PRECIP ANOMALY

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When we think about "precipitation anomalies", what exactly are we referring to? *Anomaly = deviation from some "normal" condtition or set of conditions (e.g. climate)* Oftentimes this envokes reference to some historical average for precip. or temp (oftentimes a running 30 year average, etc.)

Why would we be intersted in invetigating anomalies in rainfall/precip? * global climate change * to know when unusuall climate/environmental conditions are happening in one fo the LTER sites.

Specifically at the Luquillo (LUQ) LTER, we were intersted in knowing when it is really dry and when it is really wet, for the sampling of soil moisture. It turns out that if you sample soil moisture randomally or on some determined intervals (i.e. scheduling) that you get a pretty good sampling of normal soil moisture conditions, however, getting data when the soil is really dry or really we can be challenging. (i.e. when do you know when it's really dry or really wet).

This is important becuase it has allowed us to start to sample soil moisture around wet and dry events, and start to investigate some of the ecosystem responses. (i.e. Silver and Ruan -in prep, soil dissolved oxygen and soil moisture content).

This may all be fine and dandy, but how does one go about identifying precipitaiton anomalies?
1. you start with a definable statistical definition of wet and dry events (we used a 10% qualtile (or deciles) calcualtion). That means that we were interested in identifying the wettest and driest 10% of climate events on record (rainfall data goes back to 1975 - two datasets NADP tower and hand collected data) 2. you then relate those events to the precip record, using cumulative averaging (1-week, 2-week, 3-week, 1-month running average) 3. Then you can create a tool that backtracks current precip. data and tells you when rainfall totals for the cumulative averaging are in the desired 10% of wettest or driest events.

START OF CODE:::

```
# load libraries and set working directory
library(zoo)
```

```
## Warning: package 'zoo' was built under R version 3.1.3
```

```
##
## Attaching package: 'zoo'
##
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
library(hydroTSM)
```

```
## Warning: package 'hydroTSM' was built under R version 3.1.2
```

```
## Loading required package: xts
```

```
## Warning: package 'xts' was built under R version 3.1.2
```

```
setwd("~/Desktop/LFDP climate data")
```

```
#load in data   ---- look up way to load in the data via web download
rain1975 <- read.delim("~/Desktop/LFDP climate data/evra1975-1989.txt")
rain1990 <- read.delim("~/Desktop/LFDP climate data/evra1990-1999.txt")
rain2000 <- read.delim("~/Desktop/LFDP climate data/evra2000-2009.txt")
rain2010 <- read.csv("~/Desktop/LFDP climate data/evra2010-current_5.csv")
```

Not a necessary step - there are more elegant ways to code the following, but this way allows you to see that all data get converted to the proper formats step-by-step (use class and str / head and tail functions to check)

```
##Create vectors for desired data (in correct data class)
one <- as.Date(rain1975$DATE, format = "%m/%d/%y")
two <- rain1975$RAINFALL..MM.
three <- as.Date(rain1990$DATE, format = "%m/%d/%y")
four <- rain1990$RAINFALL..MM.
five <- as.Date(rain2000$DATE, format = "%m/%d/%y")
six <- rain2000$RAINFALL..MM.
seven <- as.Date(rain2010$DATE, format = "%m/%d/%Y")
eight <- rain2010$RAINFALL..MM

#concatenate data vectors
days <- c(one, three, five, seven)
precip <- c(two, four, six, eight)
#LFDP <- zoo(precip, order.by = days) #alternative way to do the same thing
LFDP <- xts(precip, order.by = days)

#clean workspace
remove(one, two, three, four, five, six, seven, eight)
```

From the HYDROTSM vignette

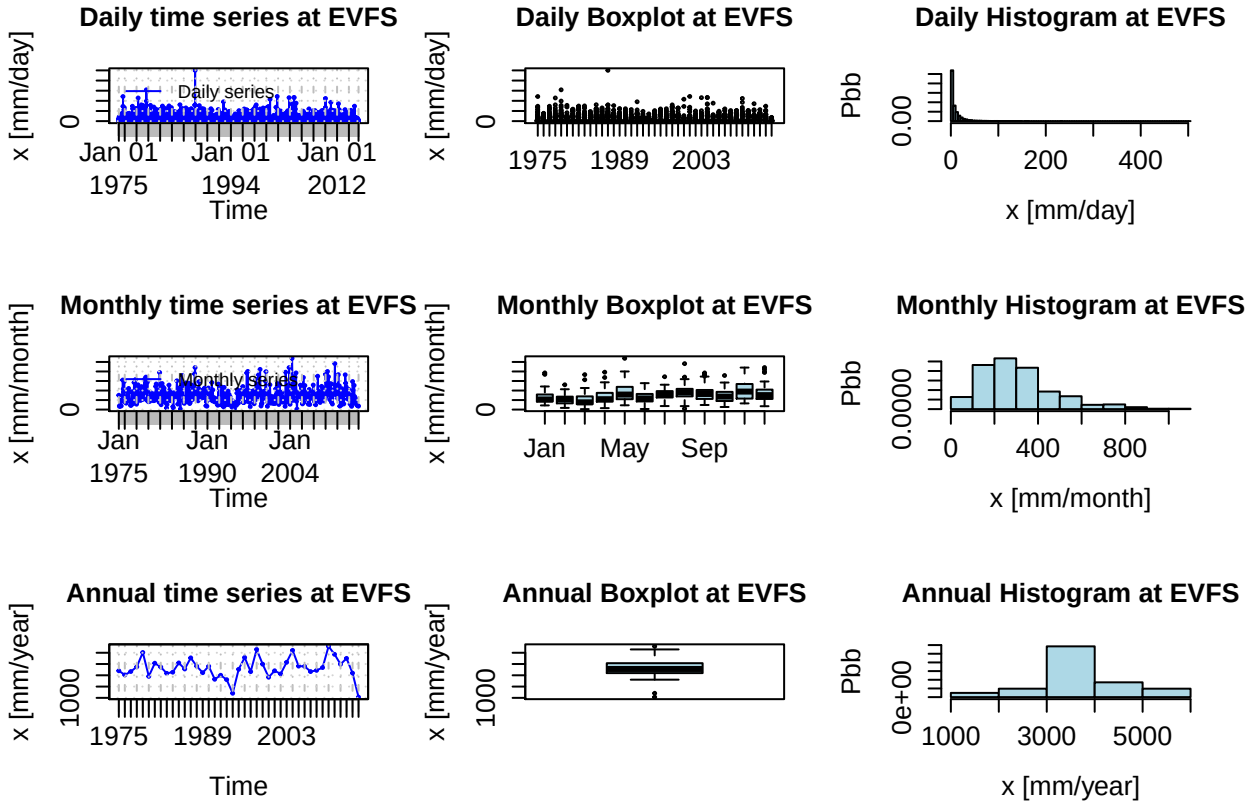
```
##window function -- selects slice of data for TSanalysis
#---use "start=as.Date("YYYY-MM-DD")" arguement to specify start of TS
x <- window(LFDP, start=as.Date("1975-01-01"), end=as.Date("2015-08-21"))

# set monthly values
m <- daily2monthly(x, FUN=sum)

# set daily values of 'x'
dates <- time(x)

# amount of years in 'x' (needed for computation)
( nyears <- yip(from=start(x), to=end(x), out.type="nmbr") )
```

```
## [1] 41
```

```
##hydroplot function
hydroplot(x, var.type="Precipitation", main="at EVFS", pfreq = "dma")
```

```
## Warning in if (is.na(match(class(x), c("zoo", "xts")))) stop("Invalid
## argument: 'class(x)' must be in c('zoo', 'xts')"): the condition has length
## > 1 and only the first element will be used
```

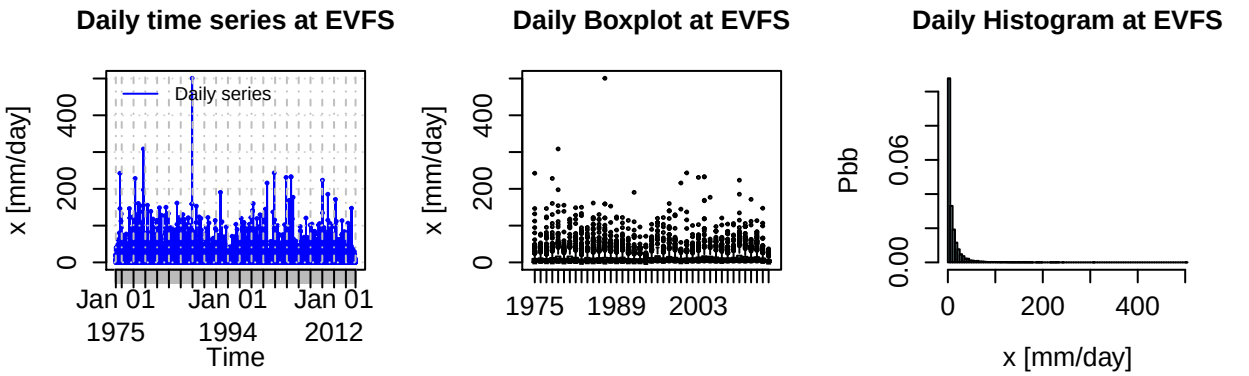
```
## Warning in if (is.na(match(class(x), c("zoo", "xts")))) stop("Invalid
## argument: 'class(x)' must be in c('zoo', 'xts')"): the condition has length
## > 1 and only the first element will be used
```

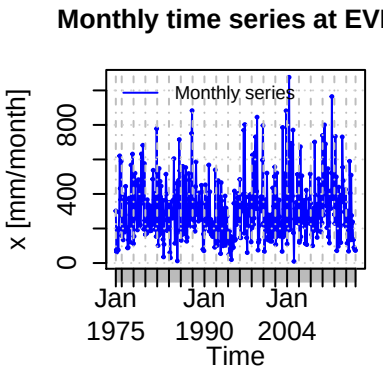


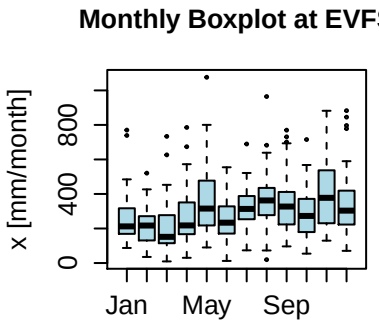

```
hydroplot(x, var.type="Precipitation", main="at EVFS", pfreq = "dm") # hydroplot function using "dm" -
```

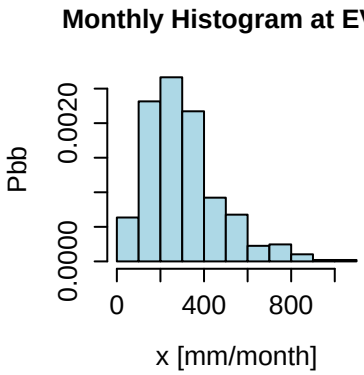
```
## Warning in if (is.na(match(class(x), c("zoo", "xts")))) stop("Invalid
## argument: 'class(x)' must be in c('zoo', 'xts')"): the condition has length
## > 1 and only the first element will be used
```

```
## Warning in if (is.na(match(class(x), c("zoo", "xts")))) stop("Invalid
## argument: 'class(x)' must be in c('zoo', 'xts')"): the condition has length
## > 1 and only the first element will be used
```










```
#amount of days with information (not NA) per year
dwi(x)
```

```
##
## 1975 365
## 1976 366
## 1977 365
## 1978 365
## 1979 365
## 1980 366
## 1981 365
## 1982 365
## 1983 365
## 1984 366
## 1985 365
## 1986 365
## 1987 365
## 1988 366
## 1989 365
## 1990 365
## 1991 365
## 1992 366
## 1993 365
## 1994 365
## 1995 365
## 1996 366
## 1997 365
## 1998 365
```

```
## 1999 365
## 2000 366
## 2001 365
## 2002 365
## 2003 365
## 2004 366
## 2005 365
## 2006 365
## 2007 365
## 2008 366
## 2009 365
## 2010 365
## 2011 365
## 2012 366
## 2013 365
## 2014 365
## 2015 233
```

```
#amount of days with information (not NA) per month per year
#dwi(x, out.unit="mpy")
```

```
##plotting the monthly percipitaion values for each year- useful for identifying dry/wet months--
#daily zoo to monthly zoo
m <- daily2monthly(x, FUN=sum, na.rm=TRUE)

# Creating a matrix with monthly values per year in each column
M <- matrix(m, ncol=12, byrow=TRUE)
```

