STOR 320.1
Modeling II

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?

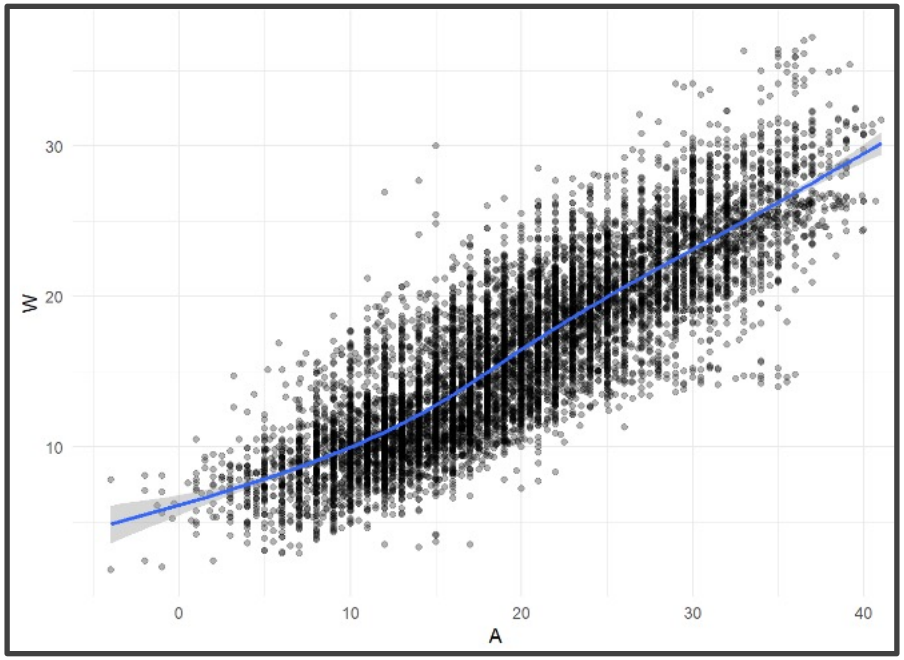
```
echo=F
```

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

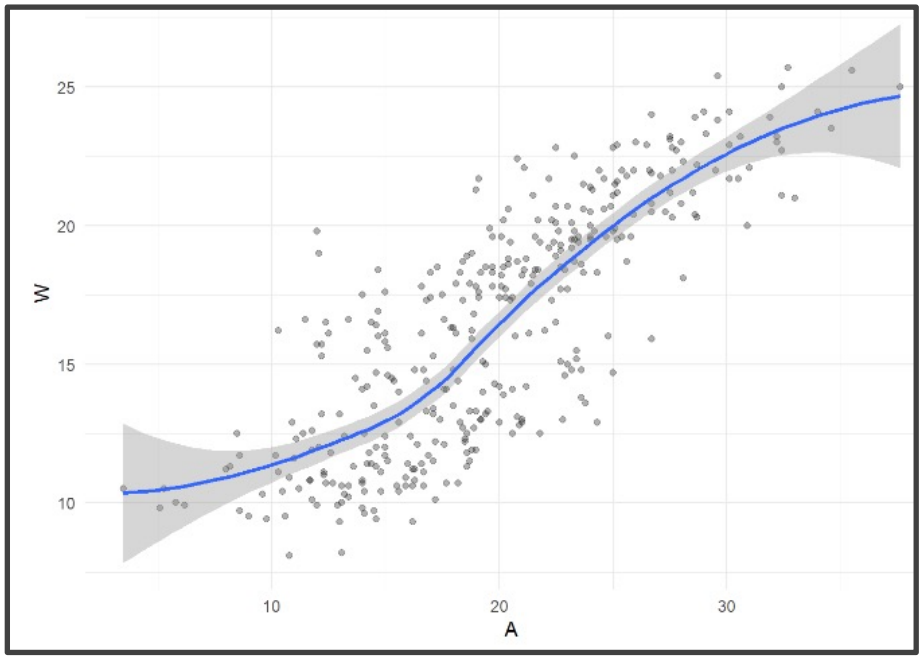
- Run Chunk 1
  - What Do You Notice About the Overall Relationship?



