Assignment 6: Generalized Linear Models

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OVERVIEW

This exercise accompanies the lessons in Environmental Data Analytics (ENV872L) on generalized linear models.

Directions

1. Change "Student Name" on line 3 (above) with your name.
2. Use the lesson as a guide. It contains code that can be modified to complete the assignment.
3. Work through the steps, **creating code and output** that fulfill each instruction.
4. Be sure to **answer the questions** in this assignment document. Space for your answers is provided in this document and is indicated by the ">" character. If you need a second paragraph be sure to start the first line with ">". You should notice that the answer is highlighted in green by RStudio.
5. When you have completed the assignment, **Knit** the text and code into a single PDF file. You will need to have the correct software installed to do this (see Software Installation Guide) Press the `Knit` button in the RStudio scripting panel. This will save the PDF output in your Assignments folder.
6. After Knitting, please submit the completed exercise (PDF file) to the dropbox in Sakai. Please add your last name into the file name (e.g., "Salk_A06_GLMs.pdf") prior to submission.

The completed exercise is due on Tuesday, 26 February, 2019 before class begins.

Set up your session

1. Set up your session. Upload the EPA Ecotox dataset for Neonicotinoids and the NTL-LTER raw data file for chemistry/physics.
2. Build a ggplot theme and set it as your default theme.

```
#1
getwd()
```

```
## [1] "C:/Users/Wanch/Desktop/ENVI 872 data/Environmental_Data_Analytics"
```

```
library(tidyverse)
```

```
## -- Attaching packages ---------------------------------------------- tidyverse 1.2.1 --

## v ggplot2 3.1.0     v purrr   0.2.5
## v tibble  2.0.1     v dplyr   0.7.8
## v tidyr   0.8.2     v stringr 1.3.1
## v readr   1.3.1     v forcats 0.3.0

## -- Conflicts ------------------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
ecotox <- read.csv("./Data/Raw/ECOTOX_Neonicotinoids_Mortality_raw.csv")

chem.phys <- read.csv("./Data/Raw/NTL-LTER_Lake_ChemistryPhysics_Raw.csv")

#2
mytheme <- theme_grey() +
  theme(axis.text = element_text(color = "black"),
        legend.position = "right")
theme_set(mytheme)
```

Neonicotinoids test

Research question: Were studies on various neonicotinoid chemicals conducted in different years?

3. Generate a line of code to determine how many different chemicals are listed in the Chemical.Name column.

4. Are the publication years associated with each chemical well-approximated by a normal distribution? Run the appropriate test and also generate a frequency polygon to illustrate the distribution of counts for each year, divided by chemical name. Bonus points if you can generate the results of your test from a pipe function. No need to make this graph pretty.

5. Is there equal variance among the publication years for each chemical? Hint: var.test is not the correct function.

```
#3 Check how many chemicals are in the dataset
str(ecotox$Chemical.Name)
```

```
##  Factor w/ 9 levels "Acetamiprid",..: 4 8 4 4 8 8 8 8 4 4 ...
```

```
#4 Determine whether publication years associated with each chemical is well-approximated by a normal d
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Acetamiprid"])
```

```
## 
##  Shapiro-Wilk normality test
## 
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Acetamiprid"]
## W = 0.90191, p-value = 5.706e-08
```

```
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Clothianidin"])
```

```
## 
##  Shapiro-Wilk normality test
## 
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Clothianidin"]
## W = 0.69577, p-value = 4.287e-11
```

```
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Dinotefuran"])
```

```
## 
##  Shapiro-Wilk normality test
## 
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Dinotefuran"]
## W = 0.82848, p-value = 8.83e-07
```

```
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Imidacloprid"])
```

```
## 
##  Shapiro-Wilk normality test
## 
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Imidacloprid"]
## W = 0.88178, p-value < 2.2e-16
```

```
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Imidaclothiz"])
```

```
## 
```

```
##  Shapiro-Wilk normality test
##
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Imidaclothiz"]
## W = 0.68429, p-value = 0.00093
```

```r
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Nitenpyram"])
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Nitenpyram"]
## W = 0.79592, p-value = 0.0005686
```

```r
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Nithiazine"])
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Nithiazine"]
## W = 0.75938, p-value = 0.0001235
```