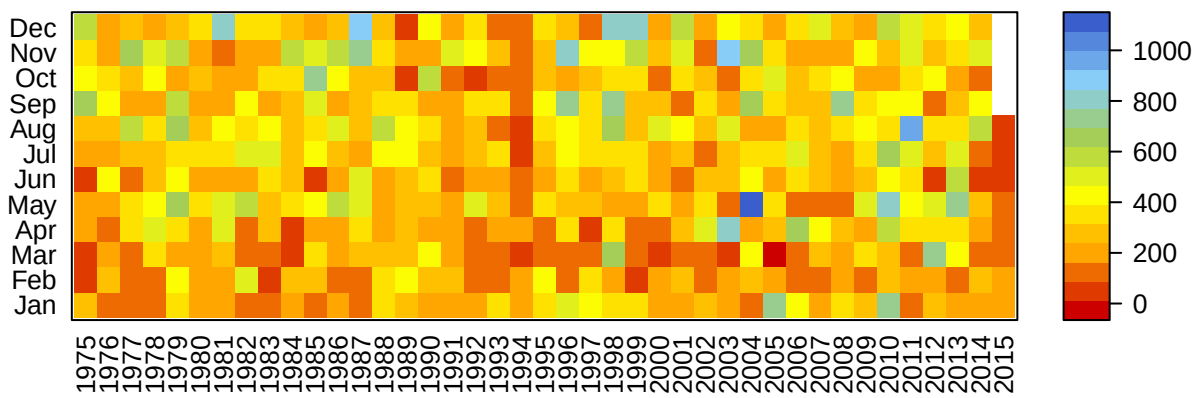
```
## Warning in matrix(m, ncol = 12, byrow = TRUE): data length [488] is not a
## sub-multiple or multiple of the number of rows [41]
```

```
#### MUST CLEAN OUT MONTHS 9-12 (September - December 2015)
M[41,12] <-NA
M[41,11] <-NA
M[41,10] <-NA
M[41,9] <-NA

## colnames and rownames of Matrix M
colnames(M) <- month.abb
rownames(M) <- unique(format(time(m), "%Y"))

# Plotting the monthly precipitation values
require(lattice)
```

```
## Loading required package: lattice
```

```
## Warning: package 'lattice' was built under R version 3.1.3
```

```
matrixplot(M, ColorRamp="Precipitation",main="Monthly precipitation at EVFS., [mm/month] \n 1975-AUG 20
```




```
##Annual Analysis
daily2annual(x, FUN=sum, na.rm=TRUE)
```

```
## 1975-01-01 1976-01-01 1977-01-01 1978-01-01 1979-01-01 1980-01-01
##    3400.10    3033.60    3335.90    3751.90    5022.90    2904.30
## 1981-01-01 1982-01-01 1983-01-01 1984-01-01 1985-01-01 1986-01-01
##    4073.70    3730.20    3174.40    3276.80    4097.60    3561.00
## 1987-01-01 1988-01-01 1989-01-01 1990-01-01 1991-01-01 1992-01-01
##    4545.00    3808.00    3230.50    3806.74    2647.72    3002.42
## 1993-01-01 1994-01-01 1995-01-01 1996-01-01 1997-01-01 1998-01-01
##    2612.27    1404.52    3532.38    4576.31    3323.34    5293.70
## 1999-01-01 2000-01-01 2001-01-01 2002-01-01 2003-01-01 2004-01-01
##    3986.68    2828.69    3402.05    3125.83    4152.98    5211.34
## 2005-01-01 2006-01-01 2007-01-01 2008-01-01 2009-01-01 2010-01-01
##    3811.95    3795.69    3329.54    3436.31    3687.54    5566.98
## 2011-01-01 2012-01-01 2013-01-01 2014-01-01 2015-01-01
##    4861.31    3977.85    4500.17    3194.31    1064.30
```

```
# annual function- computes annual average of precip.
annualfunction(x, FUN=sum, na.rm=TRUE) / nyears
```

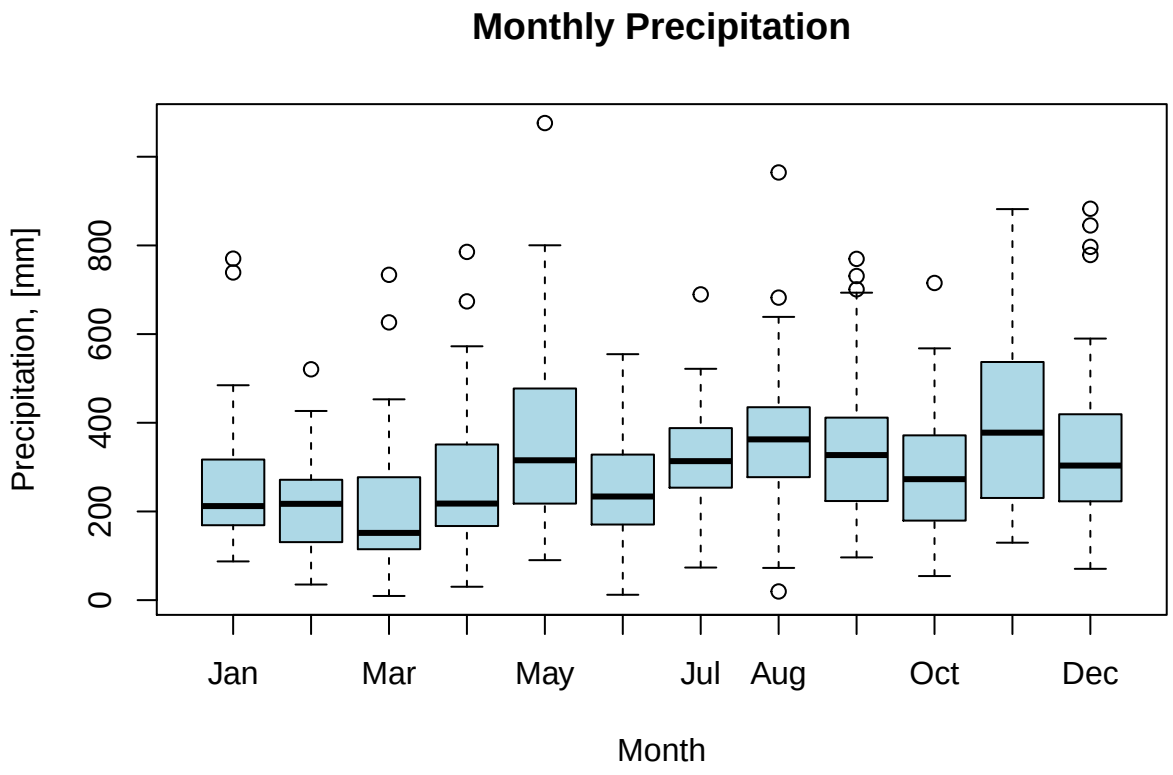
```
##             X
## [1,] 3636.069
```

```
##Monthly Analysis / monthly function computes monthly rainfall averages
monthlyfunction(m, FUN=median, na.rm=TRUE)
```

```
##     Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep
## 212.150 217.160 151.620 217.800 315.390 233.710 313.440 362.530 327.205
##     Oct     Nov     Dec
## 272.800 377.705 303.500
```

```
#vector with three letter abreviations for month names
cmonth <- format(time(m), "%b")
```

```r
#creating ordered monthly factors
months <- factor(cmonth, levels=unique(cmonth), ordered=TRUE)
#boxplot of the monthly values
boxplot(coredata(m) ~ months, col="lightblue", main="Monthly Precipitation",ylab="Precipitation, [mm]",
```




```r
##Seasonal Analysis
#setting the seasons and getting average seasonal values for each year
seasonalfunction(x, FUN=sum, na.rm=TRUE, type ="FrenchPolynesia") / nyears
```

```
##          DJFM       AM   JJAS       ON
## [1,] 1035.744 643.5634 1287.4 669.3617
```

```r
seasonalfunction(x, FUN=sum, na.rm=TRUE, verbose = TRUE) / nyears
```

```
##           DJF      MAM      JJA      SON
## [1,] 825.6285 853.6788 942.2207 1014.541
```

```r
#extracting the seasonal value for each year--dm2seasonal function
DJF <- dm2seasonal(x, season="DJF", FUN=sum)
MAM <- dm2seasonal(m, season="MAM", FUN=sum)
JJA <- dm2seasonal(m, season="JJA", FUN=sum)
SON <- dm2seasonal(m, season="SON", FUN=sum)
#Plotting the time evolution of the seasonal precipitation values
dev.off()
```

```
## null device
##           1
```

```
hydroplot(x, pfreq="seasonal", ptype = "ts+hist", FUN=sum, stype="default")
```

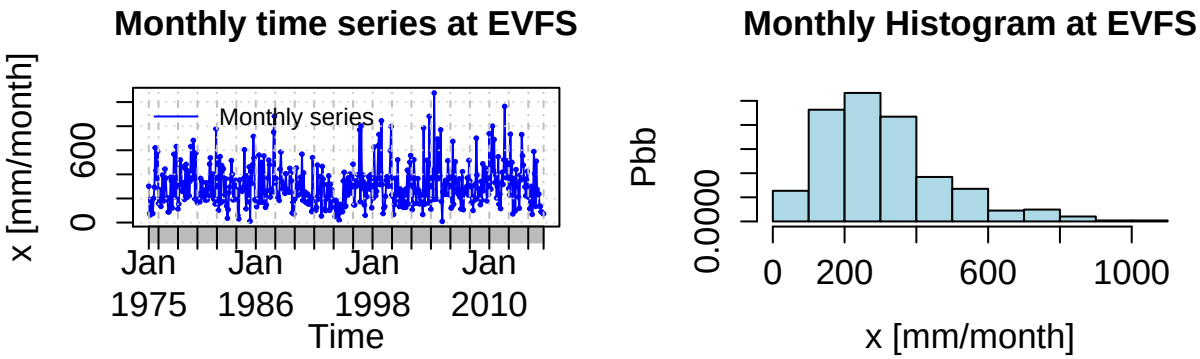
```
## [Note: 'pfreq=seasonal' => 'ptype' has been changed to 'ts+boxplot']
```

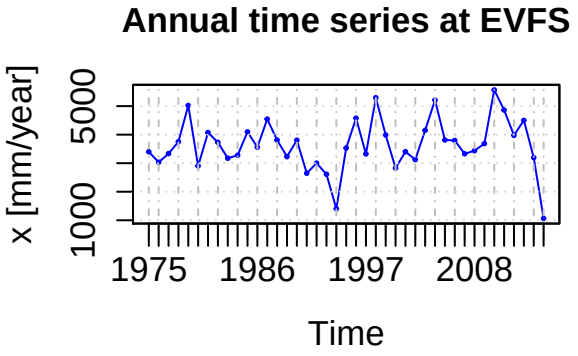
We can look at the rainfall data in terms of variance in the dataset

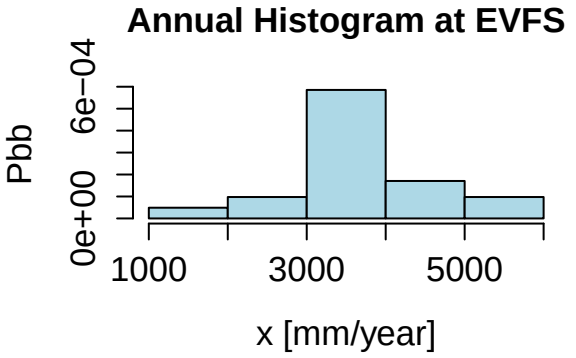
```
############HYDROPLOT FUN - plotting using variance
hydroplot(x, ptype= "ts+hist", var.type="Precipitation", main="at EVFS", pfreq = "ma", varunit = "mm")
```

```
## Warning in plot.window(...): "varunit" is not a graphical parameter

## Warning in plot.xy(xy, type, ...): "varunit" is not a graphical parameter

## Warning in title(main = "Monthly time series at EVFS", xlab = "Time", ylab
## = "x [mm/month]", : "varunit" is not a graphical parameter

## Warning in axis(side = 1, at = ticks.coords$x, labels = FALSE, col =
## "#BBBBBB", : "varunit" is not a graphical parameter

## Warning in axis(side = 1, at = labs.coords$x[labs.dates], labels =
## labs.lab, : "varunit" is not a graphical parameter

## Warning in plot.window(...): "varunit" is not a graphical parameter

## Warning in plot.xy(xy, type, ...): "varunit" is not a graphical parameter

## Warning in title(main = "Annual time series at EVFS", xlab = "Time", ylab =
## "x [mm/year]", : "varunit" is not a graphical parameter

## Warning in axis(side = 1, at = ticks.coords$x, labels = FALSE, col =
## "#BBBBBB", : "varunit" is not a graphical parameter

## Warning in axis(side = 1, at = labs.coords$x[labs.dates], labels =
## labs.lab, : "varunit" is not a graphical parameter

## Warning in if (is.na(match(class(x), c("zoo", "xts")))) stop("Invalid
## argument: 'class(x)' must be in c('zoo', 'xts')"): the condition has length
## > 1 and only the first element will be used

## Warning in title(main = main, sub = sub, xlab = xlab, ylab = ylab, ...):
## "varunit" is not a graphical parameter

## Warning in axis(1, ...): "varunit" is not a graphical parameter

## Warning in axis(2, ...): "varunit" is not a graphical parameter

## Warning in title(main = main, sub = sub, xlab = xlab, ylab = ylab, ...):
## "varunit" is not a graphical parameter
```

```
## Warning in axis(1, ...): "varunit" is not a graphical parameter

## Warning in axis(2, ...): "varunit" is not a graphical parameter
```