  - 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

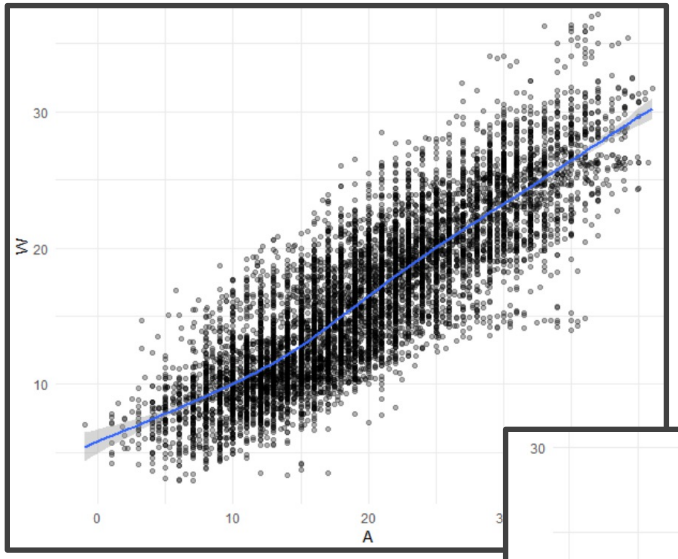
- Chunk 2 Discussion
  - What are the Differences in the Relationship Between W and A for the Various Locations?
  - Why do You Think These Differences Exist?
  - How do You Suggest We Handle the Differences?

Part 1: Examining the Relationship

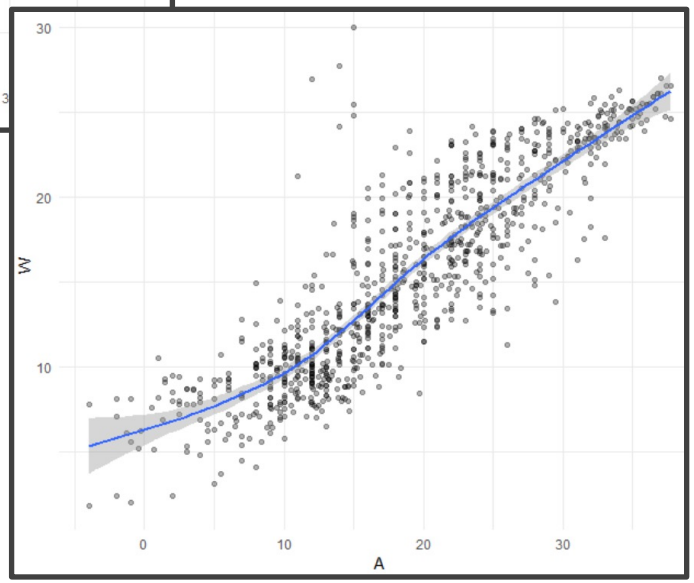
- Chunk 3
  - Randomly Samples 3 Locations
  - Plant Your Seed and Run Code
  - Usage:
    - anti_join()
    - semi_join()
  - Why Don’t We Handpick the Three Locations?

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

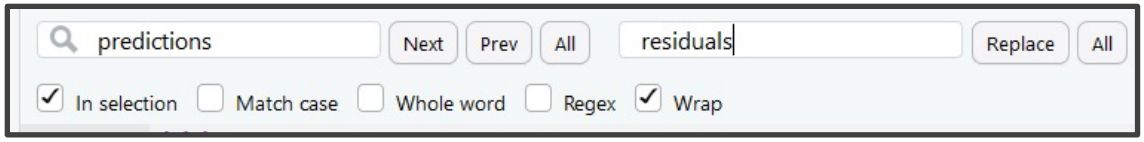
Part 3: Polynomial Model

- 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’



