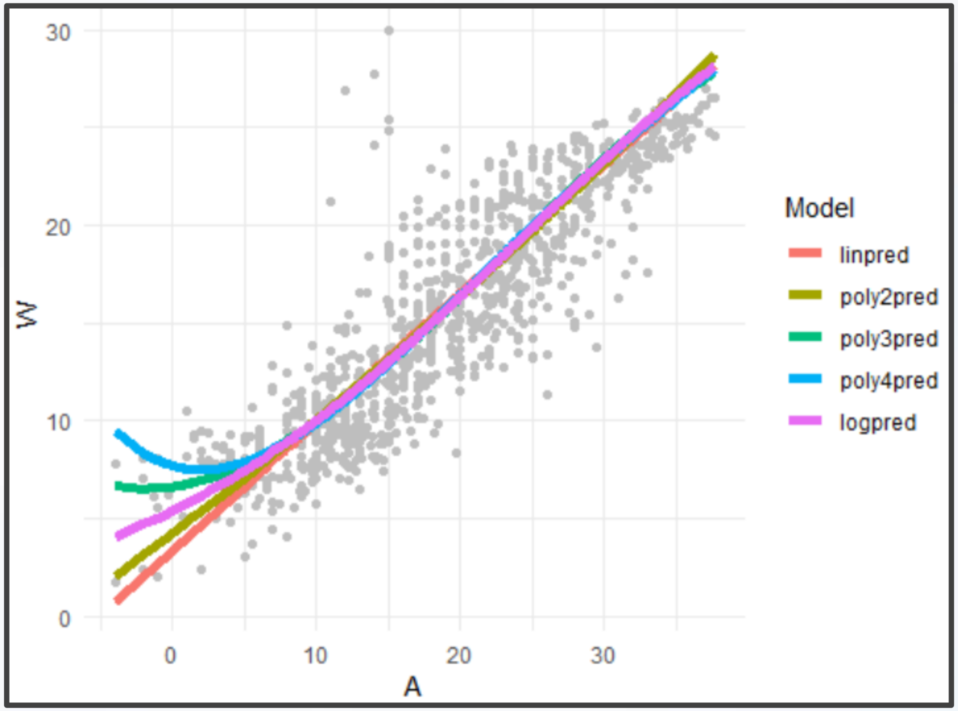
- Run Chunk 4
  - Use Logistic Model Function and Estimated Parameters from optim() to Obtain
    - Predictions
    - Residuals

# Intermission

- Run Code Chunk
  - save.image() = Used to Save Workspace into .Rdata File
  - load() = Used to Load Workspace from .Rdata File
  - .Rdata = File Extension of R Workspace File (All Objects in Global Environment)

# Part 5: Evaluation by Visualization

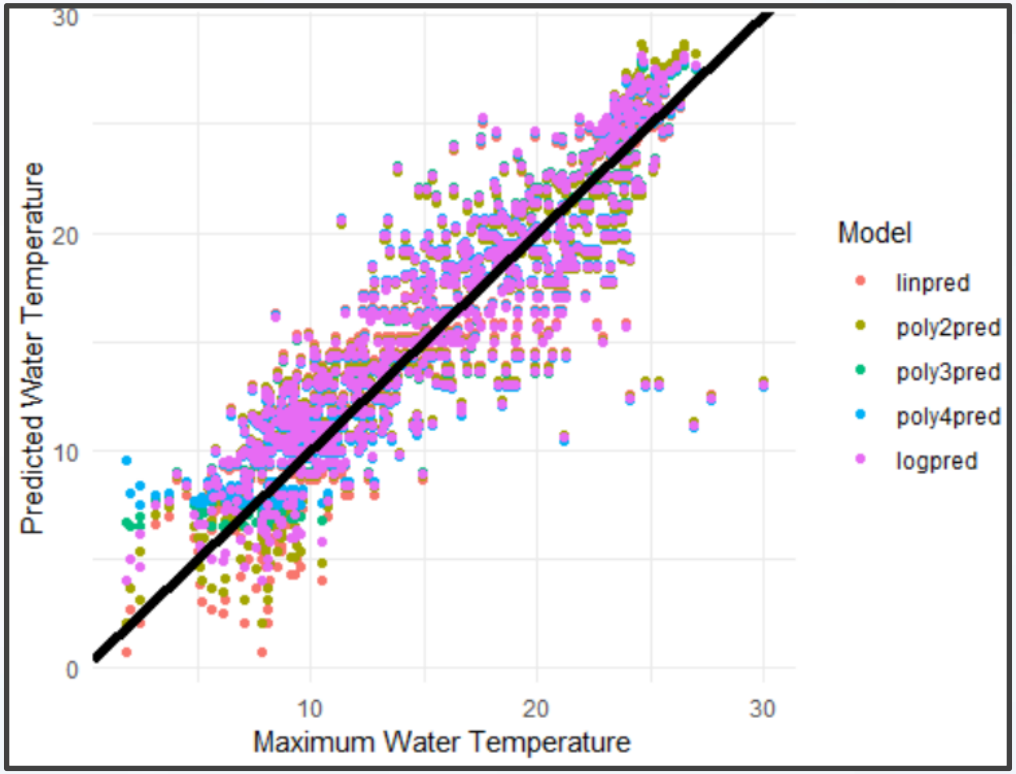
- Run Chunk 1
  - Plots of Different Models
  - What Can We Say About the Different Models?