BREAK in code One thing now that we have looked at the data, is define our deciles for the 10% of wettest and driest precip events. We do this using the quantile() function (remember to set sequence of probablitlies for you specific situation).

```
######WEEKLY####
ep <- c(0, seq(1, nrow(LFDP), by = 7), nrow(LFDP))
weeks <- period.apply(LFDP, ep, FUN=sum)
quantile(weeks, probs = seq(0, 1, 0.1), na.rm = TRUE, type = 1)
```

```
##     0%    10%    20%    30%    40%    50%    60%    70%    80%    90%
##   0.00   8.20  19.28  30.23  39.80  52.14  65.60  81.50 104.40 150.62
##   100%
## 616.90
```

```
######getting number of dry weekly events in data set to determine sampling effort nedded####
dryweeks <- subset(weeks, weeks<8.3)
print(dryweeks)
```

```
##            [,1]
## 1975-03-12 3.60
## 1975-03-26 2.20
## 1975-04-09 5.10
## 1975-05-07 0.00
```

```
## 1975-05-28 6.60
## 1975-06-11 1.70
## 1976-03-31 2.50
## 1976-04-07 4.70
## 1976-04-14 0.50
## 1976-05-26 1.60
## 1977-01-05 4.50
## 1977-01-12 6.30
## 1977-05-11 0.00
## 1978-01-18 7.50
## 1978-02-22 2.30
## 1978-06-07 6.90
## 1978-08-02 3.60
## 1978-10-04 1.20
## 1979-01-31 0.00
## 1979-03-28 7.40
## 1979-05-09 7.50
## 1979-10-24 0.60
## 1979-10-31 6.80
## 1980-01-02 1.50
## 1980-01-30 5.80
## 1980-04-02 0.60
## 1980-04-09 4.60
## 1980-06-04 3.10
## 1980-11-12 3.10
## 1981-06-24 3.90
## 1982-01-27 7.70
## 1982-03-24 1.90
## 1982-10-06 8.20
## 1982-12-15 7.10
## 1983-01-19 4.30
## 1983-01-26 8.00
## 1983-02-02 7.70
## 1983-02-09 0.60
## 1983-02-16 3.50
## 1983-03-02 0.90
## 1983-03-23 0.00
## 1983-04-06 6.10
## 1983-04-13 5.10
## 1983-06-01 4.80
## 1983-10-26 6.40
## 1983-11-16 0.80
## 1983-11-23 5.50
## 1984-03-07 7.70
## 1984-03-28 5.00
## 1984-04-04 0.00
## 1984-04-11 4.00
## 1984-04-18 0.80
## 1984-06-27 4.40
## 1985-01-23 0.30
## 1985-02-13 1.70
## 1985-05-01 2.00
## 1985-05-08 3.10
## 1985-05-29 0.00
```

```
## 1985-06-05 0.00
## 1985-06-12 1.00
## 1985-06-26 0.00
## 1986-04-16 0.00
## 1986-09-17 0.00
## 1986-12-24 8.00
## 1987-01-14 3.00
## 1987-02-25 6.20
## 1987-03-11 8.20
## 1987-03-25 6.20
## 1987-04-01 3.70
## 1987-04-29 0.60
## 1987-10-14 7.30
## 1988-03-09 5.20
## 1988-03-16 0.00
## 1988-04-13 0.00
## 1988-06-08 2.10
## 1988-09-28 1.20
## 1989-05-24 0.00
## 1989-06-28 2.10
## 1989-09-27 0.00
## 1989-10-04 0.00
## 1989-10-11 0.00
## 1989-10-18 0.00
## 1989-11-29 6.00
## 1989-12-06 0.00
## 1989-12-13 1.20
## 1989-12-20 7.10
## 1989-12-27 1.50
## 1990-04-11 6.78
## 1991-01-23 4.94
## 1991-01-30 7.75
## 1991-04-24 4.62
## 1991-06-05 3.33
## 1991-06-19 7.27
## 1991-09-04 1.39
## 1991-10-23 1.86
## 1991-10-30 0.93
## 1992-01-22 0.00
## 1992-02-19 1.54
## 1992-03-04 4.32
## 1992-04-01 0.31
## 1992-04-22 4.89
## 1992-04-29 0.00
## 1992-10-07 3.55
## 1992-10-14 0.52
## 1993-02-10 4.32
## 1993-03-10 7.24
## 1993-03-31 0.93
## 1993-08-04 6.33
## 1993-11-03 5.00
## 1993-12-15 4.48
## 1994-03-09 2.31
## 1994-03-23 0.00
```

```
## 1994-03-30 1.47
## 1994-04-27 1.39
## 1994-05-25 0.77
## 1994-06-01 4.75
## 1994-07-13 7.71
## 1994-07-27 1.54
## 1994-08-03 7.87
## 1994-08-10 4.50
## 1994-08-17 2.15
## 1994-08-24 6.47
## 1994-08-31 4.62
## 1994-09-14 8.17
## 1994-10-05 5.40
## 1994-10-12 8.02
## 1994-10-19 2.45
## 1994-11-23 8.16
## 1994-12-21 6.33
## 1994-12-28 7.42
## 1995-01-25 6.59
## 1995-02-08 7.87
## 1995-03-22 1.52
## 1995-03-29 0.75
## 1995-04-05 3.30
## 1995-04-26 7.86
## 1995-05-03 1.27
## 1995-06-28 6.09
## 1995-07-05 2.30
## 1995-12-27 4.32
## 1996-02-14 2.79
## 1996-10-23 4.83
## 1997-01-15 4.33
## 1997-03-26 4.06
## 1997-04-02 6.09
## 1997-04-30 4.32
## 1997-06-11 5.09
## 1997-10-29 3.30
## 1997-11-12 8.13
## 1997-12-10 5.33
## 1998-01-21 1.78
## 1998-02-25 3.56
## 1999-02-24 3.56
## 1999-03-03 4.32
## 1999-03-17 0.00
## 1999-04-21 4.59
## 1999-05-05 0.25
## 1999-06-02 0.76
## 2000-01-26 7.35
## 2000-03-08 0.00
## 2000-04-26 7.11
## 2000-10-18 0.00
## 2001-01-10 0.78
## 2001-03-07 0.00
## 2001-05-16 6.09
## 2002-01-02 6.33
```

```
## 2003-01-15 4.08
## 2003-03-19 6.35
## 2003-05-07 7.11
## 2003-10-08 8.11
## 2004-01-21 0.25
## 2004-01-28 3.81
## 2004-03-10 1.77
## 2005-03-09 1.26
## 2005-03-16 0.00
## 2005-03-23 1.53
## 2005-03-30 2.30
## 2005-09-07 7.88
## 2006-03-01 1.52
## 2006-05-24 0.75
## 2007-01-31 0.25
## 2007-02-14 0.00
## 2007-04-11 0.00
## 2007-05-16 1.78
## 2007-05-23 2.80
## 2008-04-23 1.25
## 2008-05-14 0.00
## 2008-05-21 6.34
## 2009-04-08 4.07
## 2010-02-10 5.84
## 2010-03-24 2.80
## 2010-03-31 3.03
## 2010-06-09 1.53
## 2011-03-02 3.05
## 2011-06-15 7.86
## 2012-06-13 1.53
## 2012-09-12 1.02
## 2013-02-27 3.30
## 2013-03-13 7.10
## 2013-03-27 5.57
## 2014-03-19 3.82
## 2014-03-26 3.05
## 2014-04-30 0.00
## 2014-07-30 1.25
## 2014-10-08 1.53
## 2014-10-22 1.02
## 2015-03-04 0.76
## 2015-04-29 0.00
## 2015-05-06 1.02
## 2015-06-10 1.53
## 2015-07-08 4.57
## 2015-07-29 2.80
## 2015-08-21 2.03
```

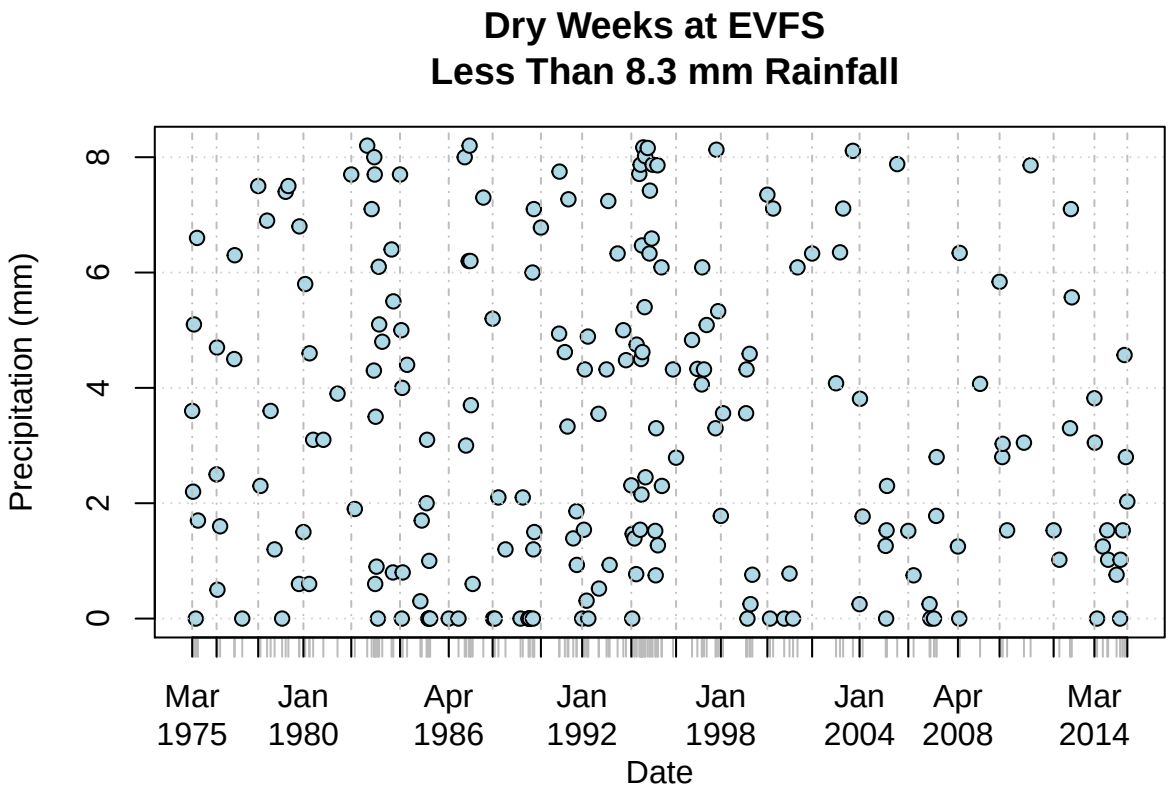
```
length(dryweeks)
```

```
## [1] 213
```