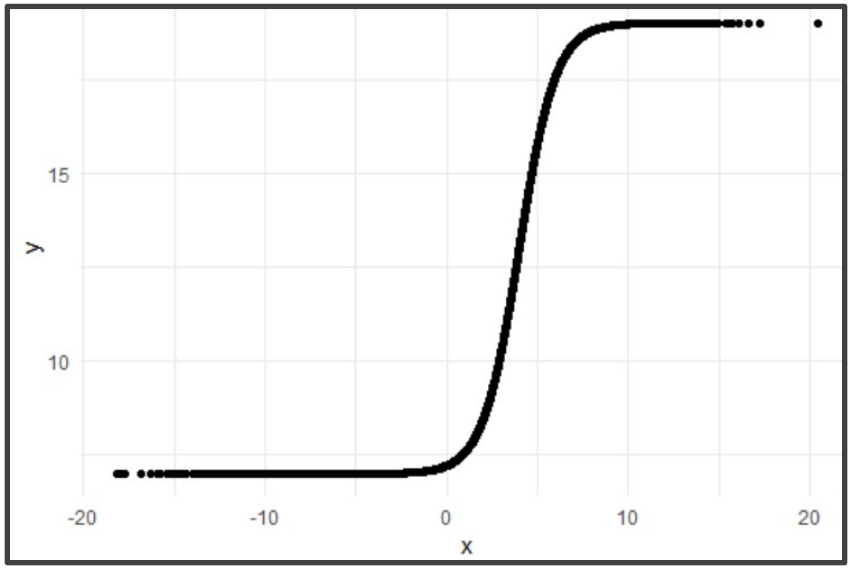
  - Run Chunk 3 After Modifying

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

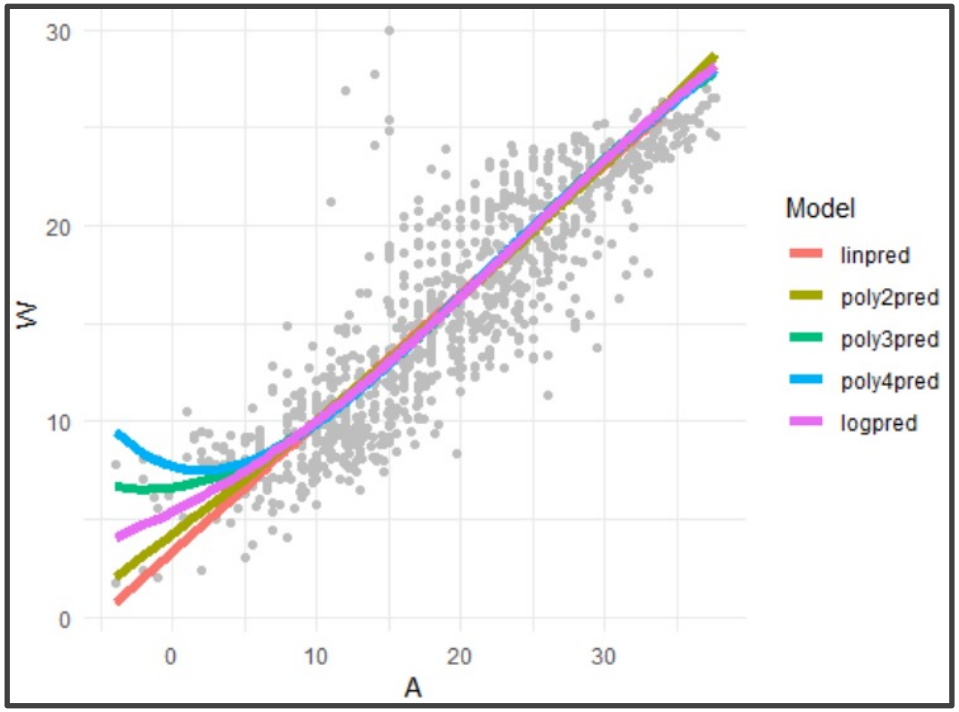
- Run Chunk 4
    - Use Logistic Model Function and Estimated Parameters from optim() to Obtain
        - Predictions
        - Residuals

