Precipitation Change in Beaufort

Web address for GitHub repository

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Contents

List of Tables

List of Figures

Initial steps * get data * Wrangle data * graph data to see what we're working with * try a seasonal Mann-kendall test * divide decades and see if there's a statistical significant difference * Optional: map of three schools in NC * Make presentation

Wrangle Data

```
#Created monthly mean precipitation + total monthly precipitation dataset for Beaufort
Beaufort_Clean<- Beaufort_RAW%>%
  group_by(year,month)%>%
   summarise(meanmonthlyprecip= mean(Area.Weighted.Mean.Precipitation..mm.per.day.),
             sumMonthlyPrecip= sum(Area.Weighted.Mean.Precipitation..mm.per.day.))%>%
  mutate(Date= my(paste0(month,"-", year)))
```

```
## `summarise()` has grouped output by 'year'. You can override using the `.groups` argu
```

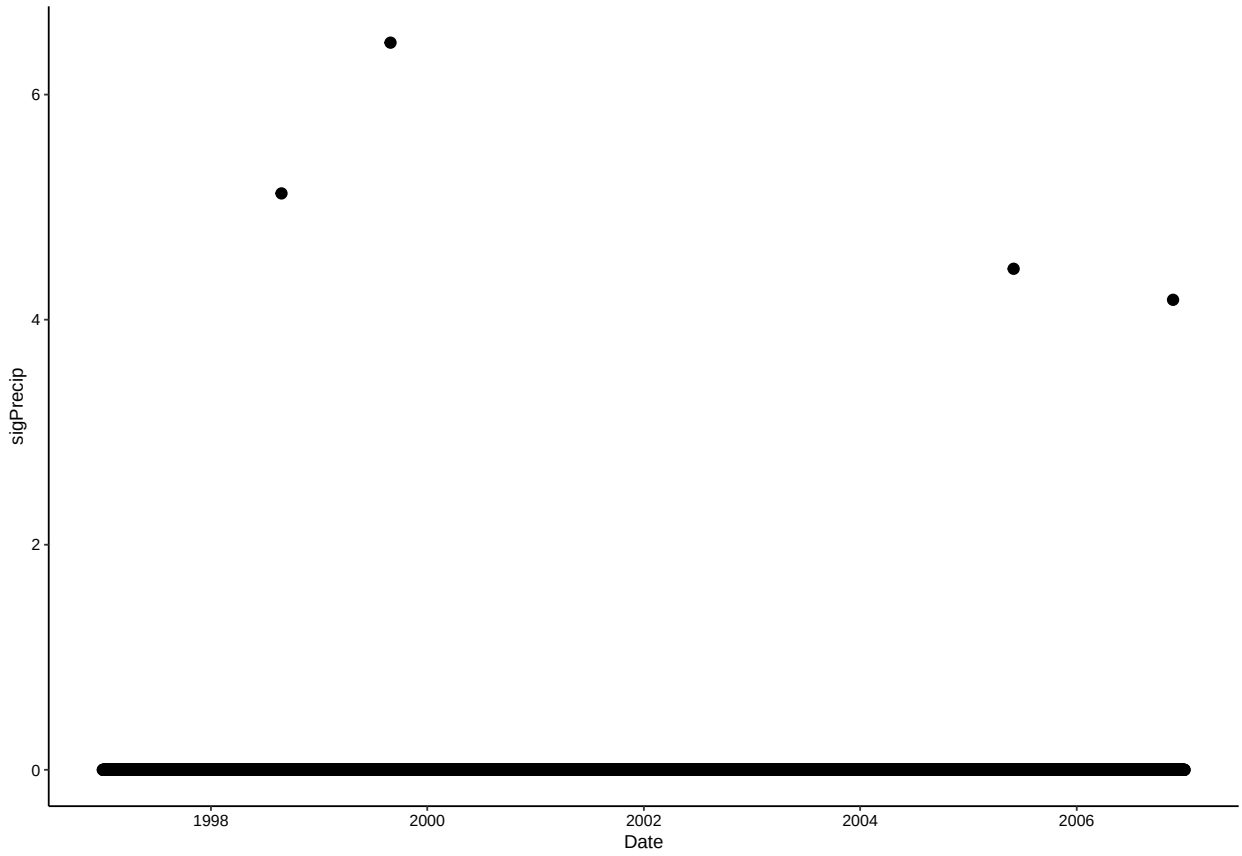
```
# Summary infos of the monthly mean precip. of beaufort
summary(Beaufort_Clean)
```

```
##       year          month       meanmonthlyprecip sumMonthlyPrecip
##  Min.   :1980   Min.   : 1.00   Min.   : 0.1667   Min.   :  5.0
##  1st Qu.:1989   1st Qu.: 3.75   1st Qu.: 2.1640   1st Qu.: 66.0
##  Median :1998   Median : 6.50   Median : 3.5161   Median :108.0
##  Mean   :1998   Mean   : 6.50   Mean   : 4.1493   Mean   :126.4
##  3rd Qu.:2007   3rd Qu.: 9.25   3rd Qu.: 5.4500   3rd Qu.:166.0
##  Max.   :2016   Max.   :12.00   Max.   :14.8667   Max.   :446.0
##                                 NA's   :9         NA's   :9
##       Date
##  Min.   :1980-01-01
##  1st Qu.:1989-03-24
##  Median :1998-06-16
##  Mean   :1998-06-16
##  3rd Qu.:2007-09-08
##  Max.   :2016-12-01
##
```

```
#10 year time frame, precipitation in inches (1997-01-01 to 2006-12-31) +significant 2
Beaufort_early<- Beaufort_RAW%>%
  mutate(PrecipInches= Area.Weighted.Mean.Precipitation..mm.per.day.*0.0394)%>%
  filter(Date >("1996-12-31"), Date < ("2007-01-01")) %>%
  mutate(sigPrecip= ifelse(PrecipInches>3.66,PrecipInches,0),
         NumSigPrecip= ifelse(PrecipInches>3.66, 1,0))%>%
  select(Date , year, month,
         day_of_month, PrecipInches, sigPrecip, NumSigPrecip)%>%
  drop_na()

#summary of Early precip
summary(Beaufort_early)
```

```
##       Date                 year          month         day_of_month
##  Min.   :1997-01-01   Min.   :1997   Min.   : 1.000   Min.   : 1.00
##  1st Qu.:1999-07-02   1st Qu.:1999   1st Qu.: 4.000   1st Qu.: 8.00
##  Median :2001-12-31   Median :2002   Median : 7.000   Median :16.00
##  Mean   :2001-12-31   Mean   :2002   Mean   : 6.521   Mean   :15.72
##  3rd Qu.:2004-06-30   3rd Qu.:2004   3rd Qu.:10.000   3rd Qu.:23.00
##  Max.   :2006-12-31   Max.   :2006   Max.   :12.000   Max.   :31.00
##   PrecipInches      sigPrecip         NumSigPrecip
##  Min.   :0.0000   Min.   :0.000000   Min.   :0.000000
##  1st Qu.:0.0000   1st Qu.:0.000000   1st Qu.:0.000000
##  Median :0.0000   Median :0.000000   Median :0.000000
##  Mean   :0.1628   Mean   :0.005538   Mean   :0.001096
##  3rd Qu.:0.0788   3rd Qu.:0.000000   3rd Qu.:0.000000
##  Max.   :6.4616   Max.   :6.461600   Max.   :1.000000
```

```r
#Summary of number of sig events per year
Beaufort_early_summary<- Beaufort_early%>%
  group_by(year)%>%
  summarise(SigPrecipEvents= sum(NumSigPrecip))

#check results
ggplot(Beaufort_early, aes(x=Date , y=sigPrecip))+
  geom_point()
```




```
EarlyTable<- kable(Beaufort_early_summary, caption = "Significant Events Over Year")
EarlyTable
```