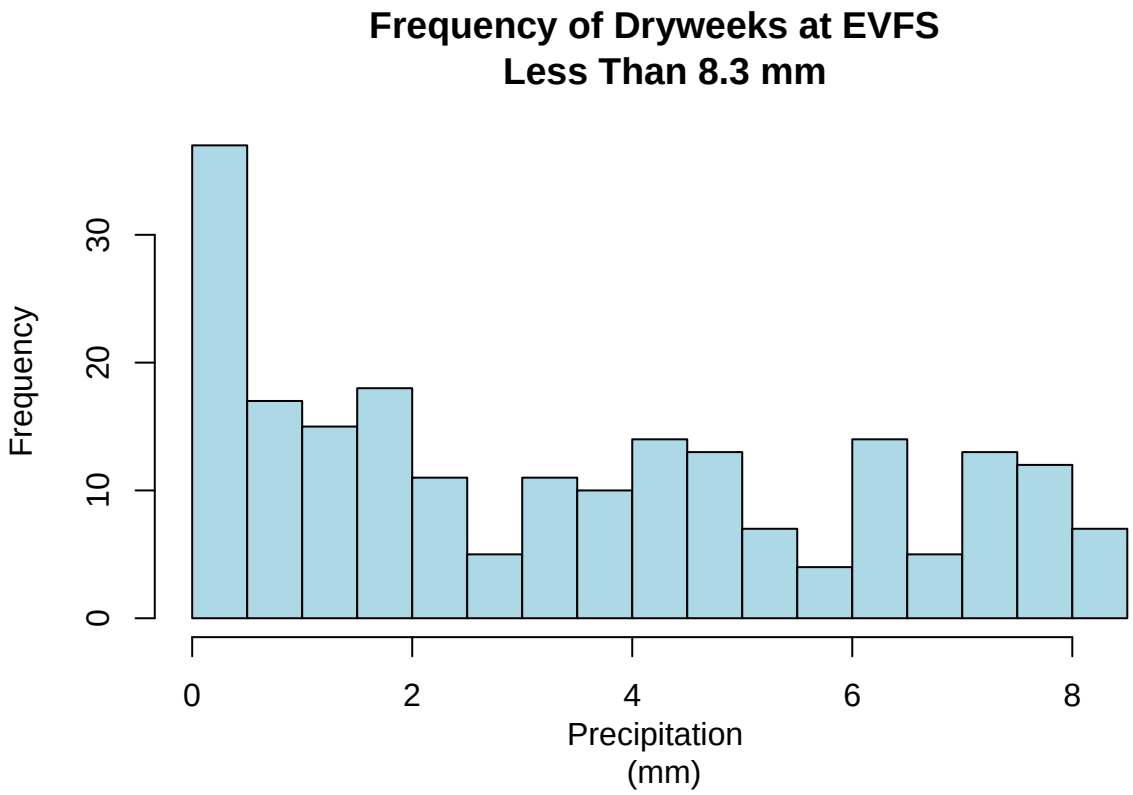
```r
length(dryweeks)/nyears
```

```
## [1] 5.195122
```

```r
####PLOTTING DRYWEEKS####
plot(dryweeks, type = "p", main ="Dry Weeks at EVFS \n Less Than 8.3 mm Rainfall", xlab = "Date", ylab =
```




```r
hist(dryweeks, breaks = seq(min(dryweeks),max(dryweeks)+0.5,0.5), main = "Frequency of Dryweeks at EVFS
```




```
###BI WEEKLY######
ep1 <- c(0, seq(1, nrow(LFDP), by = 14), nrow(LFDP))
biweeks <- period.apply(LFDP, ep1, FUN=sum)
quantile(biweeks, probs = seq(0, 1, 0.1), na.rm = TRUE, type = 1)
```

```
##     0%    10%    20%    30%    40%    50%    60%    70%    80%    90%
##   0.00  33.79  56.60  79.40  98.30 115.83 141.25 165.80 206.20 277.60
##   100%
## 692.90
```

```
######getting number of dry biweekly events in data set to determine sampling effort nedded####
drybiweeks <- subset(biweeks, biweeks<33.9)
print(drybiweeks)
```

```
##             [,1]
## 1975-01-01 21.60
## 1975-03-12 23.70
## 1975-03-26 24.70
## 1975-06-04 26.80
## 1975-06-18 31.60
## 1976-01-14 33.20
## 1976-04-07  7.20
## 1976-06-02 27.80
## 1977-01-12 10.80
## 1977-02-23 32.60
## 1977-03-23 26.60
## 1977-06-15 31.50
```

```
## 1978-01-25 26.00
## 1978-02-22 14.60
## 1979-02-07  9.90
## 1979-10-31  7.40
## 1980-04-02 11.70
## 1982-03-31 28.30
## 1982-10-13 18.60
## 1983-02-02 15.70
## 1983-02-16  4.10
## 1983-03-02 29.60
## 1983-03-30  8.80
## 1983-04-13 11.20
## 1983-11-23  6.30
## 1984-03-28 21.20
## 1984-04-11  4.00
## 1984-04-25 16.30
## 1985-01-30 16.90
## 1985-02-13 22.70
## 1985-03-27 25.50
## 1985-05-08  5.10
## 1985-06-05  0.00
## 1985-06-19 11.50
## 1986-03-12 33.40
## 1986-04-23 30.80
## 1987-01-14 28.20
## 1987-01-28 30.70
## 1987-04-08 32.60
## 1988-03-23 17.70
## 1989-10-04  0.00
## 1989-10-18  0.00
## 1989-11-29 20.00
## 1989-12-13  1.20
## 1989-12-27  8.60
## 1991-05-01 13.41
## 1991-10-30  2.79
## 1992-04-01 14.51
## 1992-04-29  4.89
## 1992-07-08 29.90
## 1992-10-14  4.07
## 1992-10-28 26.76
## 1993-02-17 28.05
## 1993-03-17 20.72
## 1993-04-28 32.87
## 1993-10-13 30.24
## 1994-03-16 31.14
## 1994-03-30  1.47
## 1994-05-25 30.40
## 1994-06-22 30.54
## 1994-08-03  9.41
## 1994-08-17  6.65
## 1994-08-31 11.09
## 1994-09-14 31.05
## 1994-10-12 13.42
## 1995-01-04 29.17
```

```
## 1995-03-29  2.27
## 1995-04-12 25.90
## 1995-07-05  8.39
## 1997-04-09 33.79
## 1997-04-23 26.67
## 1997-05-07 25.14
## 1998-01-28 16.01
## 1998-02-25 29.72
## 1999-02-24 32.76
## 1999-03-10 21.07
## 1999-06-02 21.85
## 2000-04-05 32.75
## 2000-10-18 32.77
## 2001-01-10 12.72
## 2003-01-22 23.36
## 2003-03-05 29.99
## 2003-03-19 20.58
## 2004-02-04 18.54
## 2005-03-16  1.26
## 2005-03-30  3.83
## 2006-03-29 31.76
## 2006-05-24  9.14
## 2007-02-14 25.64
## 2007-05-23  4.58
## 2008-04-23 13.94
## 2008-05-21  6.34
## 2008-07-30 31.49
## 2010-03-24 28.96
## 2010-04-07 24.90
## 2010-06-16 25.15
## 2011-03-09 33.02
## 2012-06-13 33.80
## 2012-09-19 20.33
## 2014-04-02 33.51
## 2014-06-25 25.16
## 2015-04-01 20.09
## 2015-04-29 28.20
## 2015-05-13 12.96
## 2015-06-10 33.28
## 2015-07-22 32.52
## 2015-08-05 32.02
## 2015-08-21  2.03
```

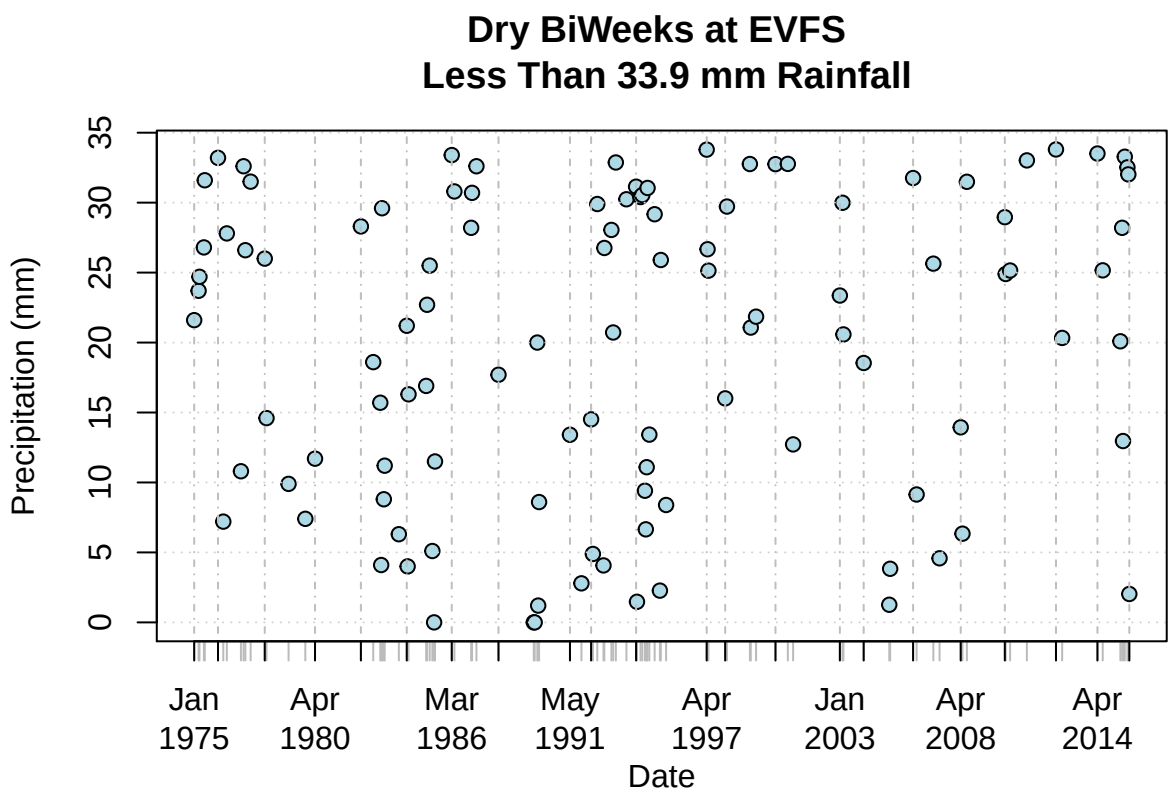
```
length(drybiweeks)
```

```
## [1] 108
```