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

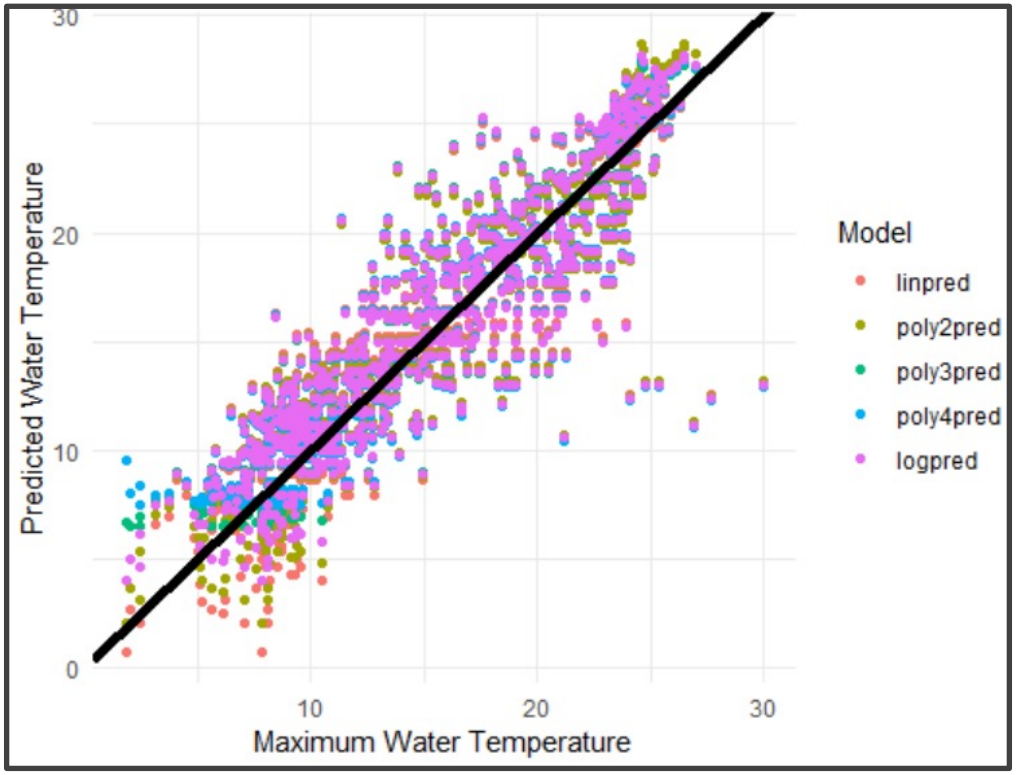
- Run Chunk 1
  - Plots of Different Models
  - What Can We Say About the Different Models?



  - Which Model Would You Use?