Table 1: Significant Events Over Year

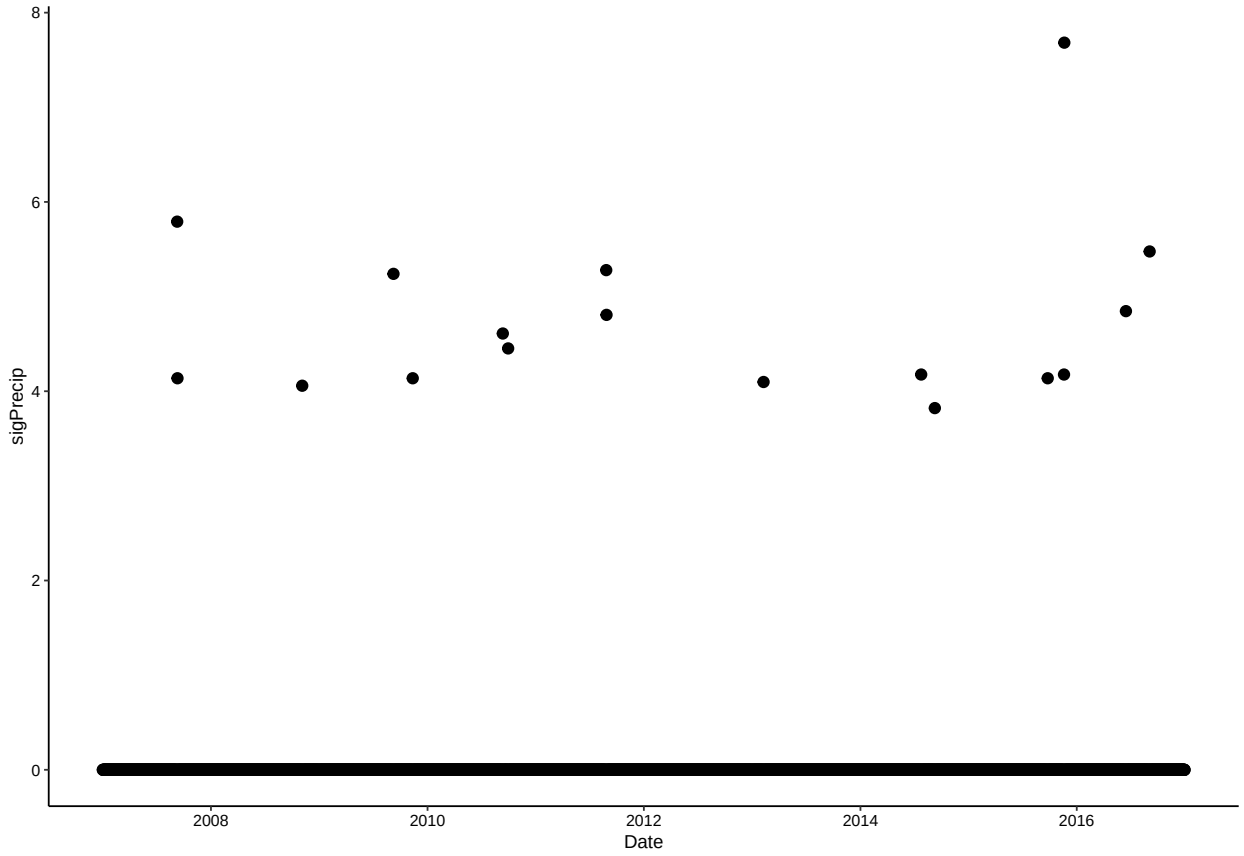
year	SigPrecipEvents
1997	0
1998	1
1999	1
2000	0
2001	0
2002	0
2003	0
2004	0
2005	1
2006	1

```
#10 year time frame, precipitation in inches (2007-01-01 to 2016-12-30) +significant 2
Beaufort_Late<- Beaufort_RAW%>%
  mutate(PrecipInches= Area.Weighted.Mean.Precipitation..mm.per.day.*0.0394)%>%
  filter(Date > "2006-12-31")%>%
```

```
  mutate(sigPrecip= ifelse(PrecipInches>3.66,PrecipInches,0),
         NumSigPrecip= ifelse(PrecipInches>3.66, 1,0))%>%
  select(Date, year, month,
         day_of_month, PrecipInches, sigPrecip, NumSigPrecip)%>%
  drop_na()

#Summary of Late precip

summary(Beaufort_Late)
```

```
##       Date                 year          month         day_of_month
##  Min.   :2007-01-01   Min.   :2007   Min.   : 1.000   Min.   : 1.00
##  1st Qu.:2009-07-02   1st Qu.:2009   1st Qu.: 4.000   1st Qu.: 8.00
##  Median :2011-12-31   Median :2012   Median : 7.000   Median :16.00
##  Mean   :2011-12-31   Mean   :2012   Mean   : 6.518   Mean   :15.72
##  3rd Qu.:2014-07-01   3rd Qu.:2014   3rd Qu.:10.000   3rd Qu.:23.00
##  Max.   :2016-12-30   Max.   :2016   Max.   :12.000   Max.   :31.00
##   PrecipInches      sigPrecip        NumSigPrecip
##  Min.   :0.0000   Min.   :0.00000   Min.   :0.000000
##  1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.000000
##  Median :0.0000   Median :0.00000   Median :0.000000
##  Mean   :0.1698   Mean   :0.02217   Mean   :0.004658
##  3rd Qu.:0.1182   3rd Qu.:0.00000   3rd Qu.:0.000000
##  Max.   :7.6830   Max.   :7.68300   Max.   :1.000000
```

```
#Summary of number of sig events per year (Late)
Beaufort_late_summary<- Beaufort_Late%>%
  group_by(year)%>%
  summarise(SigPrecipEvents= sum(NumSigPrecip))

#check results
ggplot(Beaufort_Late, aes(x=Date , y=sigPrecip))+
  geom_point()
```




```
LateTable<- kable(Beaufort_late_summary, caption = "Significant Events Over Year")
LateTable
```

