Data Screening

PAZ

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Introduction

This Data Screenining notebook follows the GUide to STatistical Analysis in Microbial Ecology (GUSTA ME). The purpose is to inspect the variables that we'll be using to test for hypotheses later on, and check whether they follow typical assumptions made in parametric tests such as normality, freedom from heteroskedasticity (difference in variability btw. two+ variables) and outliers.

Reference:

https://sites.google.com/site/mb3gustame/home Buttigieg PL, Ramette A (2014) A Guide to Statistical Analysis in Microbial Ecology: a community-focused, living review of multivariate data analyses. FEMS Microbiol Ecol. 90: 543-550.

Files

- **WaterDay__R.csv** (Book 02)

Packages

```
library(sm)
library(vioplot)

library(dplyr)
library(tidyr)
library(zoo)
library(reshape)
library(ggplot2)
library("ggrepel")

library("plotly")
library("cowplot")
library("gridExtra")
library("Cairo")
library("GGally")
library("scales")

library("plotKML")

# Stats
library("vegan")
library("cluster")
```

```r
# Saving a xlxs file
# library(xlsx)
```

Missing values

1. Missing chemical and isotope data due to machine failure or automatic sampling servicing program.

These have been considered to be Values Missing Completely at Random (MCAR) as they are associated to the end of the automatic sampler's capacity for a certain number of events where servicing was inadequate for the discharge amounts seen during a sampling week. Here the values' missingess is not related to any other value in the data set.

2. Isotope data for both soil and water samples due to concentration value being below the limit of detection.

These values must be considered to be Missing at Random (MAR) as the missing value has no relation to the value that 'should' be there, but does depend on other variables in the data set. Thus, other variables must be taken into account for MAR data to be considered random (i.e. missing data is "conditioned by" other data in the data set).

Lab parameters

```r
# Initial signature measured in tank
initialDelta = d13Co = -32.253

epsilon_mean= -2.2 # Â± 0.4
epsilon_lab = epsilon_mean

# Field values, after dilution correction (Van Breukelen 2008):
# Calculated in Book 9.1
epsilonField_max = -1.7 + 0.33
epsilonField_min = -1.7 - 0.33
epsilonField_mean = -1.7 # Â± 0.33

epsilon_field = epsilonField_mean
```

Import soils

Convert to single time observation for merging with water observation.

```r
# Soils
soils = read.csv2("Data/MassBalance_R.csv",
                  na.strings=c('#DIV/0!', '', 'NA'), header = TRUE)
names(soils)
```

```
##  [1] "ti"                 "WeekSubWeek"
##  [3] "Event"              "timeSinceApp"
##  [5] "timeSinceApp.NoSo"  "diss.d13C"
##  [7] "SD.d13C"            "CumOutDiss.g"
##  [9] "CumOutFilt.g"       "CumAppMass.g"
```

```
## [11] "CumOutMELsm.g"          "MassSoil.g.North"
## [13] "MassSoil.g.SD.North"   "Conc.mug.g.dry.soil.N"
## [15] "comp.d13C.North"       "comp.d13C.SD.North"
## [17] "ID.N"                  "Area.N"
## [19] "Area.T"                "Area.S"
## [21] "MassSoil.g.Talweg"     "MassSoil.g.SD.Talweg"
## [23] "Conc.mug.g.dry.soil.T" "comp.d13C.Talweg"
## [25] "comp.d13C.SD.Talweg"   "ID.T"
## [27] "MassSoil.g.South"      "MassSoil.g.SD.South"
## [29] "Conc.mug.g.dry.soil.S" "comp.d13C.South"
## [31] "comp.d13C.SD.South"    "ID.S"
## [33] "DD13C.North"           "DD13C.Talweg"
## [35] "DD13C.South"           "CatchMassSoil.g"
## [37] "CatchMassSoil.g.SD"    "BulkCatch.d13"
## [39] "BulkCatch.d13.SD"      "DD13.Bulk"
## [41] "Area.Catchment"        "BulkCatch.Conc"
```

```
colnames(soils)[colnames(soils) == "ti"] <- "Date.ti"
soils$Date.ti <- as.POSIXct(strptime(soils$Date.ti,
                                      "%Y-%m-%d %H:%M", tz="EST")) # csv typos, option 1
sum(is.na(soils$Date.ti)) == 0
```

```
## [1] TRUE
```

```
initialDelta
```

```
## [1] -32.253
```

```
# Get rid of imputed values to avoid unwanted bias
soils$DD13C.North <- (ifelse(!is.na(soils$comp.d13C.SD.North), soils$comp.d13C.North - (initialDelta), 
soils$DD13C.Talweg <- (ifelse(!is.na(soils$comp.d13C.SD.Talweg), soils$comp.d13C.Talweg - (initialDelta
soils$DD13C.South <- (ifelse(!is.na(soils$comp.d13C.SD.South), soils$comp.d13C.South - (initialDelta), 


dropSoil <- c("WeekSubWeek", # "Event",
              "CumOutDiss.g", "CumOutFilt.g", "CumOutAppMass.g",  "CumOutMELsm.g",
              # "CumAppMass.g",
              # "ID.N",
              "ID.T",  "Area.N", "Area.T", "Area.S",
              "comp.d13C.SE.North", "comp.d13C.SE.Talweg", "comp.d13C.SE.South",
              "ngC.SD","ngC.SE", "N_compsoil" )#, "N_ngC")
soils <- soils[ , !(names(soils) %in% dropSoil)]

soilsCheck <- soils[complete.cases(soils[ , "ID.N"]),]

timeApps <- soils[ , c("Date.ti", "timeSinceApp", "timeSinceApp.NoSo", "Event")]
```