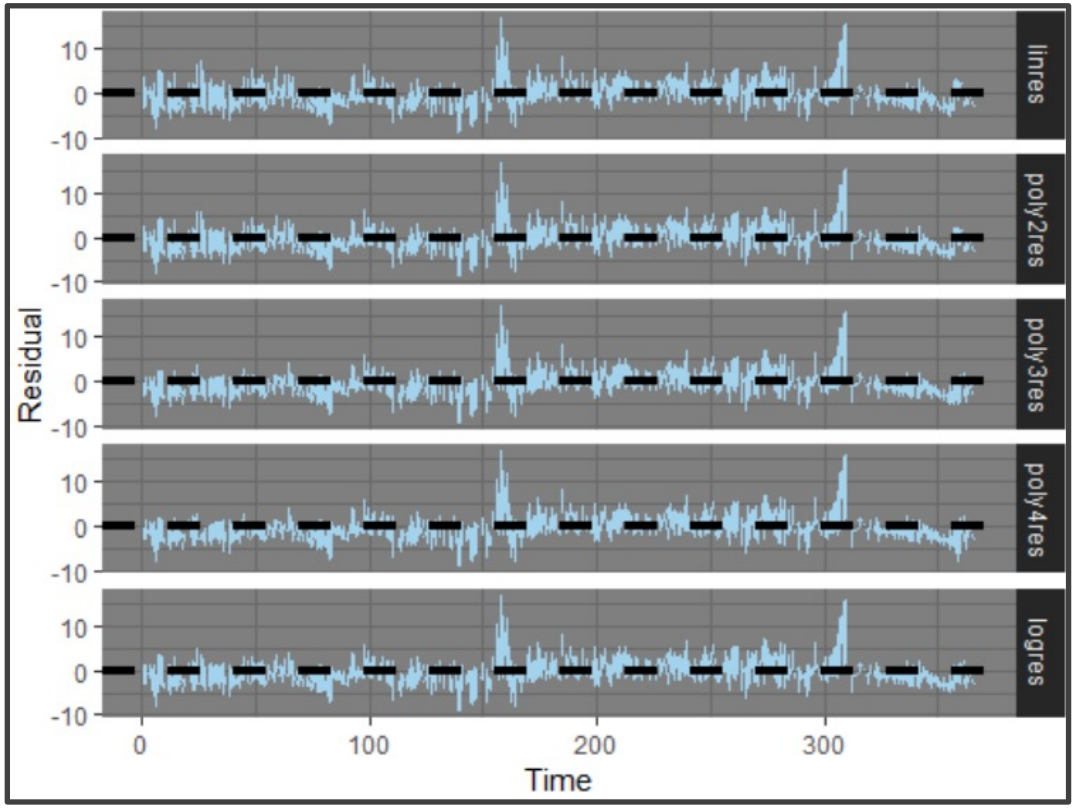
Part 5: Evaluation by Visualization

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



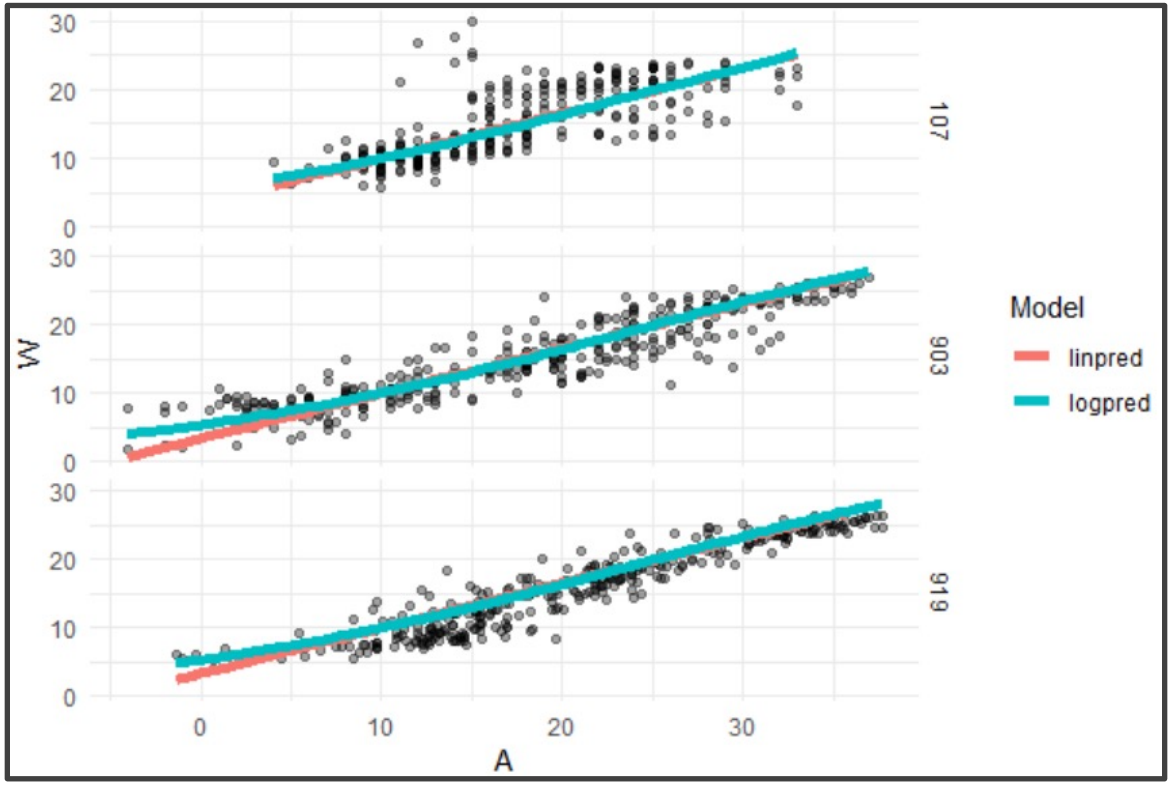