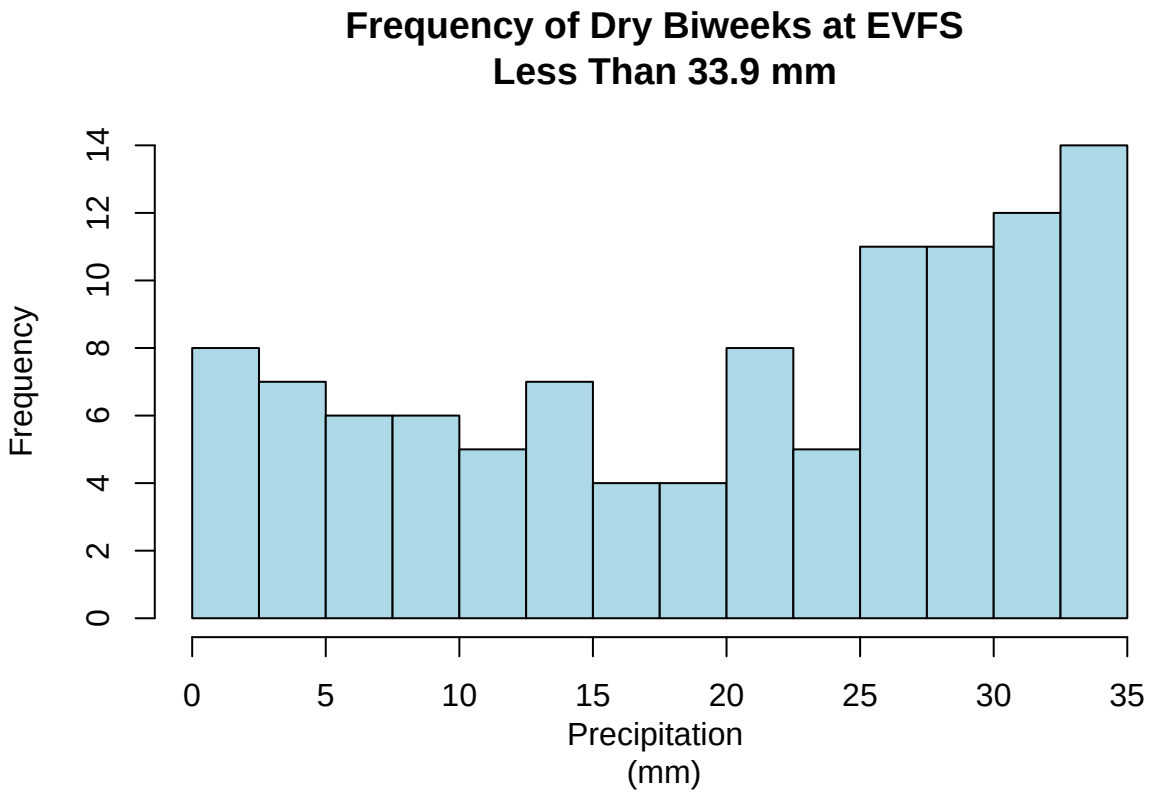
```
length(drybiweeks)/nyears
```

```
## [1] 2.634146
```

```
####PLOTTING DRYBIWEEKS####
plot(drybiweeks, type = "p", main ="Dry BiWeeks at EVFS \n Less Than 33.9 mm Rainfall", xlab = "Date", y
```




```
hist(drybiweeks, breaks = seq(min(drybiweeks),max(drybiweeks)+2.5,2.5), main = "Frequency of Dry Biweeks
```




```
###TRI WEEKLY#####
ep2 <- c(0, seq(1, nrow(LFDP), by = 21), nrow(LFDP))
triweeks <- period.apply(LFDP, ep2, FUN=sum)
quantile(triweeks, probs = seq(0, 1, 0.1), na.rm = TRUE, type =1)
```

```
##      0%     10%     20%     30%     40%     50%     60%     70%     80%
##    0.00   65.29  100.88  132.07  158.49  179.80  212.09  255.80  305.00
##     90%    100%
##  385.07 1130.20
```

```
######getting number of dry triweekly events in data set to determine sampling effort nedded####
drytriweeks <- subset(triweeks, triweeks<67.04)
print(drytriweeks)
```

```
##             [,1]
## 1975-01-01 21.60
## 1975-03-05 58.40
## 1975-03-26 28.30
## 1975-06-18 51.80
## 1976-04-07 47.70
## 1977-01-26 62.90
## 1977-03-30 66.10
## 1978-01-18 47.90
## 1979-10-31 40.30
## 1981-01-14 50.60
## 1982-01-27 59.00
## 1983-02-09 16.30
```

```
## 1983-03-02 33.10
## 1983-04-13 20.00
## 1983-11-30 41.10
## 1984-03-14 53.20
## 1984-04-04 21.20
## 1984-04-25 20.30
## 1985-01-23 62.20
## 1985-02-13 39.30
## 1985-06-19 11.50
## 1985-07-10 58.60
## 1986-02-26 48.20
## 1986-09-24 52.30
## 1987-01-28 33.70
## 1987-03-11 63.30
## 1988-03-23 22.90
## 1989-10-11  0.00
## 1989-12-13  7.20
## 1991-02-06 62.36
## 1991-08-14 66.34
## 1992-04-01 60.81
## 1992-04-22 58.44
## 1992-10-28 27.28
## 1993-08-18 48.74
## 1993-10-20 64.81
## 1994-03-16 57.37
## 1994-04-06 14.28
## 1994-06-08 49.45
## 1994-08-10 13.91
## 1994-08-31 13.24
## 1994-10-12 33.53
## 1995-01-04 35.50
## 1995-03-29 61.45
## 1995-07-12 42.68
## 1996-02-28 39.61
## 1997-04-02 44.19
## 1997-04-23 54.37
## 1998-03-04 60.95
## 1999-02-24 50.79
## 1999-03-17 21.07
## 2000-10-25 65.29
## 2001-01-17 33.54
## 2001-03-21 57.91
## 2003-03-26 44.19
## 2004-02-04 18.79
## 2005-03-09 60.16
## 2005-03-30  3.83
## 2006-03-01 62.22
## 2006-05-24 60.45
## 2007-03-14 62.48
## 2007-06-06 49.27
## 2010-02-17 52.34
## 2010-03-31 31.99
## 2012-06-27 49.30
## 2012-09-19 41.91
```

```
## 2014-06-11 47.47
## 2014-07-02 39.40
## 2015-01-07 64.74
## 2015-05-13 12.96
## 2015-06-24 63.50
## 2015-07-15 66.30
## 2015-08-05 44.22
## 2015-08-21 56.40
```

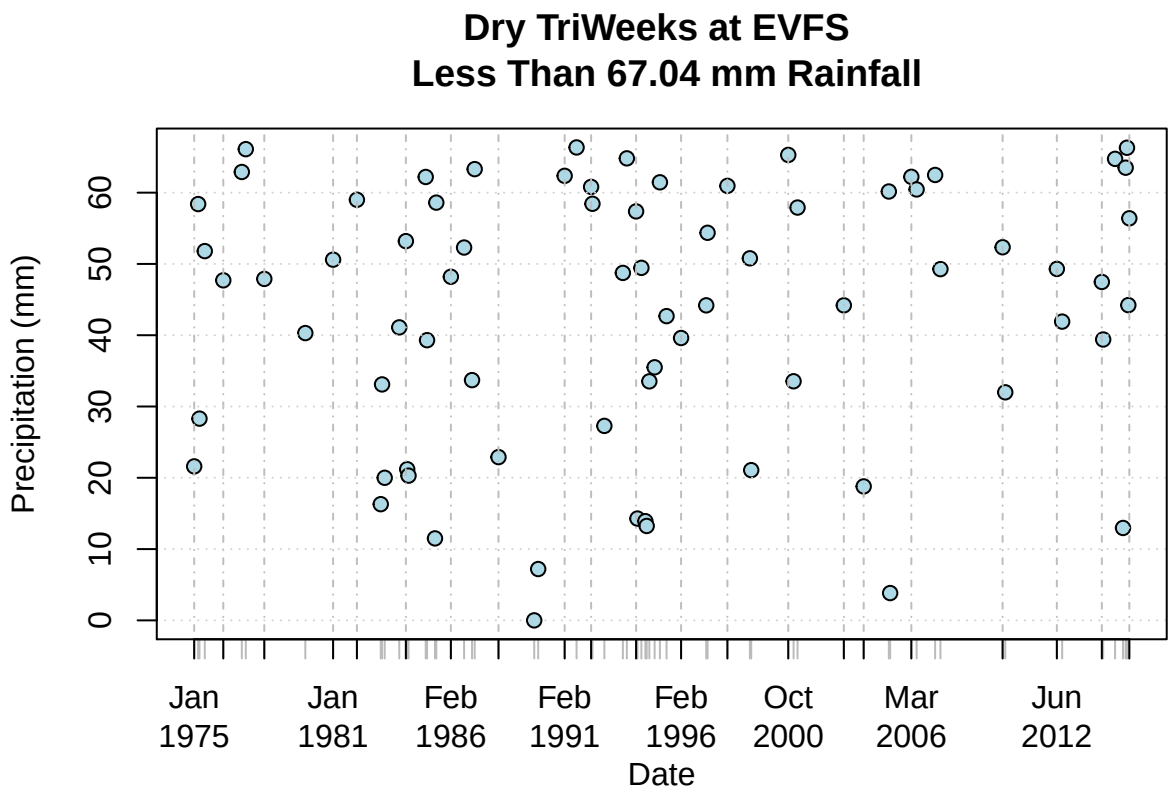
```
length(drytriweeks)
```

```
## [1] 74
```

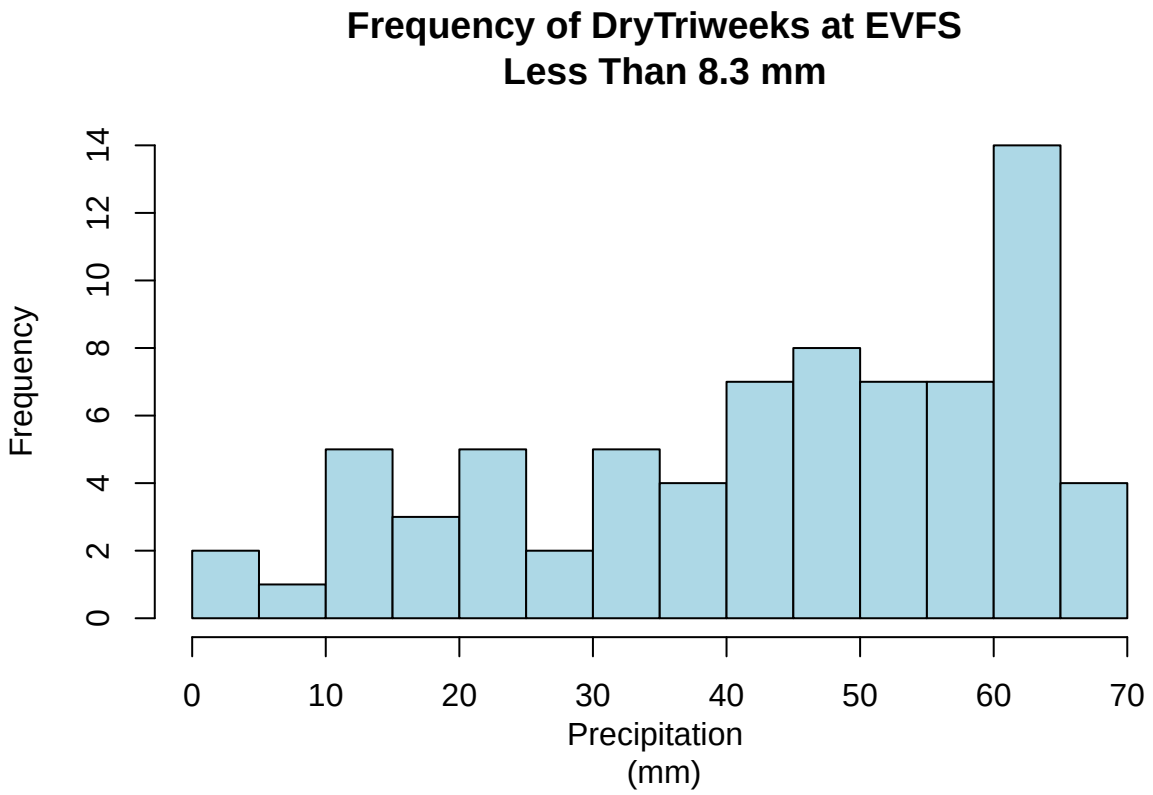
```
length(drytriweeks)/nyears
```

```
## [1] 1.804878
```

```
####PLOTTING DRYTRIWEEKS####
plot(drytriweeks, type = "p", main ="Dry TriWeeks at EVFS \n Less Than 67.04 mm Rainfall", xlab = "Date
```