Table 2: Significant Events Over Year

year	SigPrecipEvents
2007	2
2008	1
2009	2
2010	2
2011	2
2012	0
2013	1
2014	2
2015	3
2016	2

```
#plot mean monthly precip data to see rough trend


  geom_smooth(method = lm)
```

```
## geom_smooth: na.rm = FALSE, orientation = NA, se = TRUE
## stat_smooth: na.rm = FALSE, orientation = NA, se = TRUE, method = function (formula,
## {
##     ret.x <- x
##     ret.y <- y
##     cl <- match.call()
##     mf <- match.call(expand.dots = FALSE)
##     m <- match(c("formula", "data", "subset", "weights", "na.action", "offset"), name
##     mf <- mf[c(1, m)]
##     mf$drop.unused.levels <- TRUE
##     mf[[1]] <- quote(stats::model.frame)
##     mf <- eval(mf, parent.frame())
##     if (method == "model.frame")
##         return(mf)
##     else if (method != "qr")
##         warning(gettextf("method = '%s' is not supported. Using 'qr'", method), domai
##     mt <- attr(mf, "terms")
##     y <- model.response(mf, "numeric")
##     w <- as.vector(model.weights(mf))
##     if (!is.null(w) && !is.numeric(w))
##         stop("'weights' must be a numeric vector")
##     offset <- model.offset(mf)
##     mlm <- is.matrix(y)
##     ny <- if (mlm)
##         nrow(y)
##     else length(y)
##     if (!is.null(offset)) {
##         if (!mlm)
##             offset <- as.vector(offset)
##         if (NROW(offset) != ny)
##             stop(gettextf("number of offsets is %d, should equal %d (number of observ
##     }
##     if (is.empty.model(mt)) {
##         x <- NULL
##         z <- list(coefficients = if (mlm) matrix(NA, 0, ncol(y)) else numeric(), resi
##         if (!is.null(offset)) {
##             z$fitted.values <- offset
##             z$residuals <- y - offset
##         }
##     }
##     else {
##         x <- model.matrix(mt, mf, contrasts)
##         z <- if (is.null(w))
##             lm.fit(x, y, offset = offset, singular.ok = singular.ok, ...)
##         else lm.wfit(x, y, w, offset = offset, singular.ok = singular.ok, ...)
```

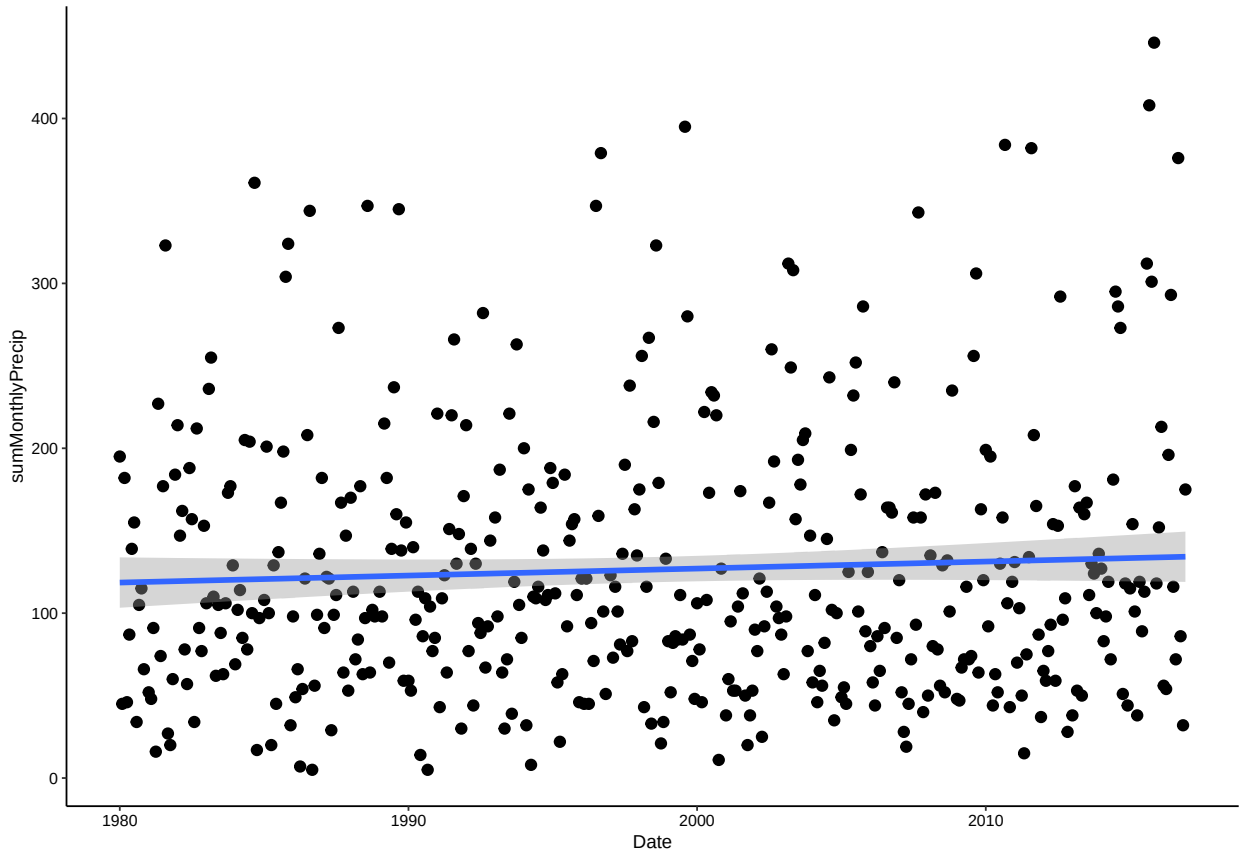
```
##     }
##     class(z) <- c(if (mlm) "mlm", "lm")
##     z$na.action <- attr(mf, "na.action")
##     z$offset <- offset
##     z$contrasts <- attr(x, "contrasts")
##     z$xlevels <- .getXlevels(mt, mf)
##     z$call <- cl
##     z$terms <- mt
##     if (model)
##         z$model <- mf
##     if (ret.x)
##         z$x <- x
##     if (ret.y)
##         z$y <- y
##     if (!qr)
##         z$qr <- NULL
##     z
## }
## position_identity
```

```
#plot total monthly precip data to see rough trend