Soils from Book: 06, to merge with "timeApps"

```
# Quasi-Molten SOILS
soilGroups = read.csv2("Data/WeeklySoils_Rng.csv",
                       na.strings=c('#DIV/0!', '', 'NA'), header = TRUE)
soilGroups$Date.ti <- as.POSIXct(strptime(soilGroups$Date.ti,
                                          "%Y-%m-%d %H:%M", tz="EST")) # csv typos, option 1
sum(is.na(soilGroups$Date.ti)) == 0
```

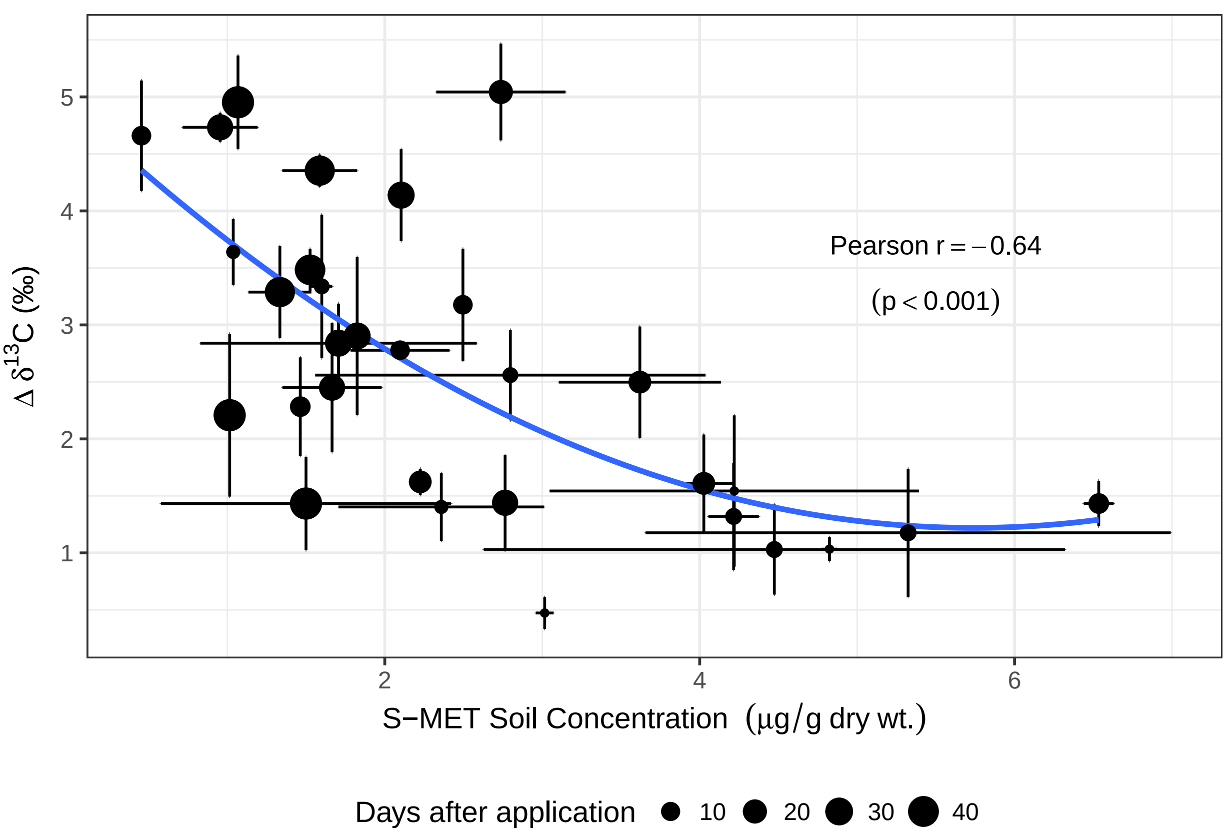
```
## [1] TRUE
```

```r
soilGroups$comp.d13C <- ifelse(is.na(soilGroups$comp.d13C.SD), NA, soilGroups$comp.d13C)
soilGroups$ngC.Label <- ifelse(soilGroups$ngC.mean < 10, "< 10 ng", "> 10 ng")

soilGroups <- subset(soilGroups, comp.d13C.SD <= 0.75)

#str(soils)

soilGrApp <- merge(soilGroups, timeApps, by = "Date.ti", all = F)
soilGrApp <- soilGrApp[complete.cases(soilGrApp[ , "timeSinceApp"]),]

soilGrApp$DD13C.comp <- ifelse(is.na(soilGrApp$comp.d13C.SD), NA, soilGrApp$DD13C.comp)
soilGrApp <- subset(soilGrApp, comp.d13C.SD <= 0.75)

cor.test(soilGroups$comp.d13C, soilGroups$Conc.mug.g.dry.soil)
```

```
##
##  Pearson's product-moment correlation
##
## data:  soilGroups$comp.d13C and soilGroups$Conc.mug.g.dry.soil
## t = -4.472, df = 29, p-value = 0.0001097
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8098686 -0.3677772
## sample estimates:
##       cor
## -0.638862
```

```r
pearson_r <- cor.test(soilGroups$comp.d13C, soilGroups$Conc.mug.g.dry.soil)[4]
r_label <- sprintf("Pearson~r == %0.2f", pearson_r)
p_value <- cor.test(soilGroups$comp.d13C, soilGroups$Conc.mug.g.dry.soil)[3]

if (p_value < 0.0001){
  p_label <- "(p < 0.0001)"
} else if (p_value < 0.001) {
  p_label <- "(p < 0.001)"
} else if (p_value < 0.015) {
  p_label <- ("p < 0.01")
} else {
  p_label <- "Check significance"
}

soilGrApp$Source <- ifelse(soilGrApp$Transect == "T", "Valley", "Plateau")
soilGrApp$Source <- as.factor(soilGrApp$Source)