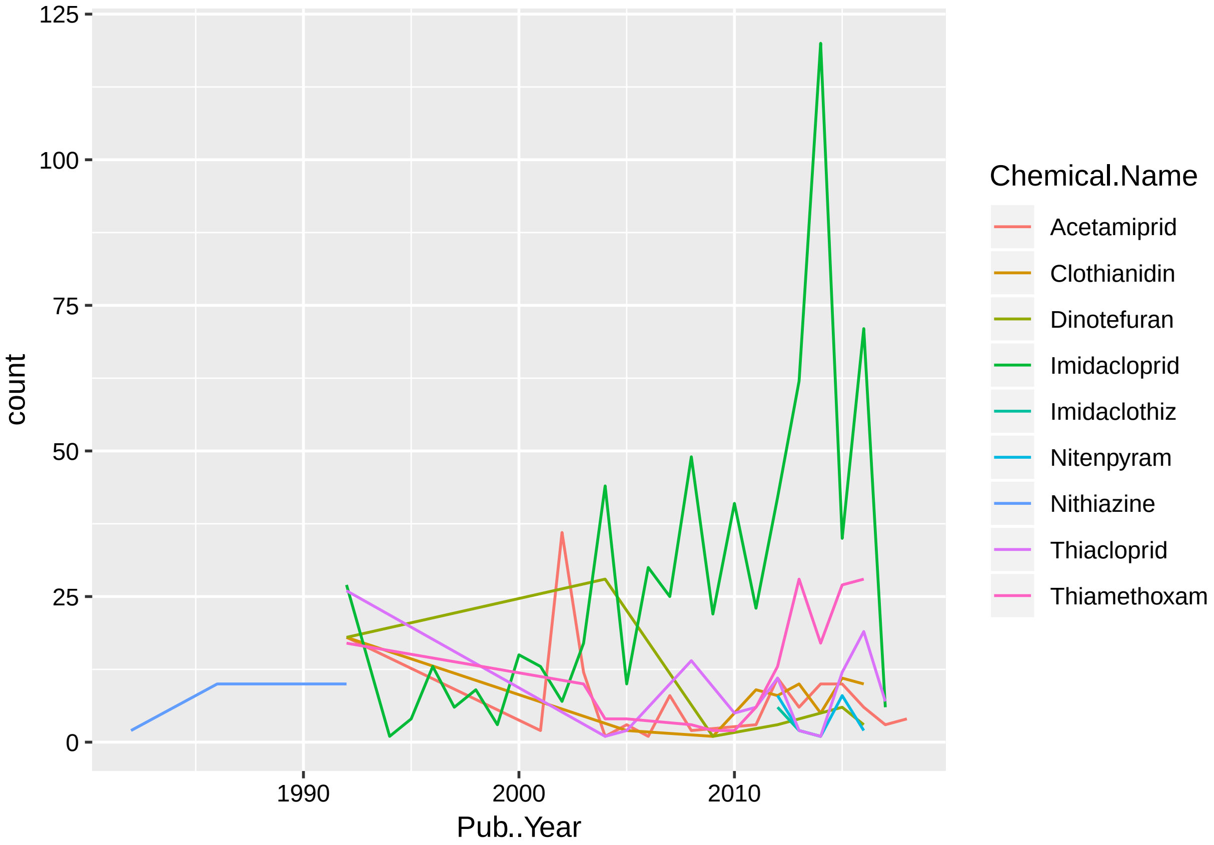
```r
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Thiacloprid"])
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Thiacloprid"]
## W = 0.7669, p-value = 1.118e-11
```

```r
shapiro.test(ecotox$Pub..Year[ecotox$Chemical.Name == "Thiamethoxam"])
```

```
##
##  Shapiro-Wilk normality test
##
## data:  ecotox$Pub..Year[ecotox$Chemical.Name == "Thiamethoxam"]
## W = 0.7071, p-value < 2.2e-16
```

```r
year.freq <- ggplot(ecotox, aes(x = Pub..Year, color = Chemical.Name)) +
         geom_freqpoly(stat = "count")
print(year.freq)
```



```
#5 Check whether there is an equal variance among the publication years for each chemical
bartlett.test(ecotox$Pub..Year ~ ecotox$Chemical.Name)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  ecotox$Pub..Year by ecotox$Chemical.Name
## Bartlett's K-squared = 139.59, df = 8, p-value < 2.2e-16
```

6. Based on your results, which test would you choose to run to answer your research question?

   ANSWER: I would choose ANOVA test to answer the research question.