ggplot(Beaufort_Clean, aes(x=Date, y=sumMonthlyPrecip))+
  geom_point()+
  geom_smooth(method = lm)
```

```
## `geom_smooth()` using formula 'y ~ x'
```

```
## Warning: Removed 9 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 9 rows containing missing values (geom_point).
```




```
t.test(Beaufort_Clean$meanmonthlyprecip)
```

```
##
##  One Sample t-test
##
## data:  Beaufort_Clean$meanmonthlyprecip
## t = 32.567, df = 434, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  3.898851 4.399669
## sample estimates:
## mean of x
##   4.14926
```

```
#significant
```

```
t.test(Beaufort_early$PrecipInches, Beaufort_Late$PrecipInches)
```

```
##
##  Welch Two Sample t-test
##
## data:  Beaufort_early$PrecipInches and Beaufort_Late$PrecipInches
## t = -0.64906, df = 7133.8, p-value = 0.5163
```

```
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02812072  0.01413102
## sample estimates:
## mean of x mean of y
## 0.1627598 0.1697546
```

```
#not significant

t.test(Beaufort_early$sigPrecip, Beaufort_Late$sigPrecip)
```

```
##
##  Welch Two Sample t-test
##
## data:  Beaufort_early$sigPrecip and Beaufort_Late$sigPrecip
## t = -2.7068, df = 5451.7, p-value = 0.006815
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.028681849 -0.004586864
## sample estimates:
##   mean of x   mean of y
## 0.005537589 0.022171945
```

```
#significant!
```

```
library(Kendall)
#Note: probably won't include this because the data is seasonal data
MannKendall(Beaufort_early$PrecipInches)
```

```
## tau = -0.00554, 2-sided pvalue =0.66022
```

```
MannKendall(Beaufort_early$sigPrecip)
```

```
## tau = 0.00613, 2-sided pvalue =0.65011
```

```
#neither are significant

MannKendall(Beaufort_Late$PrecipInches)
```

```
## tau = 0.0638, 2-sided pvalue =0.00000035763
```

```
#significant
MannKendall(Beaufort_Late$sigPrecip)
```

```
## tau = 0.00857, 2-sided pvalue =0.52552
```

```
#not significant
```

```
Late_full_ts <- ts(Beaufort_Late$PrecipInches, start= c(1,2007), frequency = 365)
SeasonalMannKendall(Late_full_ts)
```

```
## WARNING: Error exit, tauk2. IFAULT =  12
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## WARNING: Error exit, tauk2. IFAULT =  12
```

```
## tau = 0.066, 2-sided pvalue =0.0000066885
```

```
#significant

Late_sig_ts <- ts(Beaufort_Late$sigPrecip, start= c(1,2007), frequency = 365)
SeasonalMannKendall(Late_sig_ts)
```

```
## WARNING: Error exit, tauk2. IFAULT =  12
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```