p <- ggplot(data = subset(soilGrApp, !is.na(ngC.Label)), aes(x=Conc.mug.g.dry.soil, y=DD13C.comp))+
  geom_errorbar(aes(ymin = DD13C.comp - comp.d13C.SD, ymax = DD13C.comp + comp.d13C.SD)) +
  geom_errorbarh(aes(xmin = Conc.mug.g.dry.soil - Conc.ComSoil.SD, xmax = Conc.mug.g.dry.soil + Conc.Co
  stat_smooth(data = subset(soilGrApp, !is.na(ngC.Label)),
              aes(x=Conc.mug.g.dry.soil, y=DD13C.comp), method = "lm", formula = y ~ poly(x, 2), se=F) +
  geom_point(aes(group = ID, size = timeSinceApp.NoSo)) + # , colour = Source)) +  # , shape = ngC.Labe
  theme_bw() +
  theme(legend.position = "bottom") +
  labs(size="   Days after application", colour="Source" ) + #, shape = "Mass Carbon") +
```

```
  ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
  xlab(expression(paste("S-MET Soil Concentration  ", {({mu}*g / g~dry~wt.)}))) +
  annotate("text", x = 5.5, y = 3.7, label = as.character(r_label), parse = T, size = 3.5) +
  annotate("text", x = 5.5, y = 3.2, label = p_label, parse = T, size = 3.5) +
  scale_size_continuous(range = c(1, 5)) +
  guides(size=guide_legend(nrow=1))

  #scale_color_hue("Group") +
  #scale_fill_manual(
  #  "CI horizontal line", values=rep(1,4),
  #  guide=guide_legend(override.aes = list(colour=c("orange", "darkred"))),
  #  labels=c("CI of 95%", "CI of 99%")
  #)
  #geom_text_repel(data = subset(soilGrApp, (!is.na(ngC.Label) & Wnum > 10) ), aes(label=Wnum),
  #                arrow = arrow(length = unit(0.005, 'npc'), type = "closed"),
  #                force = 1,
  #                point.padding = unit(1.0, 'lines'),
  #                max.iter = 2e3,
  #                nudge_x = .2)
p
```




```
#ggsave(p, filename = "DDvsConc_soils.png", width = 8, height = 5, units = "in", scale = 1)

#ggplotly(p)
  #stat_smooth(method = "lm", formula = y ~ poly(x, 2)) +
  #stat_smooth(method = "lm", formula = y~x, se=F)
```