  - Which Model Would You Use?

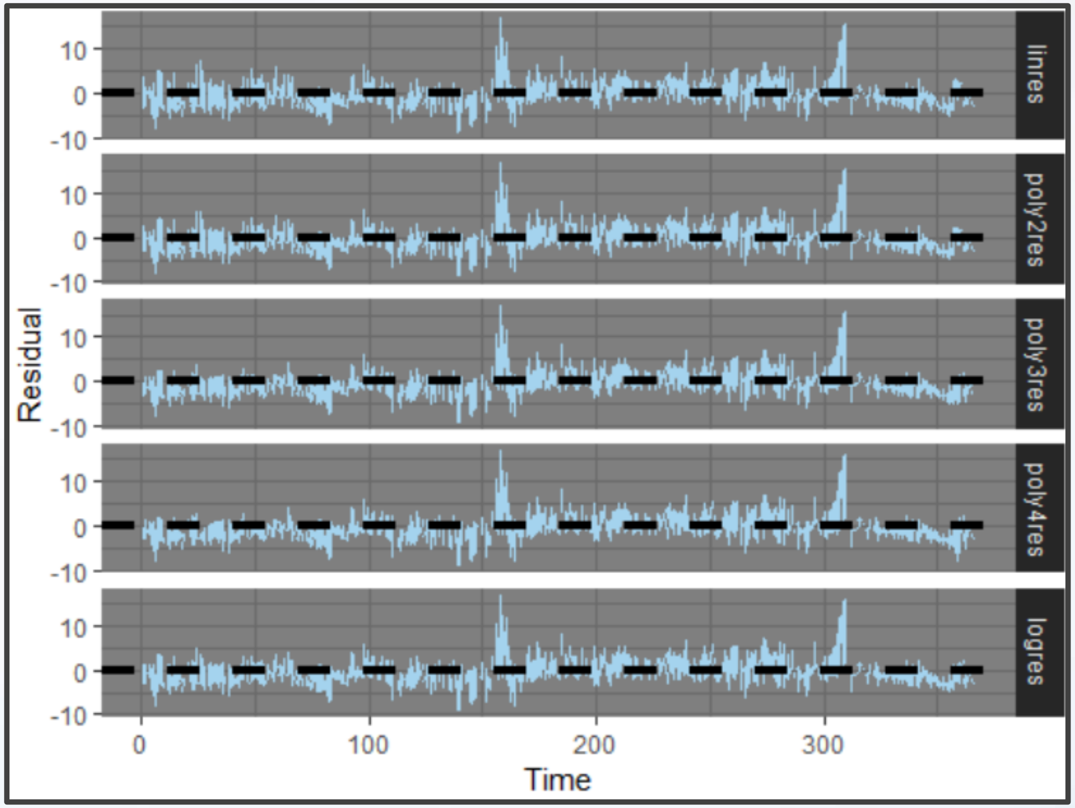
# Part 5: Evaluation by Visualization

- Run Chunk 2
  - Comparing Predictions vs Actual Maximum Water Temperatures
  - Models Give Similar Predictions