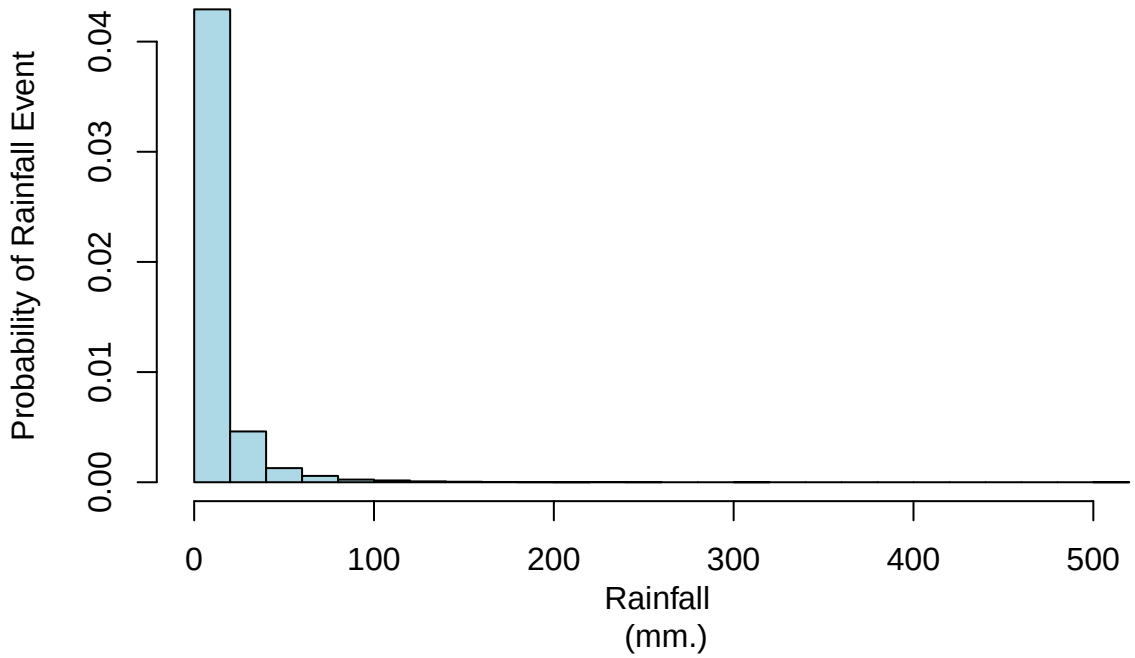

```
hist(drytriweeks, breaks = seq(min(drytriweeks),max(drytriweeks)+5,5), main = "Frequency of DryTriweeks
```




```
###QUAD WEEKS (almost montly)-- every 28 days######
ep3 <- c(0, seq(1, nrow(LFDP), by = 28), nrow(LFDP))
quadweeks <- period.apply (LFDP, ep2, FUN=sum)
quantile(quadweeks, probs = seq(0, 1, 0.1), na.rm = TRUE, type =1)
```

```
##      0%     10%     20%     30%     40%     50%     60%     70%     80%
##    0.00   65.29  100.88  132.07  158.49  179.80  212.09  255.80  305.00
##     90%    100%
##  385.07 1130.20
```

```
###plotting histogram with hist function###
hist(LFDP, prob = T, breaks = seq(min(LFDP),max(LFDP)+20,20), main ="Distribution of Rainfall Events at
```




```
######WET WEEKS##########
wetweeks <- subset(weeks, weeks>150.62)
print(wetweeks)
```

```
##              [,1]
## 1975-01-29 150.90
## 1975-09-17 412.10
## 1975-11-26 171.50
## 1975-12-03 156.20
## 1975-12-10 320.10
## 1976-09-15 181.00
## 1976-10-13 167.20
## 1977-04-27 193.50
## 1977-08-24 185.20
## 1977-10-12 169.40
## 1977-11-30 386.10
## 1978-04-12 347.70
## 1978-05-31 287.10
## 1978-11-01 267.20
## 1978-11-15 175.60
## 1978-11-22 200.90
## 1979-02-21 351.70
## 1979-04-25 158.80
## 1979-05-16 209.30
## 1979-05-30 214.30
## 1979-07-04 191.90
## 1979-09-05 616.90
## 1979-10-03 167.70
## 1979-11-21 179.50
```

```
## 1979-11-28 159.00
## 1980-05-21 198.90
## 1980-07-23 153.00
## 1980-12-10 192.10
## 1981-04-08 161.30
## 1981-04-22 211.40
## 1981-05-20 178.90
## 1981-08-12 156.90
## 1981-12-16 321.30
## 1981-12-30 317.60
## 1982-02-10 232.10
## 1982-05-12 265.30
## 1982-06-02 192.00
## 1982-07-28 164.20
## 1982-09-15 230.30
## 1983-05-25 153.90
## 1983-06-22 185.10
## 1983-07-06 354.30
## 1983-08-24 208.90
## 1983-12-07 177.90
## 1984-02-15 159.60
## 1984-05-30 184.10
## 1984-06-13 154.70
## 1984-08-29 152.30
## 1984-11-07 357.60
## 1985-04-03 226.90
## 1985-05-15 259.20
## 1985-05-22 200.00
## 1985-07-17 158.80
## 1985-07-24 157.10
## 1985-09-18 195.10
## 1985-10-09 318.30
## 1985-10-30 198.40
## 1985-11-20 278.40
## 1986-05-07 172.60
## 1986-05-14 252.00
## 1986-09-03 173.40
## 1986-10-15 177.60
## 1986-11-12 180.90
## 1987-03-18 227.40
## 1987-04-15 326.80
## 1987-05-20 229.10
## 1987-05-27 174.40
## 1987-06-24 291.30
## 1987-11-25 209.70
## 1987-12-02 394.60
## 1987-12-09 525.90
## 1987-12-23 176.30
## 1988-01-06 188.80
## 1988-02-03 222.60
## 1988-03-30 212.60
## 1988-08-17 213.20
## 1988-08-31 205.50
## 1988-09-14 242.50
```

```
## 1989-02-22 221.80
## 1989-04-05 157.30
## 1989-05-31 154.90
## 1989-06-07 162.80
## 1989-09-20 162.50
## 1990-03-14 303.56
## 1990-05-16 182.03
## 1990-08-15 197.45
## 1990-10-17 156.66
## 1990-12-05 156.12
## 1991-01-02 256.69
## 1991-11-13 225.37
## 1992-05-06 330.20
## 1992-09-30 190.50
## 1992-12-02 153.45
## 1992-12-30 244.97
## 1993-05-05 167.52
## 1995-02-01 206.51
## 1995-03-01 280.41
## 1995-09-20 186.59
## 1995-12-20 194.56
## 1996-01-17 170.68
## 1996-09-11 561.09
## 1996-11-13 231.63
## 1996-11-27 296.67
## 1997-01-01 151.62
## 1997-01-29 183.38
## 1997-05-14 173.74
## 1997-08-27 208.78
## 1997-10-15 182.62
## 1997-11-26 215.03
## 1998-01-07 216.93
## 1998-03-11 427.98
## 1998-04-22 210.31
## 1998-08-26 305.07
## 1998-09-23 387.36
## 1998-12-02 274.58
## 1998-12-09 290.58
## 1998-12-30 228.87
## 1999-05-12 182.12
## 1999-06-23 225.28
## 1999-07-14 177.03
## 1999-11-17 232.64
## 1999-12-08 523.49
## 2000-08-23 237.75
## 2001-08-29 207.00
## 2001-11-14 363.96
## 2001-12-19 153.91
## 2001-12-26 172.48
## 2002-04-17 158.77
## 2002-06-05 158.49
## 2002-09-04 177.29
## 2003-04-09 180.35
## 2003-04-16 180.86
```

```
## 2003-04-23 399.80
## 2003-08-27 238.76
## 2003-11-12 304.81
## 2003-11-19 429.51
## 2003-12-10 179.34
## 2004-03-31 206.25
## 2004-05-12 493.78
## 2004-05-19 258.06
## 2004-05-26 183.39
## 2004-06-16 180.07
## 2004-09-15 286.24
## 2004-09-22 314.94
## 2004-11-03 194.82
## 2004-11-17 430.79
## 2005-01-05 155.95
## 2005-01-12 224.29
## 2005-01-19 159.75
## 2005-01-26 195.58
## 2005-10-12 176.90
## 2005-11-30 158.78
## 2006-04-05 221.73
## 2006-04-12 152.39
## 2006-04-26 260.61
## 2006-07-05 154.18
## 2006-07-12 187.45
## 2006-12-06 203.72
## 2007-04-04 168.14
## 2007-04-25 241.30
## 2007-05-02 183.63
## 2007-10-31 263.13
## 2007-12-12 218.18
## 2008-04-09 162.81
## 2008-09-10 216.03
## 2008-09-24 328.92
## 2008-10-15 217.15
## 2009-05-13 216.42
## 2009-07-22 176.28
## 2009-08-26 166.89
## 2009-09-23 179.58
## 2010-01-06 177.84
## 2010-01-20 439.16
## 2010-02-24 211.33
## 2010-03-10 223.77
## 2010-04-14 170.93
## 2010-04-28 304.54
## 2010-05-05 152.64
## 2010-05-12 232.92
## 2010-05-19 294.64
## 2010-06-23 285.75
## 2010-07-21 402.86
## 2010-12-15 203.72
## 2010-12-22 184.65
## 2011-05-04 209.55
## 2011-05-25 152.41
```

```
## 2011-06-22 151.89
## 2011-07-27 165.87
## 2011-08-03 188.72
## 2011-08-24 508.76
## 2011-09-14 171.45
## 2011-10-12 160.78
## 2011-11-30 216.92
## 2011-12-14 231.38
## 2012-03-28 380.00
## 2012-04-04 153.16
## 2012-05-23 268.50
## 2012-10-31 183.66
## 2013-04-03 289.07
## 2013-04-24 163.31
## 2013-05-15 177.55
## 2013-05-29 198.62
## 2013-06-05 151.63
## 2013-07-03 215.90
## 2013-11-27 163.58
## 2013-12-04 160.02
## 2014-05-14 196.84
## 2014-08-27 276.85
## 2014-09-24 206.50
## 2014-11-05 156.46
## 2014-11-12 183.37
## 2014-12-17 174.51
```

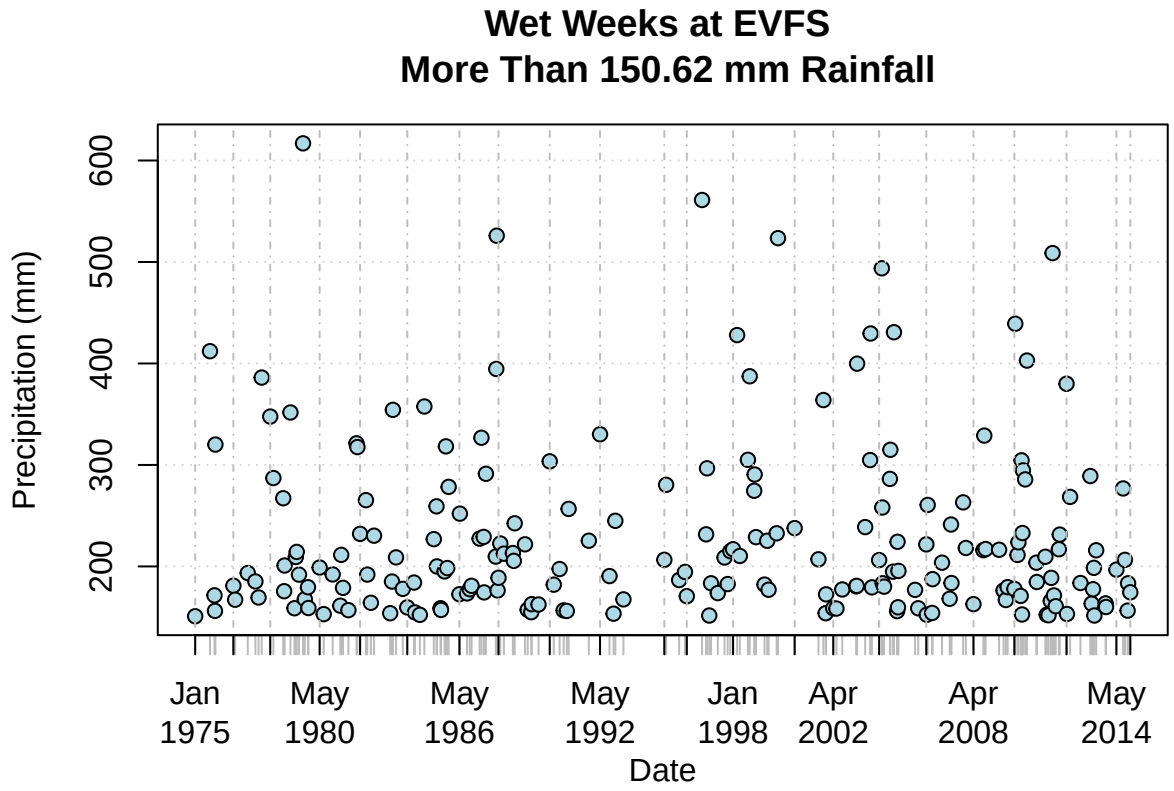
```
length(wetweeks)
```

```
## [1] 212
```