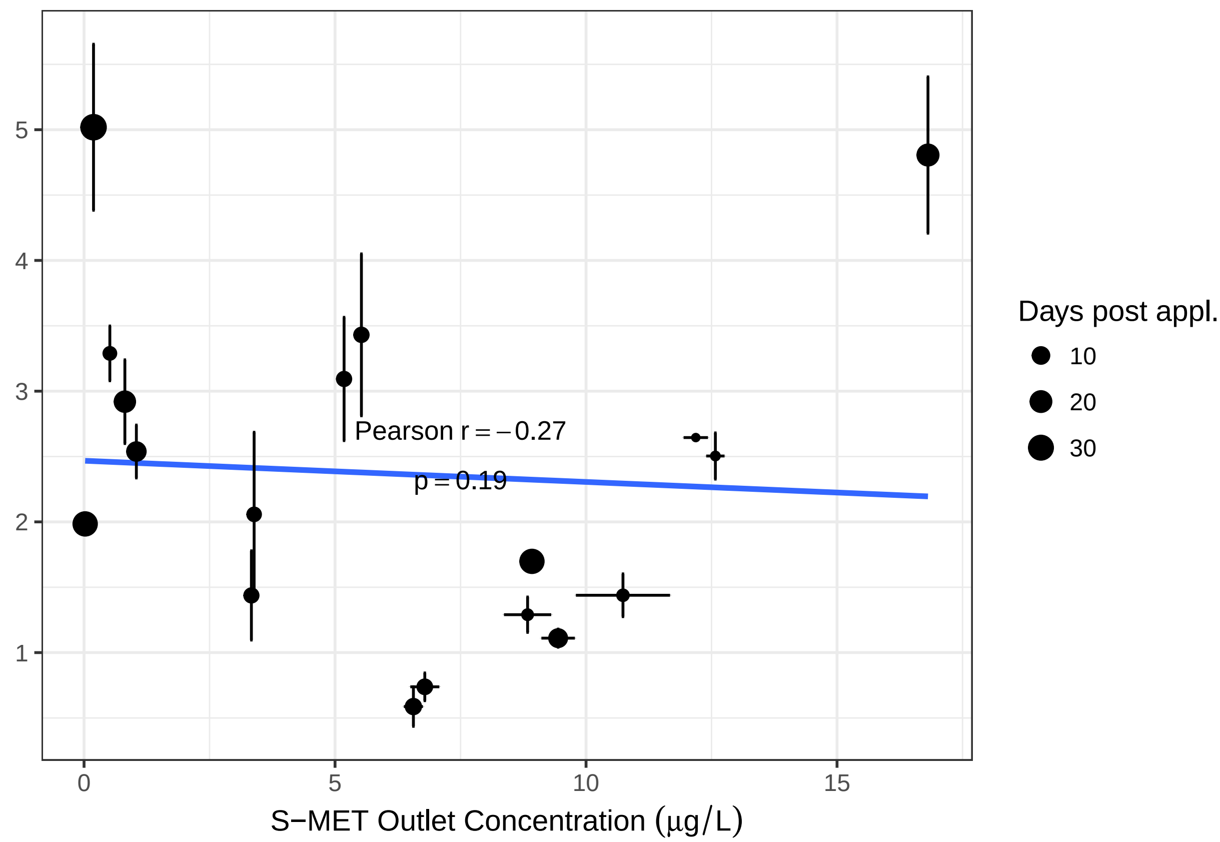
Import waters

Compare mass balance, theoretical and CSIA

```
waters = read.csv2("Data/WeeklyHydroContam_R.csv")
waters$ti <- as.POSIXct(strptime(waters$ti, "%Y-%m-%d %H:%M", tz="EST"))
colnames(waters)[colnames(waters) == "ti"] <- "Date.ti"
waters$Events <- factor(waters$Events, levels = unique(waters$Events))
waters$Event <- factor(waters$Event, levels = unique(waters$Event))


#waters$remain_maxHalf
#waters$remain_minHalf

waterCo <- max(waters$Conc.mug.L)
d13Co
```

```
## [1] -32.253
```

```
waters$yRaleigh <- log((1000+d13Co+waters$DD13C.diss)/(1000+d13Co))
waters$xRaleigh <- log(waters$Conc.mug.L/waterCo)
waters$DIa <- waters$maxQ*waters$Volume.m3/waters$Duration.Hrs

# For evidence of desorption effects, Event 7-1 (May 12th) would need to show SD < 0.54 (currently at 0
# Contingent on sample repeats
waterClean <- subset(waters, Sampled == "Sampled" & SD.d13C < 0.64) # | filt.SD.d13C <= 0.75 )

# cor.test(waterClean$TotSMout.g, waterClean$DD13C.diss)

pearson_water_r <- cor.test(waterClean$Conc.mug.L, waterClean$DD13C.diss)[4]
water_r_label <- sprintf("Pearson~r == %0.2f", pearson_water_r)