```
## tau = 0.0243, 2-sided pvalue =0.7341
```

```
#not significant

Early_full_ts <- ts(Beaufort_early$PrecipInches, start = c(1,1997), frequency = 365)
SeasonalMannKendall(Early_full_ts)
```

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## WARNING: Error exit, tauk2. IFAULT =  12
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```

```
## tau = -0.00305, 2-sided pvalue =0.83608
```

```
#not significant

Early_sig_ts <- ts(Beaufort_early$sigPrecip, start = c(1,1997), frequency = 365)
SeasonalMannKendall(Early_sig_ts)
```

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```

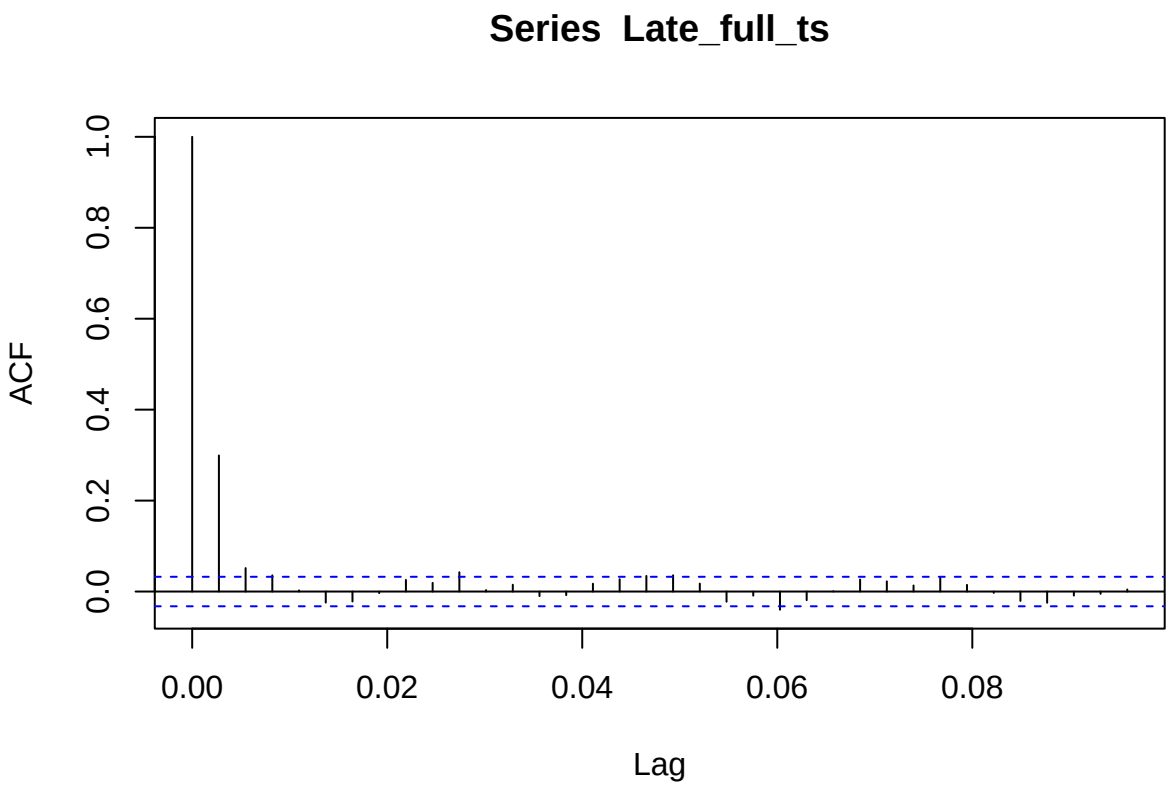
```
## tau = 0.0497, 2-sided pvalue =0.72772
```