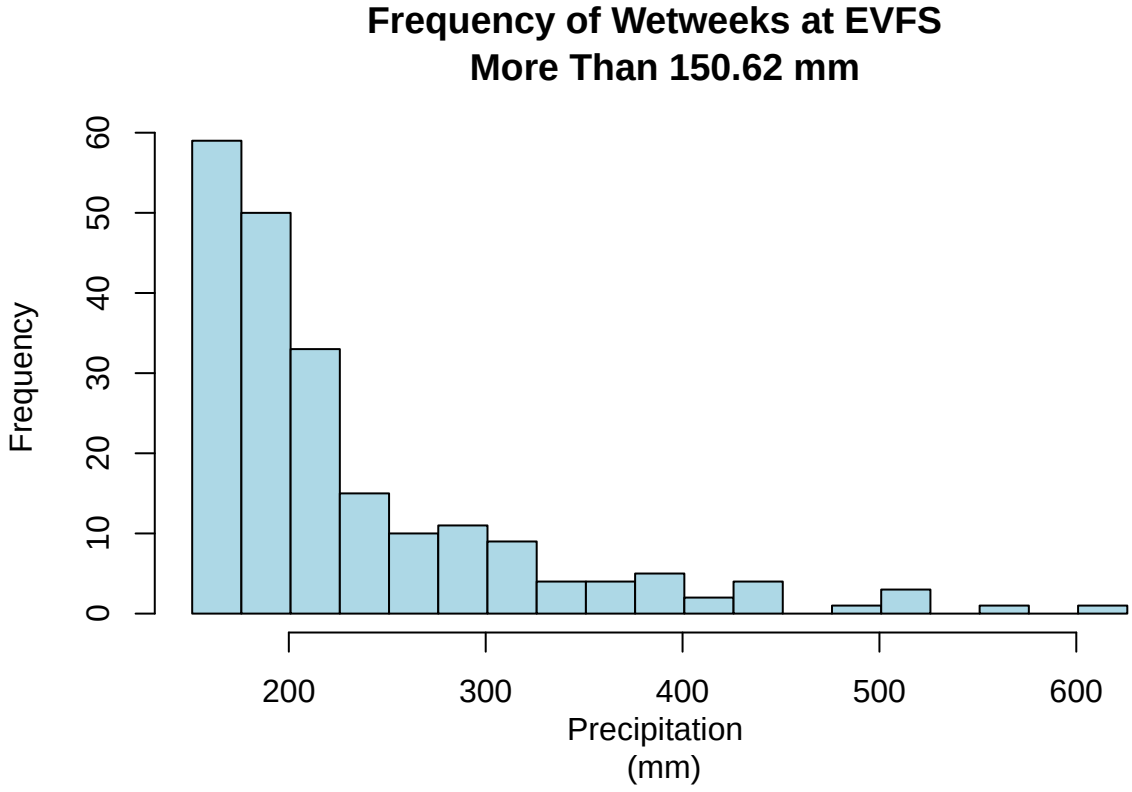
```
length(wetweeks)/nyears
```

```
## [1] 5.170732
```

```
####PLOTTING WETWEEKS####
plot(wetweeks, type = "p", main ="Wet Weeks at EVFS \n More Than 150.62 mm Rainfall", xlab = "Date", yla
```




```
hist(wetweeks, breaks = seq(min(wetweeks),max(wetweeks)+25,25), main = "Frequency of Wetweeks at EVFS \
```



```
######WET BIWEEKS##########
wetbiweeks <- subset(biweeks, biweeks>277.6)
print(wetbiweeks)
```

```
##              [,1]
## 1975-09-24 473.60
## 1975-12-03 327.70
## 1975-12-17 419.60
## 1977-08-24 294.60
## 1977-11-30 514.10
## 1978-04-19 393.60
## 1978-05-31 388.80
## 1978-11-01 364.30
## 1979-02-21 364.70
## 1979-05-30 312.10
## 1979-09-05 692.90
## 1979-11-28 338.50
## 1980-05-28 321.70
## 1981-05-27 315.90
## 1981-12-23 365.30
## 1982-01-06 392.40
## 1982-02-17 350.80
## 1982-05-12 297.00
## 1982-08-04 303.20
## 1982-09-15 315.40
## 1983-07-06 399.90
## 1983-08-31 278.00
## 1984-11-07 491.30
## 1985-05-22 459.20
## 1985-09-25 311.80
## 1985-10-09 464.60
## 1985-11-20 428.10
## 1986-05-21 287.80
## 1986-11-19 330.90
## 1987-04-22 340.50
## 1987-05-20 279.40
## 1987-07-01 341.70
## 1987-12-02 604.30
## 1987-12-16 562.40
## 1988-02-10 284.10
## 1988-08-24 296.70
## 1988-09-21 326.80
## 1989-09-20 311.80
## 1990-03-21 337.49
## 1990-10-17 278.84
## 1991-01-09 313.27
## 1991-11-13 334.58
## 1992-05-13 385.07
## 1992-09-30 279.13
## 1993-01-06 359.74
## 1995-03-01 372.61
## 1996-09-11 580.92
## 1996-11-20 310.89
```

```
## 1996-12-04 409.47
## 1997-01-29 318.74
## 1997-08-27 293.86
## 1998-01-14 294.14
## 1998-03-11 459.21
## 1998-08-26 444.78
## 1998-09-23 529.59
## 1998-12-02 377.45
## 1998-12-16 376.04
## 1998-12-30 305.96
## 1999-11-17 358.89
## 1999-12-15 539.49
## 2000-08-23 312.41
## 2001-11-14 438.64
## 2001-12-26 326.39
## 2003-04-16 361.21
## 2003-04-30 415.53
## 2003-09-03 330.46
## 2003-11-12 370.08
## 2003-11-26 495.80
## 2004-03-31 311.64
## 2004-05-12 639.84
## 2004-05-26 441.45
## 2004-09-15 356.61
## 2004-09-29 330.43
## 2004-11-24 511.05
## 2005-01-19 384.04
## 2005-10-12 326.76
## 2006-04-12 374.12
## 2006-04-26 284.50
## 2006-12-06 326.15
## 2007-04-25 281.67
## 2007-11-07 279.88
## 2007-12-19 314.21
## 2008-09-10 336.04
## 2008-09-24 363.72
## 2009-05-20 366.55
## 2009-08-26 286.02
## 2010-01-27 483.63
## 2010-03-10 288.79
## 2010-05-05 457.18
## 2010-05-19 527.56
## 2010-06-30 384.81
## 2010-07-28 504.21
## 2011-05-04 339.62
## 2011-08-10 298.69
## 2011-08-24 593.61
## 2011-11-30 360.44
## 2011-12-14 351.53
## 2012-04-04 533.16
## 2012-05-30 299.74
## 2013-04-03 294.64
## 2013-05-15 299.98
## 2013-05-29 288.04
```

```
## 2013-07-10 333.64
## 2013-12-11 306.84
## 2014-09-03 377.41
## 2014-11-12 339.83
```

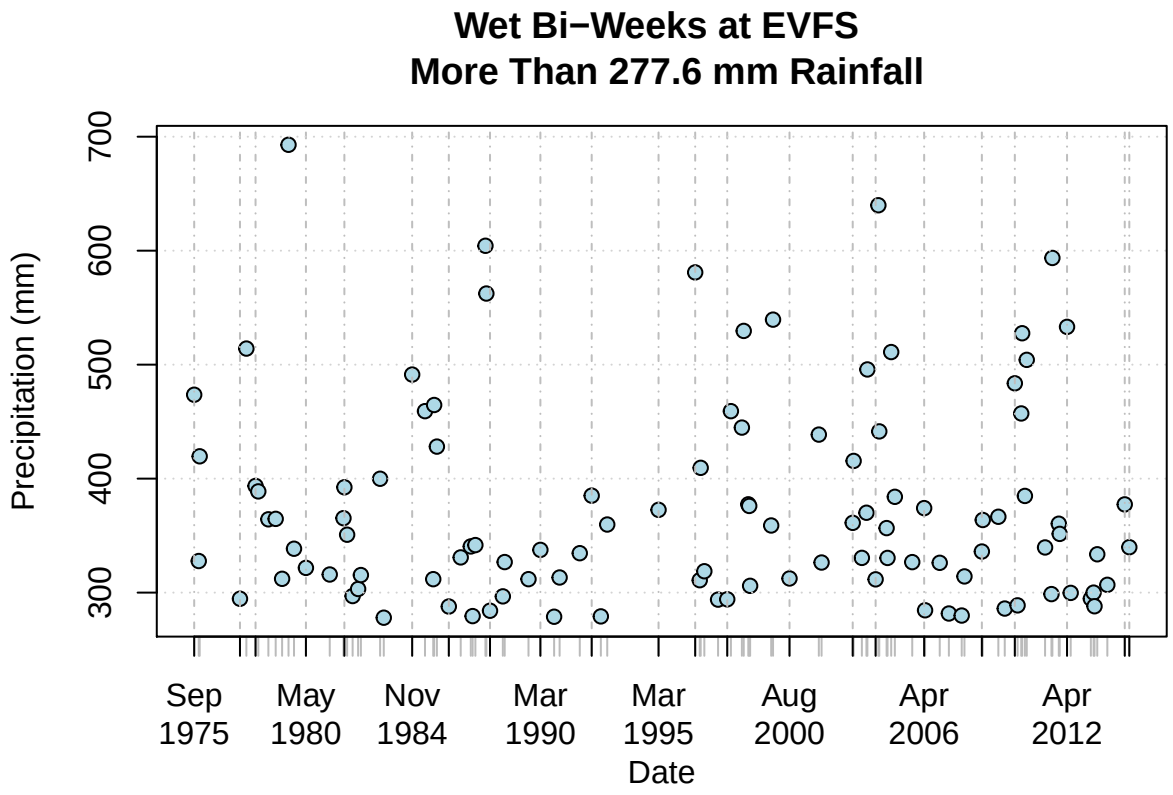
```
length(wetbiweeks)
```

```
## [1] 106
```

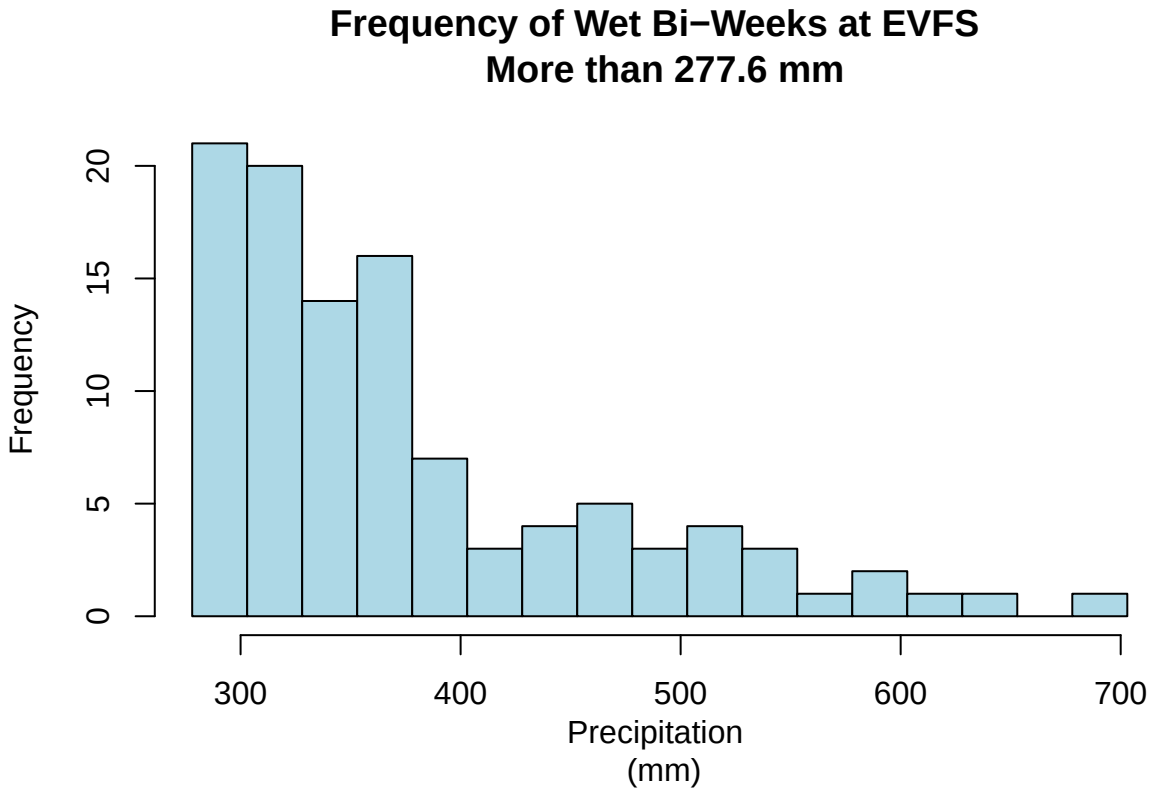
```
length(wetbiweeks)/nyears
```

```
## [1] 2.585366
```

```
####PLOTTING BIWETWEEKS####
plot(wetbiweeks, type = "p", main ="Wet Bi-Weeks at EVFS \n More Than 277.6 mm Rainfall", xlab = "Date"
```




```
hist(wetbiweeks, breaks = seq(min(wetbiweeks),max(wetbiweeks)+25,25), main = "Frequency of Wet Bi-Weeks
```




```
######WET TRIWEEKS##########
wettriweeks <- subset(triweeks, triweeks>385.07)
print(wettriweeks)
```

```
##               [,1]
## 1975-10-01  489.10
## 1975-12-24  473.90
## 1977-08-24  410.80
## 1977-12-07  578.60
## 1978-04-12  409.90
## 1978-06-14  428.50
## 1978-11-08  403.90
## 1978-11-29  403.20
## 1979-06-06  456.20
## 1979-09-19  744.30
## 1979-11-21  408.00
## 1981-12-16  460.00
## 1982-01-06  436.40
## 1982-02-17  499.20
## 1982-09-15  395.40
## 1983-07-06  585.00
## 1984-11-21  571.70
## 1985-05-29  459.20
## 1985-10-02  458.10
## 1985-10-23  476.40
## 1986-05-21  460.40
## 1986-09-03  451.00
## 1986-11-26  388.80
```

```
## 1987-06-03  443.70
## 1987-06-24  398.90
## 1987-12-09 1130.20
## 1990-03-28  388.10
## 1992-05-13  385.07
## 1995-03-08  441.19
## 1996-09-25  672.37
## 1996-11-27  607.56
## 1998-03-25  547.36
## 1998-09-09  547.12
## 1998-09-30  541.02
## 1998-12-02  479.31
## 1998-12-23  453.13
## 1999-11-24  491.72
## 1999-12-15  588.01
## 2000-08-23  408.43
## 2001-11-28  420.86
## 2002-04-24  386.37
## 2003-05-07  422.64
## 2003-09-10  389.64
## 2003-11-12  403.09
## 2003-12-03  530.35
## 2004-05-19  897.90
## 2004-09-22  671.55
## 2004-11-24  583.69
## 2005-01-26  579.62
## 2006-04-12  393.17
## 2006-05-03  406.17
## 2007-12-12  427.20
## 2008-09-10  401.81
## 2008-10-01  386.58
## 2009-05-20  459.50
## 2010-01-27  567.39
## 2010-03-10  500.12
## 2010-05-12  690.10
## 2010-06-02  435.89
## 2010-08-04  555.77
## 2010-12-29  474.97
## 2011-05-04  385.59
## 2011-07-27  416.35
## 2011-09-07  680.46
## 2011-11-30  451.37
## 2011-12-21  433.33
## 2012-04-04  558.56
## 2013-04-17  394.74
## 2013-05-29  465.59
## 2013-07-10  474.60
## 2014-09-03  444.71
```