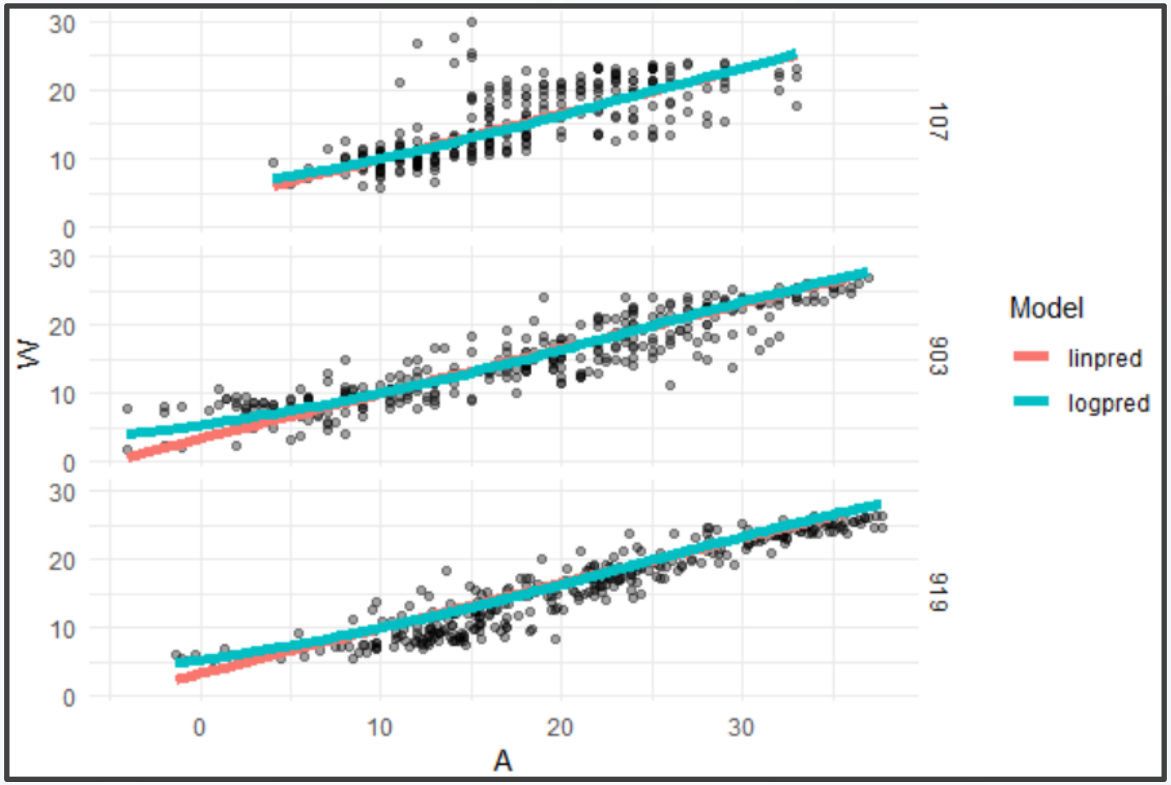
# Part 5: Evaluation by Visualization

- Run Chunk 3
  - Shows Residuals Under the 4 Models Plotted Over Time
  - What is the Problem?