```
#not significant
```

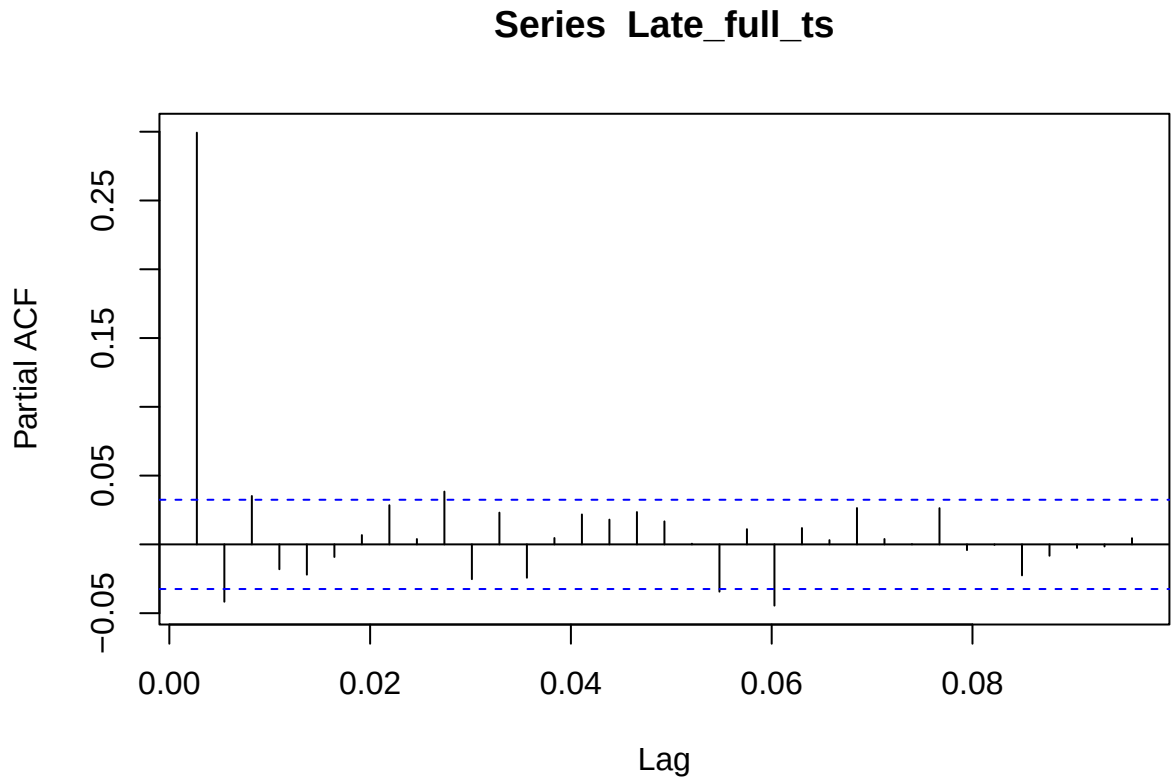
Let's inspect the ACF and PACF plots. Notice the ACF plot has repeating positive and

negative components (indicating seasonality), whereas the PACF decays over time without a clear seasonal structure.

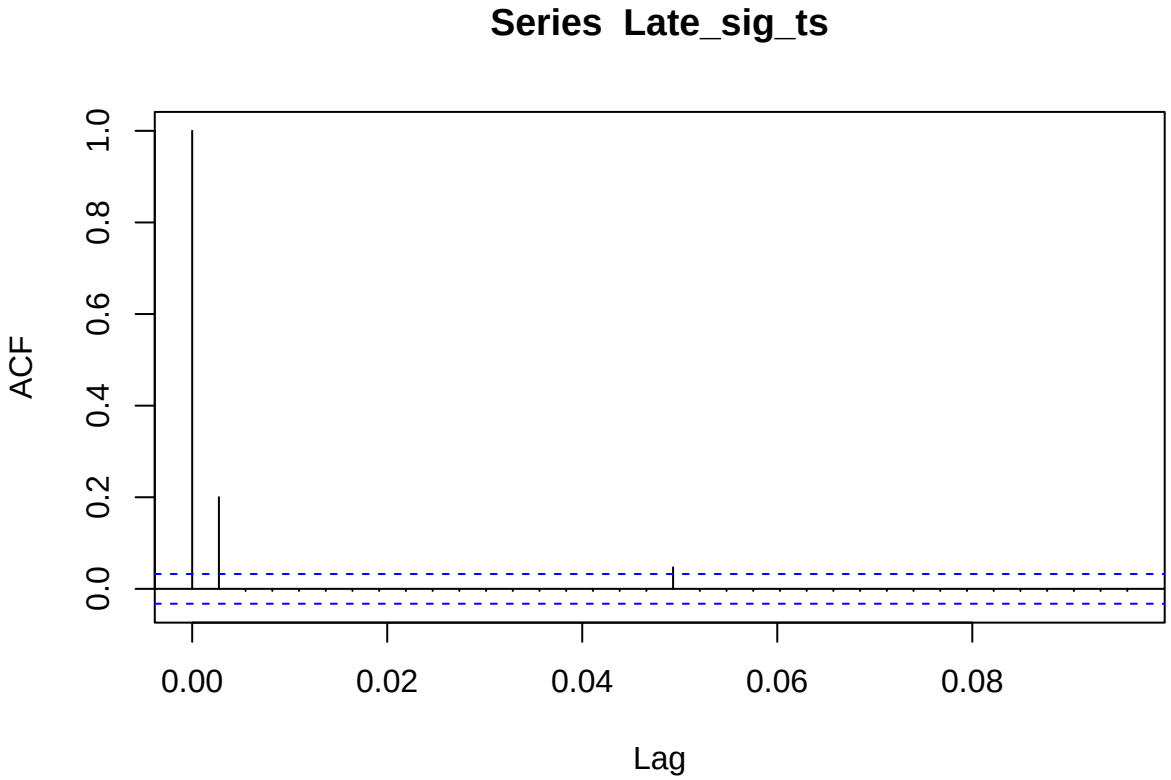
```
acf(Late_full_ts)
```



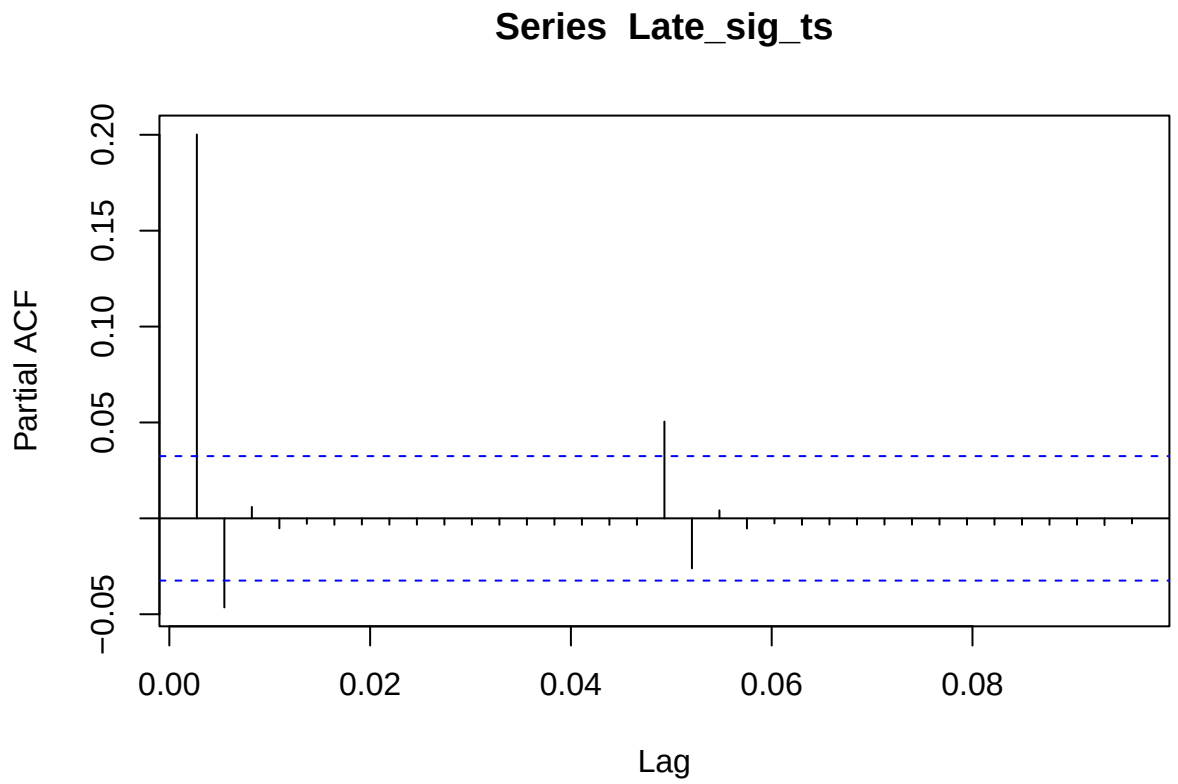