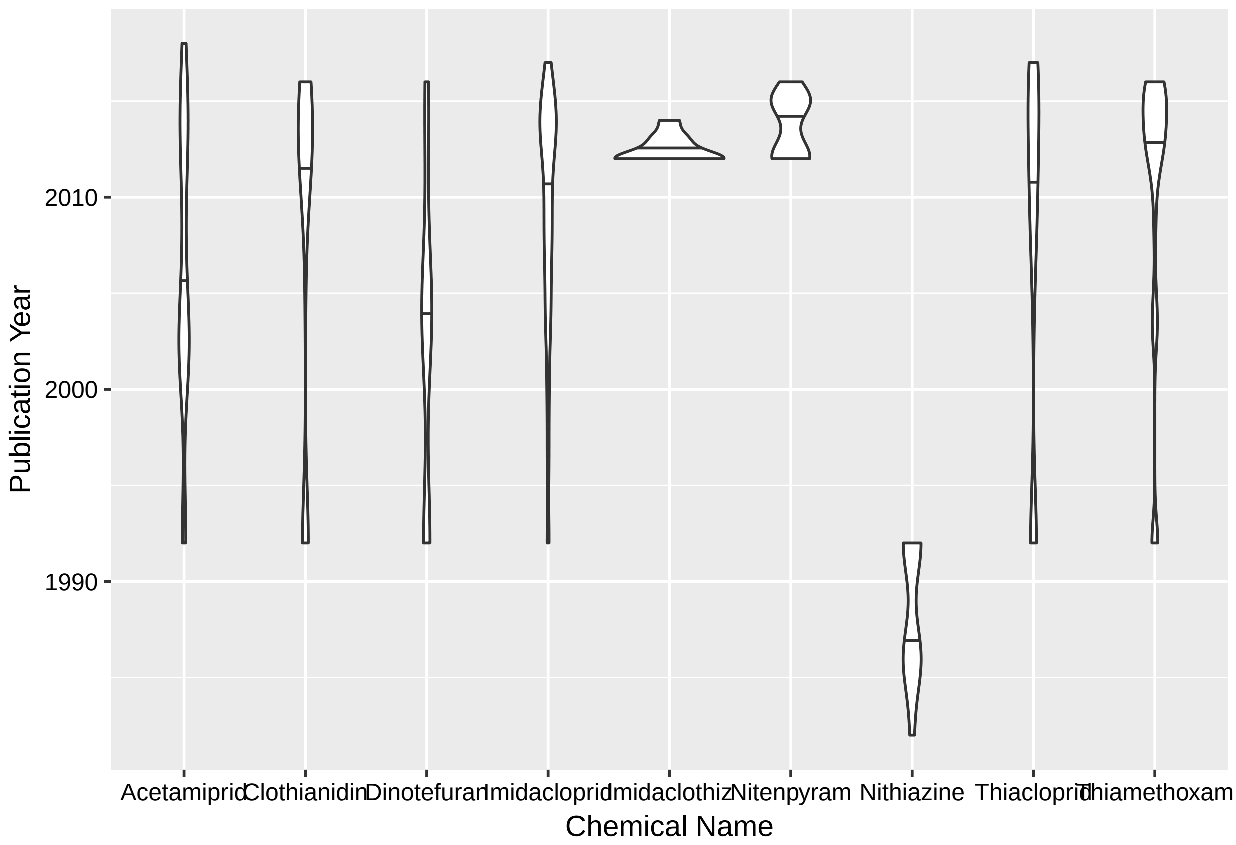
7. Run this test below.
8. Generate a boxplot representing the range of publication years for each chemical. Adjust your graph to make it pretty.

```
#7 Run an ANOVA test for the research question
pub.year.chemical.anova <- lm(ecotox$Pub..Year ~ ecotox$Chemical.Name)
summary(pub.year.chemical.anova)
```

```
##
## Call:
## lm(formula = ecotox$Pub..Year ~ ecotox$Chemical.Name)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -18.366  -3.993   1.889   4.889  13.441
```

```
##
## Coefficients:
##                                   Estimate Std. Error  t value Pr(>|t|)
## (Intercept)                      2005.9926     0.6082 3298.222  < 2e-16
## ecotox$Chemical.NameClothianidin    2.0479     1.0246    1.999  0.04584
## ecotox$Chemical.NameDinotefuran    -3.4333     1.1057   -3.105  0.00194
## ecotox$Chemical.NameImidacloprid    3.1181     0.6651    4.689 3.05e-06
## ecotox$Chemical.NameImidaclothiz    6.4518     2.4412    2.643  0.00832
## ecotox$Chemical.NameNitenpyram      7.7216     1.6630    4.643 3.78e-06
## ecotox$Chemical.NameNithiazine    -17.6290     1.6299  -10.816  < 2e-16
## ecotox$Chemical.NameThiacloprid     1.6394     0.9190    1.784  0.07467
## ecotox$Chemical.NameThiamethoxam    4.3738     0.8261    5.295 1.40e-07
##
## (Intercept)                      ***
## ecotox$Chemical.NameClothianidin *
## ecotox$Chemical.NameDinotefuran  **
## ecotox$Chemical.NameImidacloprid ***
## ecotox$Chemical.NameImidaclothiz **
## ecotox$Chemical.NameNitenpyram   ***
## ecotox$Chemical.NameNithiazine   ***
## ecotox$Chemical.NameThiacloprid  .
## ecotox$Chemical.NameThiamethoxam ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.093 on 1274 degrees of freedom
## Multiple R-squared:  0.1726, Adjusted R-squared:  0.1674
## F-statistic: 33.21 on 8 and 1274 DF,  p-value: < 2.2e-16
```

```
#8 Generate a boxplot to represent the range publication years for each chemical
plot.pub.year.anova <-
  ggplot(ecotox, aes(x = Chemical.Name, y = Pub..Year)) +
  geom_violin(draw_quantiles = 0.5) +
  xlab(expression("Chemical Name")) +
  ylab(expression("Publication Year"))
print(plot.pub.year.anova)
```