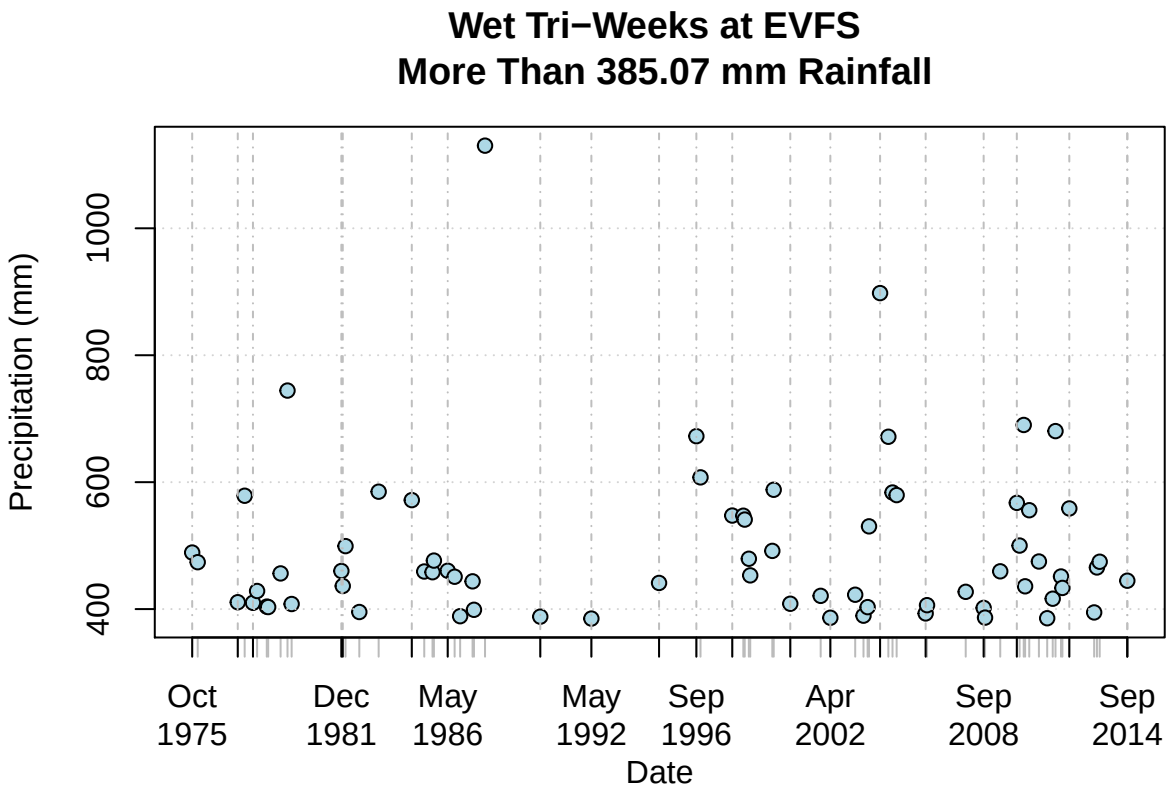
```
length(wettriweeks)
```

```
## [1] 71
```

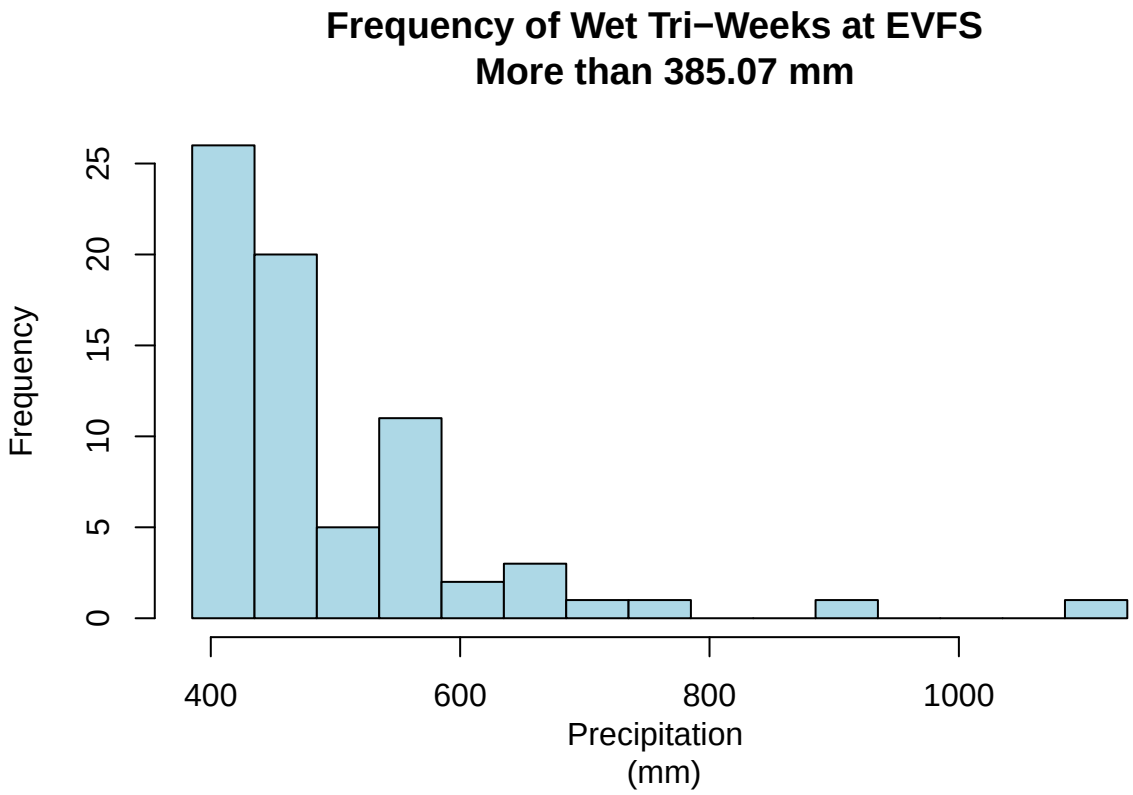
```r
length(wettriweeks)/nyears
```

```
## [1] 1.731707
```

```r
####PLOTTING WETWEEKS####
plot(wettriweeks, type = "p", main ="Wet Tri-Weeks at EVFS \n More Than 385.07 mm Rainfall", xlab = "Da
```




```r
hist(wettriweeks, breaks = seq(min(wettriweeks),max(wettriweeks)+50,50), main = "Frequency of Wet Tri-W
```




```
######THE KILLER PLOT-------- wet weeks vs. dry weeks ------------------
plot(LFDP, type= "n", main = "Wet vs Dry Weekly Rainfall Events \n at EVFS", xlab = "Date", ylab = "Pre
```

```
## Warning in plot.window(...): "yaxis" is not a graphical parameter
```

```
## Warning in plot.xy(xy, type, ...): "yaxis" is not a graphical parameter
```

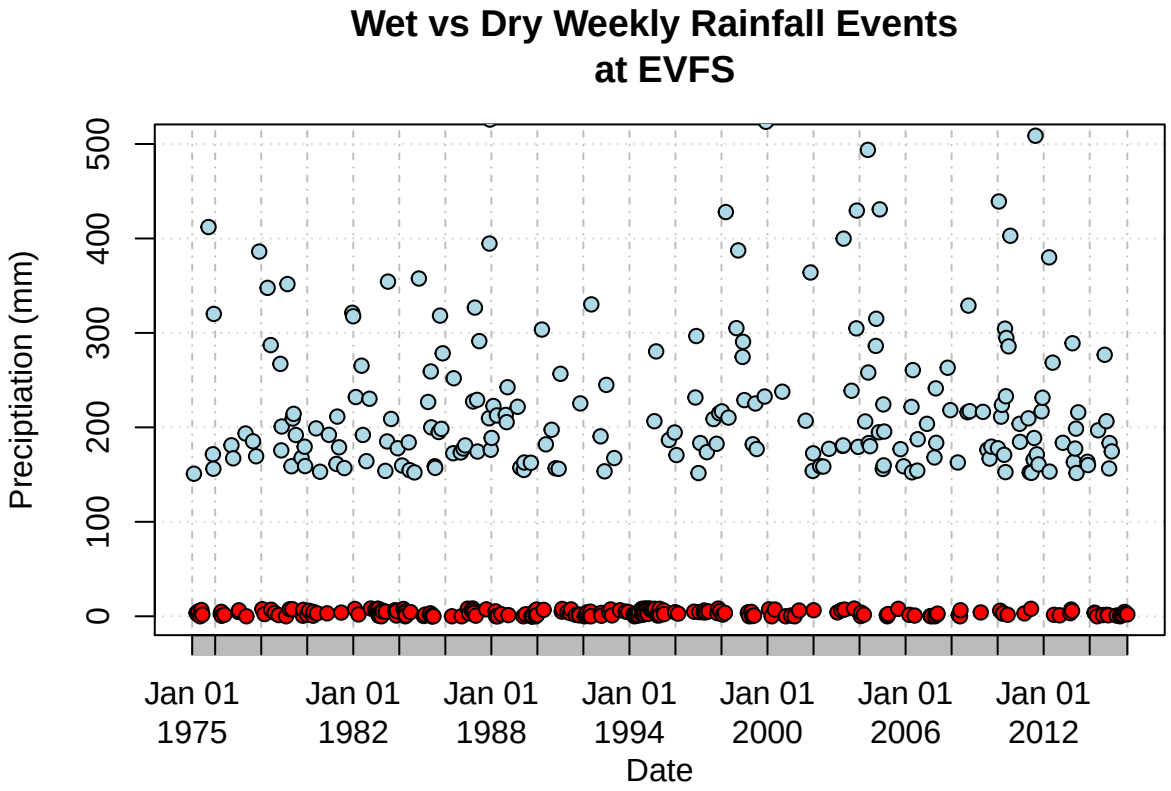
```
## Warning in axis(1, at = xycoords$x, labels = FALSE, col = "#BBBBBB", ...):
## "yaxis" is not a graphical parameter
```

```
## Warning in axis(1, at = xycoords$x[ep], labels = names(ep), las = 1, lwd =
## 1, : "yaxis" is not a graphical parameter
```

```
## Warning in axis(2, ...): "yaxis" is not a graphical parameter
```

```
## Warning in title(main = "Wet vs Dry Weekly Rainfall Events \n at EVFS", :
## "yaxis" is not a graphical parameter
```

```
points(wetweeks, pch = 21, bg = "light blue")
points(dryweeks, pch = 21, bg = "red")
```




```
#####http://r.789695.n4.nabble.com/break-axis-using-plotrix-td803987.html#a803987#####
```

BREAK in code — RAINFALL SIGNATURES

Now, that we have done some preliminary anlyses of our precip data time series, we can start to dig a little deeper (i.e. visualize the data). These analyses may be trivial, but I like them becuase you can see the "rainfall signatures" for each year.