```
pacf(Late_full_ts)
```



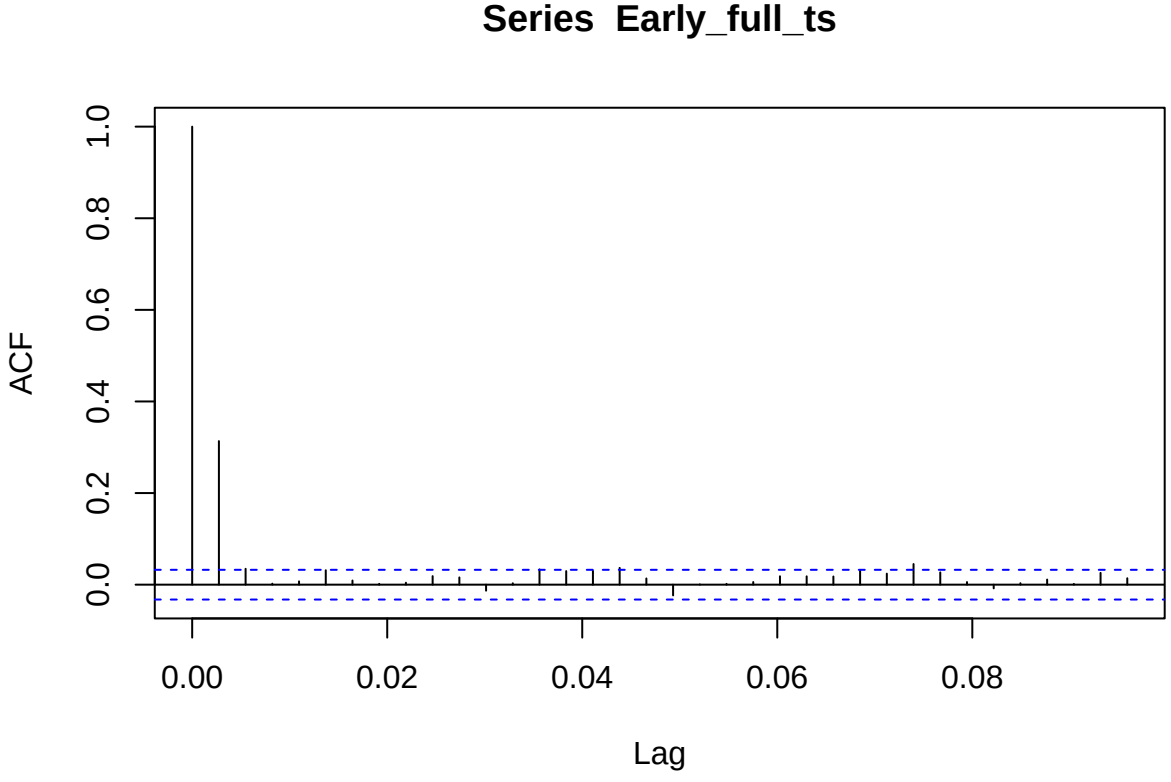

```
acf(Late_sig_ts)
```



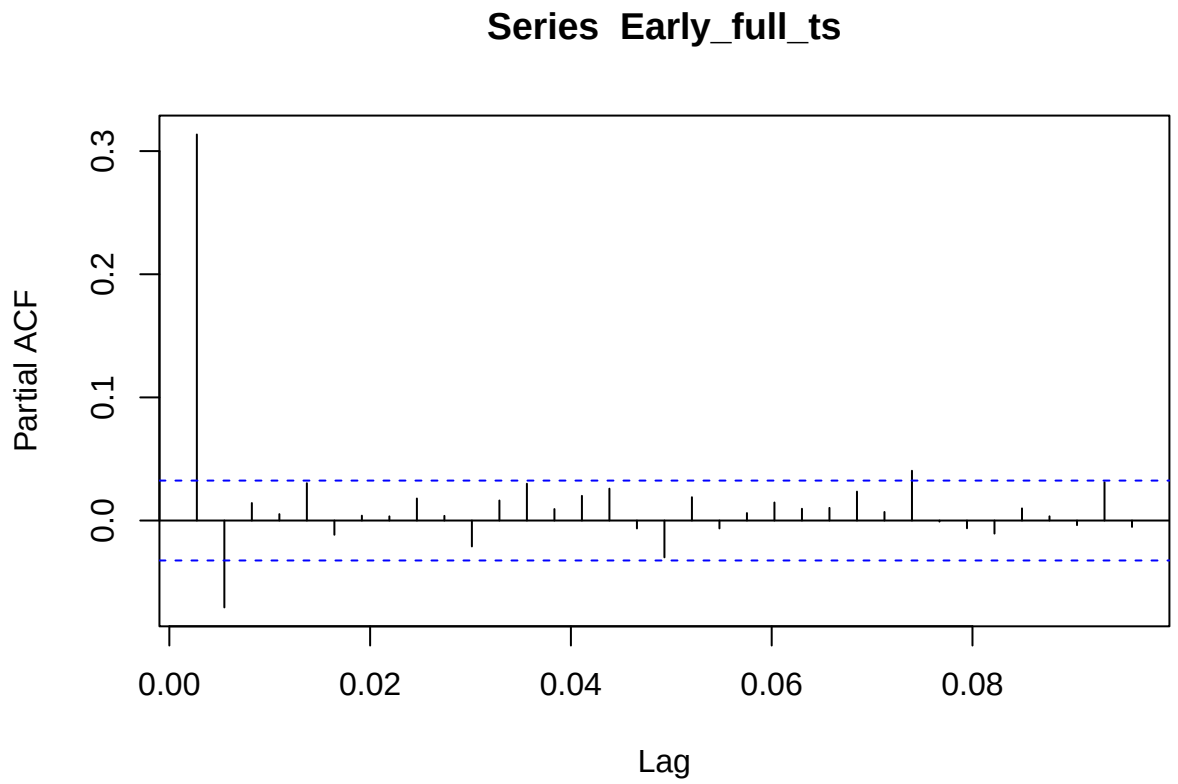
```
pacf(Late_sig_ts)
```



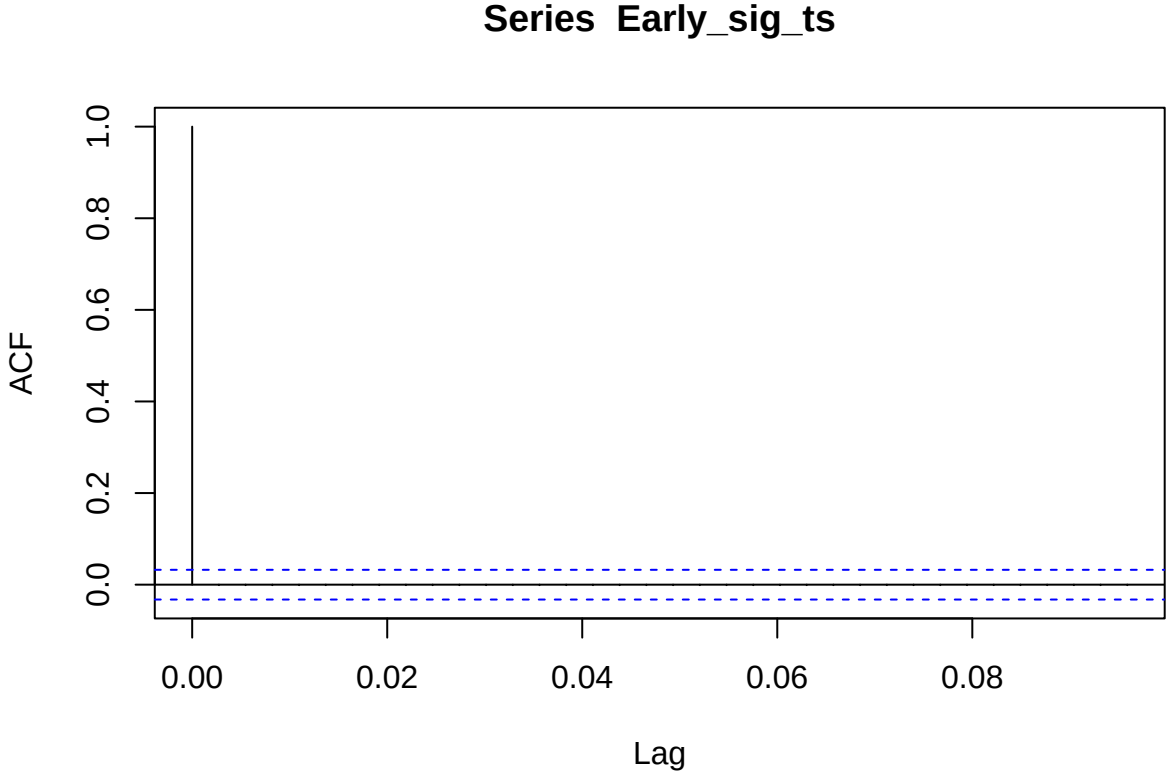