9. How would you summarize the conclusion of your analysis? Include a sentence summarizing your findings and include the results of your test in parentheses at the end of the sentence.

   ANSWER: Research question: Studies on various neonicotinoid chemicals are conducted in different years(ANOVA; F = 33.21, DF = 1274, p < 0.0001).

NTL-LTER test

Research question: What is the best set of predictors for lake temperatures in July across the monitoring period at the North Temperate Lakes LTER?

11. Wrangle your NTL-LTER dataset with a pipe function so that it contains only the following criteria:

- Only dates in July (hint: use the daynum column). No need to consider leap years.
- Only the columns: lakename, year4, daynum, depth, temperature_C
- Only complete cases (i.e., remove NAs)

12. Run an AIC to determine what set of explanatory variables (year4, daynum, depth) is best suited to predict temperature. Run a multiple regression on the recommended set of variables.

```
#11 Wrangle the data to prepare for AIC analysis
tidy.chem.phys <-
  chem.phys %>%
  filter(daynum %in% (183:212)) %>%
  select(lakename:daynum, depth, temperature_C) %>%
  na.omit()

#12 Run an AIC to determine which variable(s) are best predictor for temperature, then run a multiple r
```

```r
temp.aic <-lm(data = tidy.chem.phys, temperature_C ~ year4 + daynum + depth)
step(temp.aic)
```

```
## Start:  AIC=25233.58
## temperature_C ~ year4 + daynum + depth
## 
##          Df Sum of Sq    RSS   AIC
## <none>                137124 25234
## - year4   1       115 137239 25239
## - daynum  1      1015 138139 25301
## - depth   1    392438 529563 37958
```

```
## 
## Call:
## lm(formula = temperature_C ~ year4 + daynum + depth, data = tidy.chem.phys)
## 
## Coefficients:
## (Intercept)        year4       daynum        depth  
##   -10.13919      0.01232      0.03789     -1.94770
```

```r
temp.model <- lm(data = tidy.chem.phys, temperature_C ~ year4 + daynum + depth)
summary(temp.model)
```

```
## 
## Call:
## lm(formula = temperature_C ~ year4 + daynum + depth, data = tidy.chem.phys)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -9.6680 -3.0016  0.0914  2.9773 13.6150 
## 
## Coefficients:
##                Estimate Std. Error  t value Pr(>|t|)    
## (Intercept) -10.139191   8.801260   -1.152  0.24934    
## year4         0.012323   0.004385    2.810  0.00496 ** 
## daynum        0.037893   0.004539    8.348  < 2e-16 ***
## depth        -1.947704   0.011865 -164.149  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 3.816 on 9415 degrees of freedom
## Multiple R-squared:  0.7416, Adjusted R-squared:  0.7415 
## F-statistic:  9008 on 3 and 9415 DF,  p-value: < 2.2e-16
```