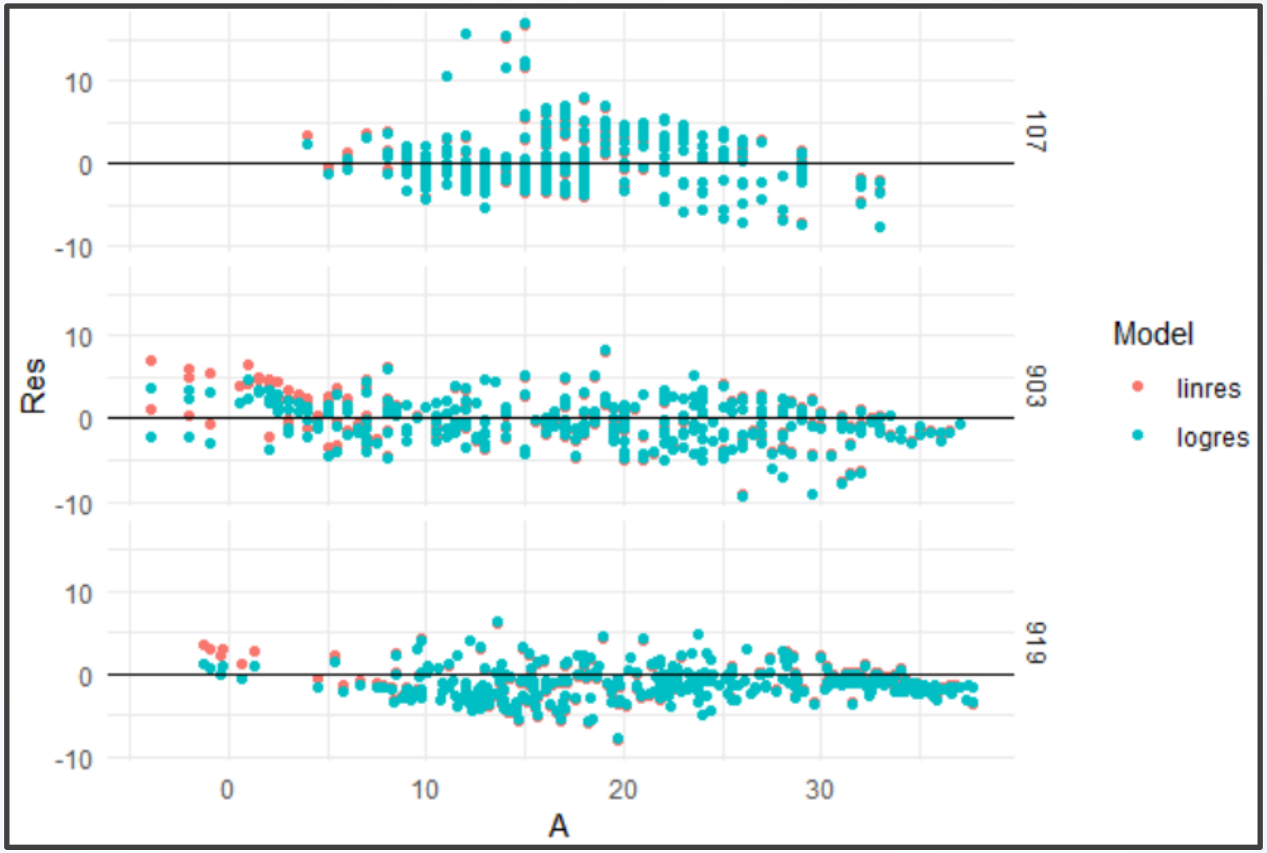
# Part 5: Evaluation by Visualization

- Run Chunk 4
    - Evaluate Models For the Three Locations Separately



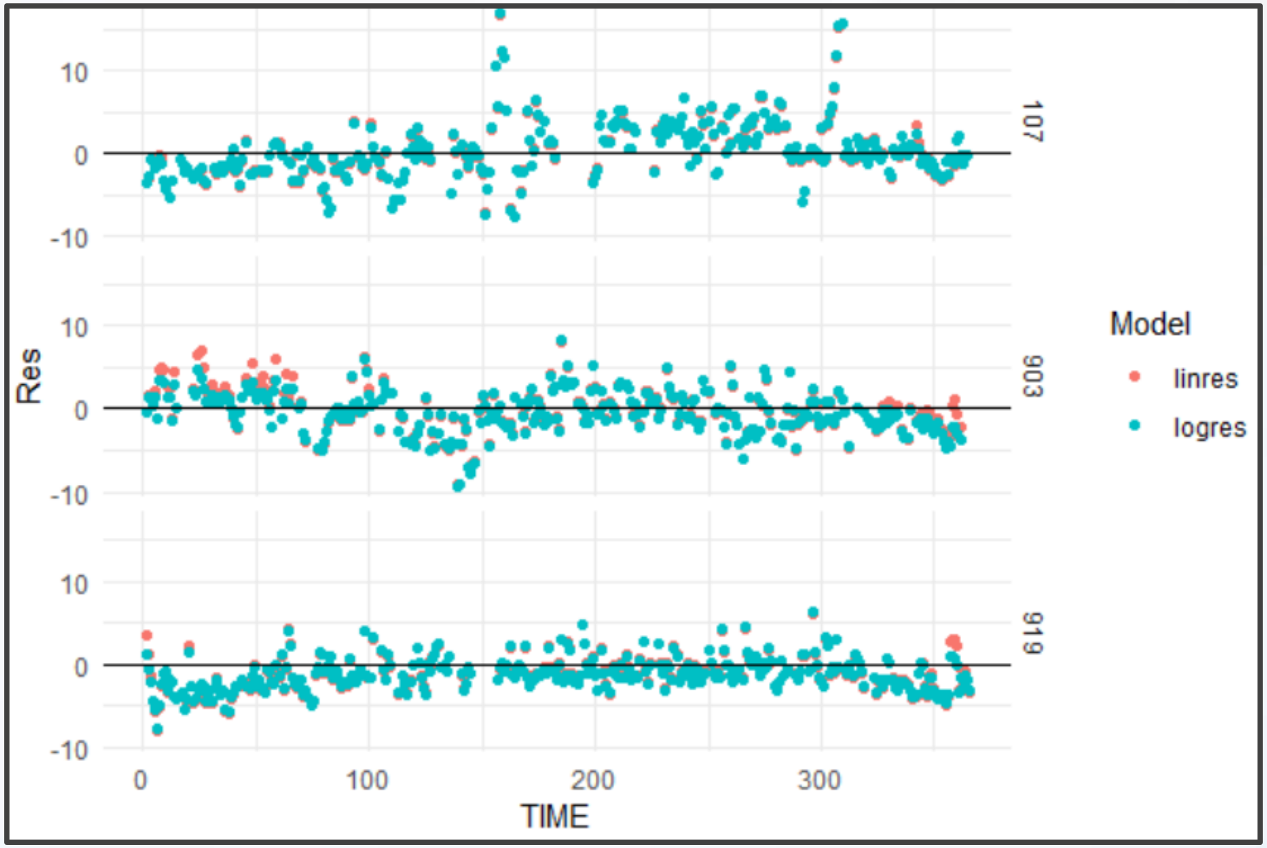
# Part 5: Evaluation by Visualization

- Run Chunk 5
  - Evaluate Error For the Three Locations Separately (by A)