```
acf(Early_full_ts)
```



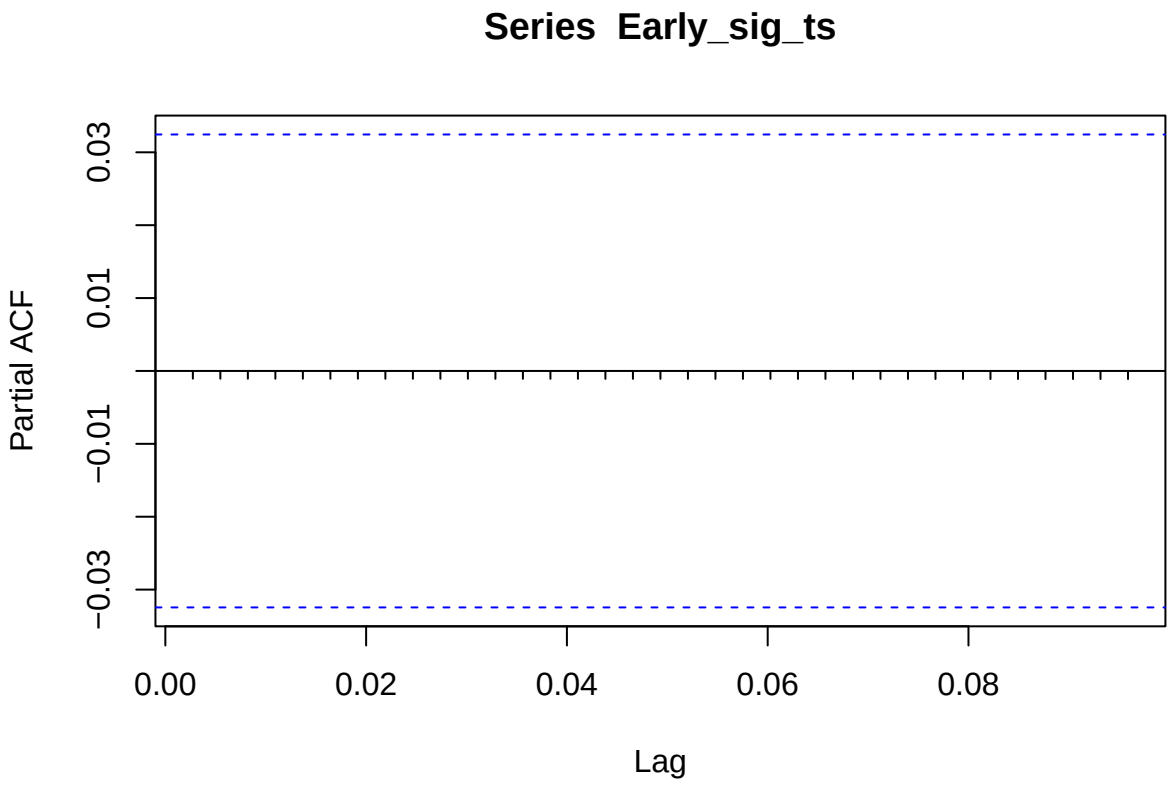
```
pacf(Early_full_ts)
```




```
acf(Early_sig_ts)
```



```
pacf(Early_sig_ts)
```



1 Rationale and Research Questions

Hypothesis: There is a significant increase in significant storm events in Beaufort, NC

We will be looking at the trends of precipitation over time for Beaufort, NC.

2 Dataset Information

** Significant precipitation events are considered “1 year events” using NOAA.

3 Exploratory Analysis

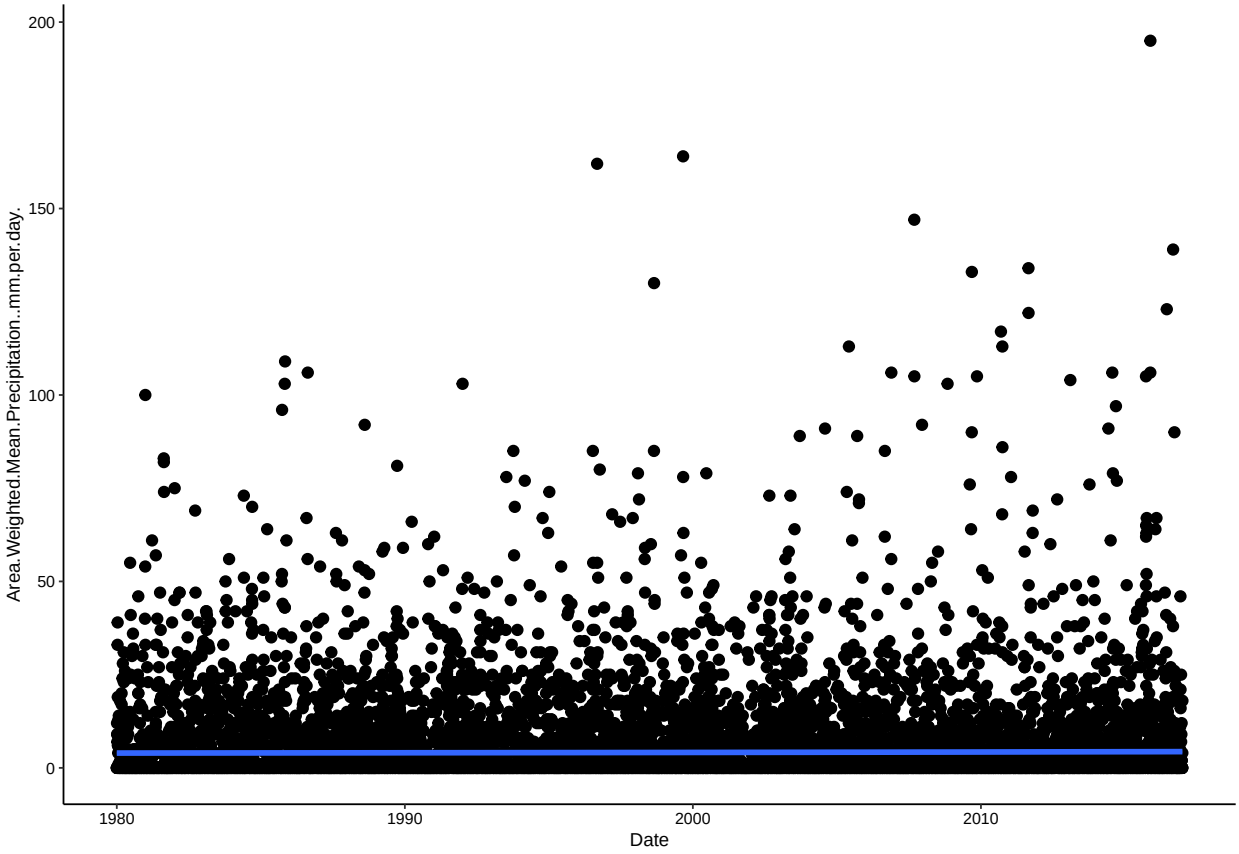
4 Analysis

```
#plot data to see possible trend
ggplot(Beaufort_RAW, aes(x=Date, y=Area.Weighted.Mean.Precipitation..mm.per.day.))+
  geom_point()+
  geom_smooth()
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

```
## Warning: Removed 9 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 9 rows containing missing values (geom_point).
```



4.1 Question 1: Is there is an increase in precipitation over time at Beaufort, NC?

- We will be using a Seasonal Kendall-Mann test to determine any trends in precipitation data.
- We will be using Seasonal Mann-Kendall test because precipitation has seasonal trends. We want to look at the precipitation trends without the variable of seasonality.

4.2 Question 2: Is there an increase in precipitation by decade?

- We will first visually compare the number of significant precipitation events for each decade, then run a t-test to determine if there is a significant difference in number of significant precipitation events comparing decades.

5 Summary and Conclusions

6 References

<add references here if relevant, otherwise delete this section>