13. What is the final linear equation to predict temperature from your multiple regression? How much of the observed variance does this model explain?

    ANSWER: The final linear equation is: temperature = -10.1 + 0.01 year4 + 0.04 daynum - 1.95 depth + 3.816. This model explains 74% of the variance observed.

14. Run an interaction effects ANCOVA to predict temperature based on depth and lakename from the same wrangled dataset.

```r
#14 Run an interaction effects ANCOVA to predict temperature based on depth and lakename
ancova.temp <- lm(data = tidy.chem.phys, temperature_C ~ depth * lakename)
summary(ancova.temp)
```

```
## 
## Call:
## lm(formula = temperature_C ~ depth * lakename, data = tidy.chem.phys)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -7.6773 -2.8928 -0.2863  2.7567 16.3606 
## 
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)    
## (Intercept)                     22.9455     0.5860  39.156  < 2e-16 ***
## depth                           -2.5820     0.2410 -10.713  < 2e-16 ***
## lakenameCrampton Lake            2.2173     0.6802   3.260 0.001119 ** 
## lakenameEast Long Lake          -4.3884     0.6189  -7.090 1.43e-12 ***
## lakenameHummingbird Lake        -2.8915     0.8634  -3.349 0.000814 ***
## lakenamePaul Lake                0.6607     0.5986   1.104 0.269716    
## lakenamePeter Lake               0.3459     0.5973   0.579 0.562564    
## lakenameTuesday Lake            -2.8622     0.6066  -4.718 2.41e-06 ***
## lakenameWard Lake                2.4180     0.8432   2.868 0.004145 ** 
## lakenameWest Long Lake          -2.3753     0.6184  -3.841 0.000123 ***
## depth:lakenameCrampton Lake      0.8058     0.2465   3.269 0.001083 ** 
## depth:lakenameEast Long Lake     0.9465     0.2432   3.892 0.000100 ***
## depth:lakenameHummingbird Lake  -0.4840     0.2971  -1.629 0.103394    
## depth:lakenamePaul Lake          0.4005     0.2421   1.655 0.098027 .  
## depth:lakenamePeter Lake         0.5792     0.2418   2.395 0.016619 *  
## depth:lakenameTuesday Lake       0.6574     0.2426   2.710 0.006737 ** 
## depth:lakenameWard Lake         -0.6930     0.2861  -2.422 0.015457 *  
## depth:lakenameWest Long Lake     0.8090     0.2432   3.327 0.000883 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 3.47 on 9401 degrees of freedom
## Multiple R-squared:  0.7867, Adjusted R-squared:  0.7863 
## F-statistic:  2040 on 17 and 9401 DF,  p-value: < 2.2e-16
```