# Part 5: Evaluation by Visualization

- Run Chunk 6
  - Evaluate Error For the Three Locations Separately (by Time)



# Part 6: Evaluation by Numerical Summary

- Run Chunk 1
  - Mean Bias

$$\mathrm{MB} = \frac{1}{N}\sum \hat{\varepsilon}_k$$

  - Mean Absolute Error

$$\mathrm{MAE} = \frac{1}{N}\sum |\hat{\varepsilon}_k|$$

  - Root Mean Squared Error

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum \hat{\varepsilon}_k^2}$$

  - MB, MAE, and RMSE are in Degrees Celsius

# Part 6: Evaluation by Numerical Summary

- Summarizing Table
  - Evaluate MB, MAE, and RMSE on Test Data to Choose Best Model Going Forward
  - Sketch of Table We Want

| Model | MB | MAE | RMSE |
|---|---|---|---|
| Linear | | | |
| Poly(2) | | | |
| Poly(3) | | | |
| Poly(4) | | | |
| Logistic | | | |

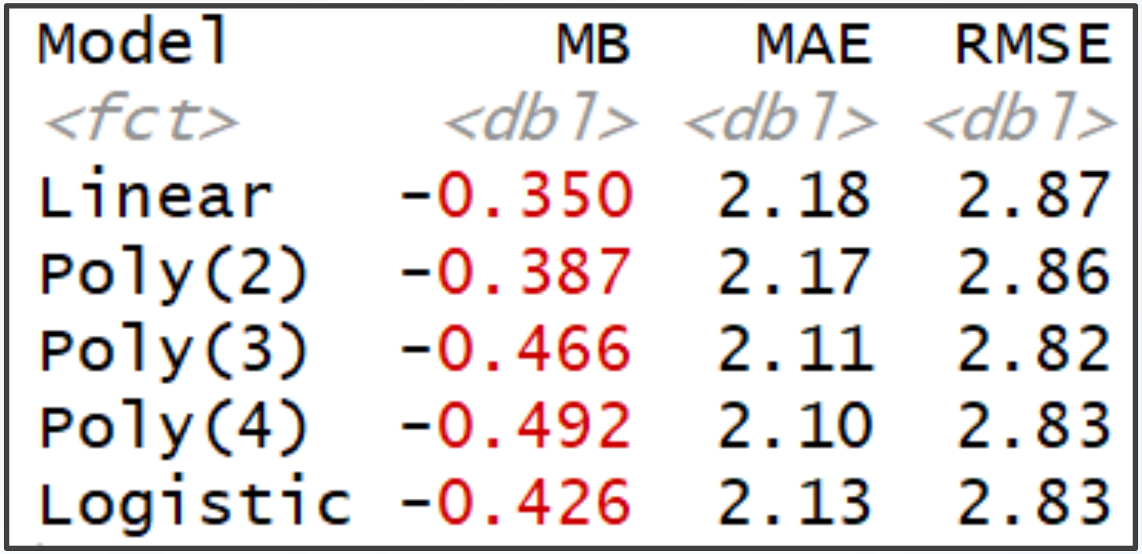
  - Before Writing Code, Have a Plan for the Output

# Part 6: Evaluation by Numerical Summary

- Chunk 2
  - Run Line-By-Line
  - Think About Ways to Quickly Apply All 3 Functions to All Residuals
- Run Chunk 3
  - Combine rename(), gather(), group_by(), and summarize()
- Chunk 4
  - Change eval=F to eval=T and Knit the File (What is Seen?)

# Part 6: Evaluation by Numerical Summary

- My Results Based on My Seed



```
Model        MB     MAE   RMSE
<fct>     <dbl>   <dbl>  <dbl>
Linear   -0.350   2.18   2.87
Poly(2)  -0.387   2.17   2.86
Poly(3)  -0.466   2.11   2.82
Poly(4)  -0.492   2.10   2.83
Logistic -0.426   2.13   2.83
```

  - When Results Are This Close, Always Consider the Most Simple Model