Part 5: Evaluation by Visualization

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



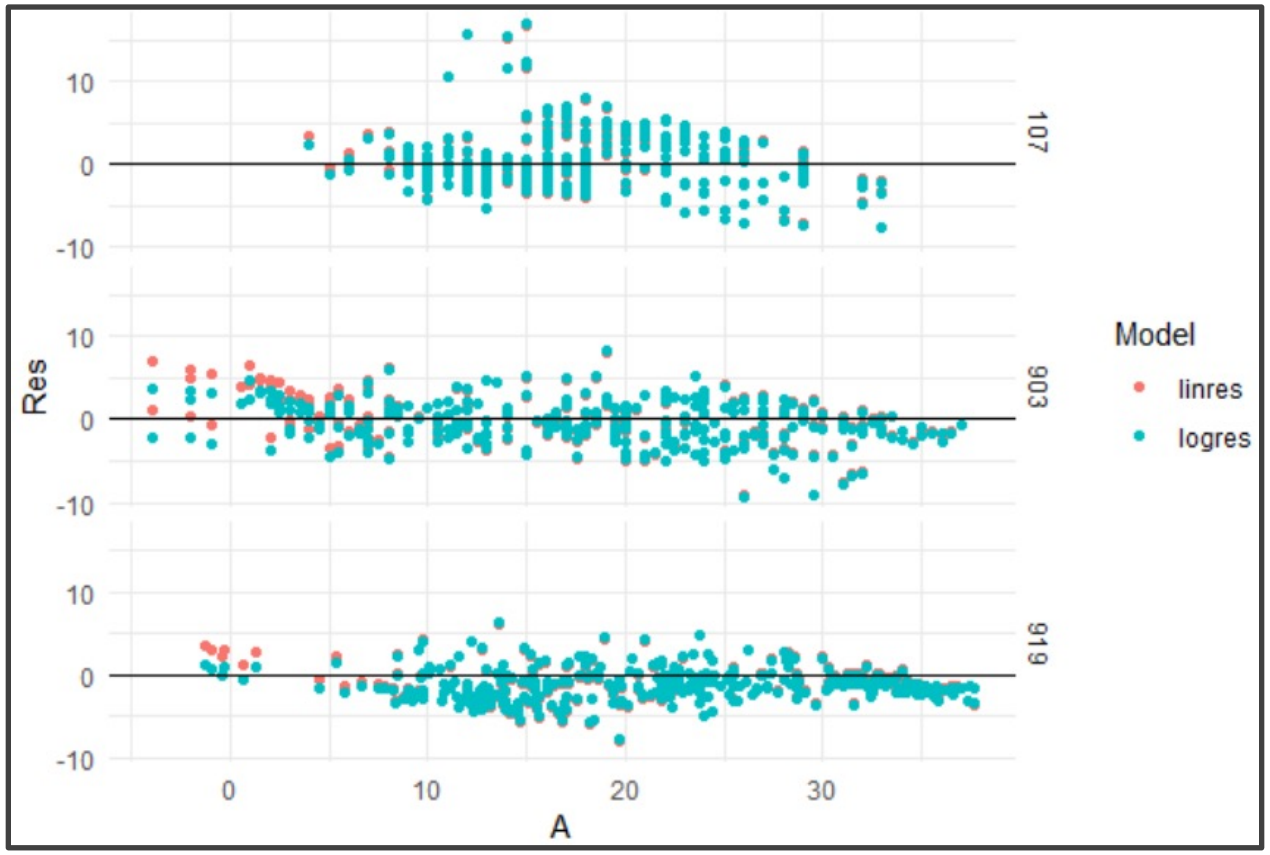
Part 5: Evaluation by Visualization