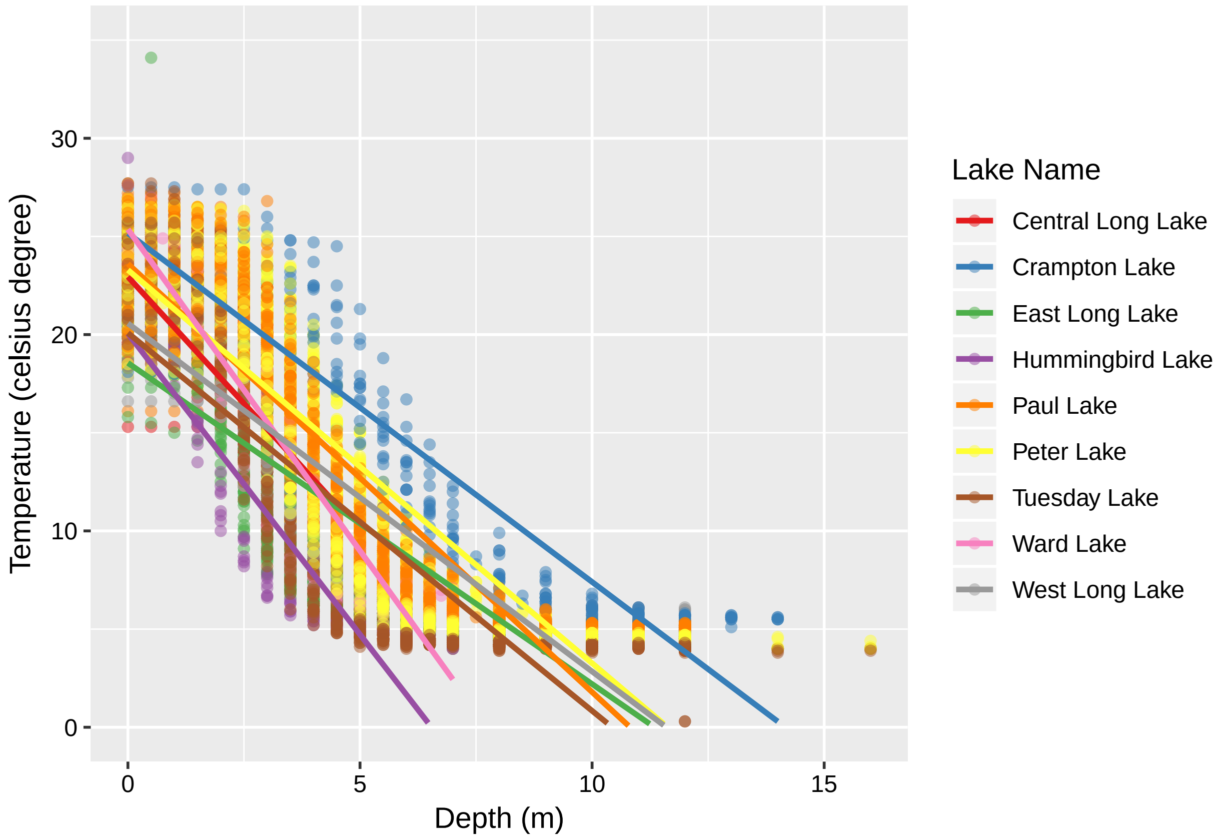
15. Is there an interaction between depth and lakename? How much variance in the temperature observations does this explain?

    ANSWER: There is an interaction between depth and lake name because there are six lakes showing that depth has a significant impact on the temperature of the lake and this is different among those lakes(ANCOVA; F = 2040, DF = 9401, $p < 0.0001$). This test explains 78% of the variance.

16. Create a graph that depicts temperature by depth, with a separate color for each lake. Add a geom_smooth (method = "lm", se = FALSE) for each lake. Make your points 50 % transparent. Adjust your y axis limits to go from 0 to 35 degrees. Clean up your graph to make it pretty.

```
#16 Create a graph that depicts temperature by depth
lake.temp.depth <-
  ggplot(tidy.chem.phys, aes(x = depth, y = temperature_C, color = lakename)) +
  geom_point(alpha = 0.5) +
  scale_color_brewer(palette = "Set1") +
  geom_smooth(method = "lm", se = FALSE) +
  ylim(0, 35) +
  xlab(expression("Depth (m)")) +
  ylab(expression("Temperature (celsius degree)")) +
  labs(color = "Lake Name")
print(lake.temp.depth)
```

```
## Warning: Removed 72 rows containing missing values (geom_smooth).
```


Temperature (celsius degree)
Depth (m)
Lake Name
Central Long Lake
Crampton Lake
East Long Lake
Hummingbird Lake
Paul Lake
Peter Lake
Tuesday Lake
Ward Lake
West Long Lake