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



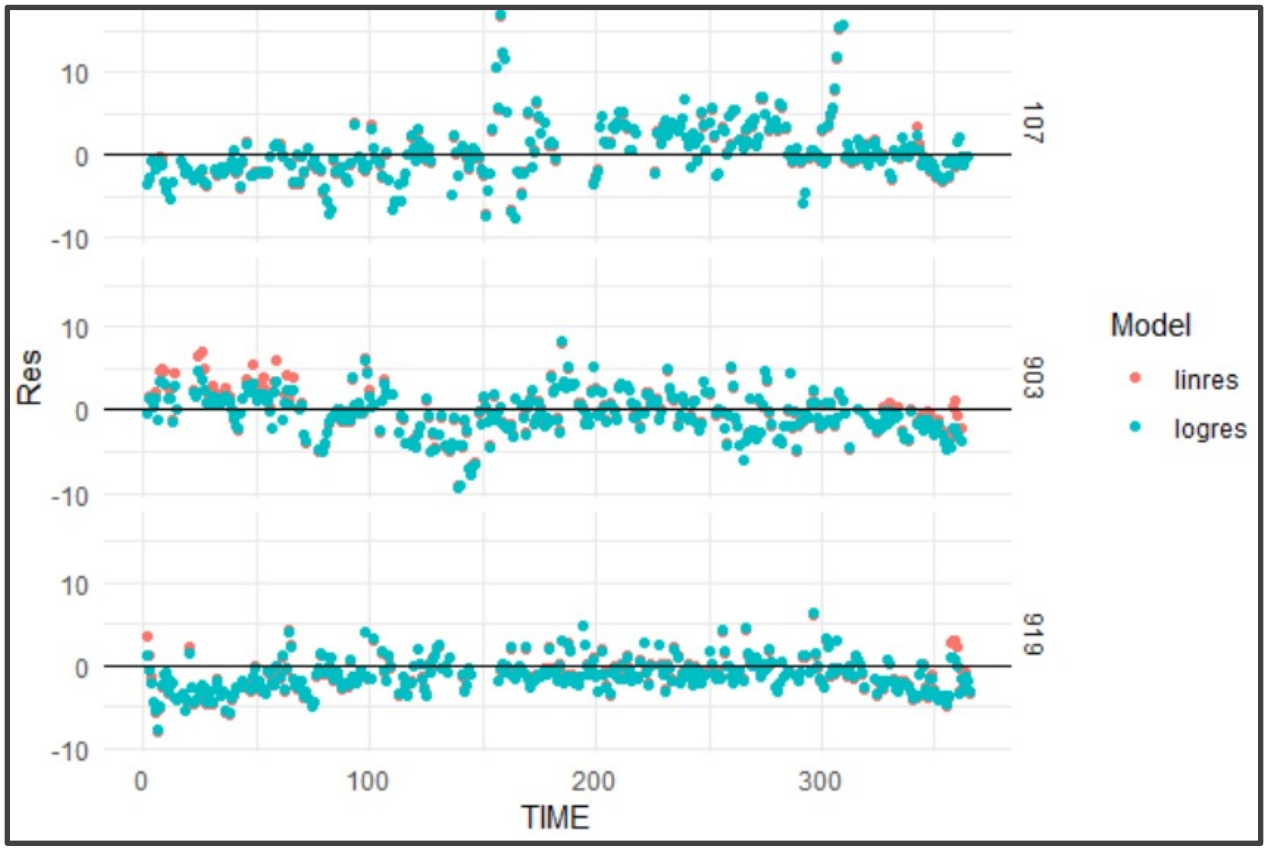
Part 5: Evaluation by Visualization

- 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