water_p_value <- cor.test(waterClean$Conc.mug.L, waterClean$DD13C.diss)[3]
water_p_label <- sprintf("p == %0.2f", water_p_value)

waterIsoConc  <- ggplot(data = subset(waterClean, ngC.mean.diss > 5), aes(x=Conc.mug.L, y=DD13C.diss))+
  stat_smooth(data = subset(waterClean, ngC.mean.diss > 5),
              aes(x=Conc.mug.L, y=DD13C.diss), method = "lm", formula = y~x, se=F) +
  geom_errorbar(aes(ymin = DD13C.diss - SD.d13C, ymax = DD13C.diss + SD.d13C)) +
  geom_errorbarh(aes(xmin = Conc.mug.L - Conc.SD, xmax = Conc.mug.L + Conc.SD)) +
  geom_point(aes(size = timeSinceApp)) +
  theme_bw() +
  scale_size_continuous(range = c(1, 4)) +
  labs(size="Days post appl.") +
  theme(axis.title.y = element_blank()) +
  #scale_y_continuous(breaks=c(1, 2, 3 , 4 ,5) ) +
  scale_y_continuous(breaks=seq(1,5,1)) +
  #ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
  xlab(expression(paste("S-MET Outlet Concentration ", {({mu}*g / L)}))) +
  annotate("text", x = 7.5, y = 2.7, label = as.character(water_r_label), parse = T, size = 3.5) +
  annotate("text", x = 7.5, y = 2.3, label = water_p_label, parse = T, size = 3.5)


waterIsoConc
```



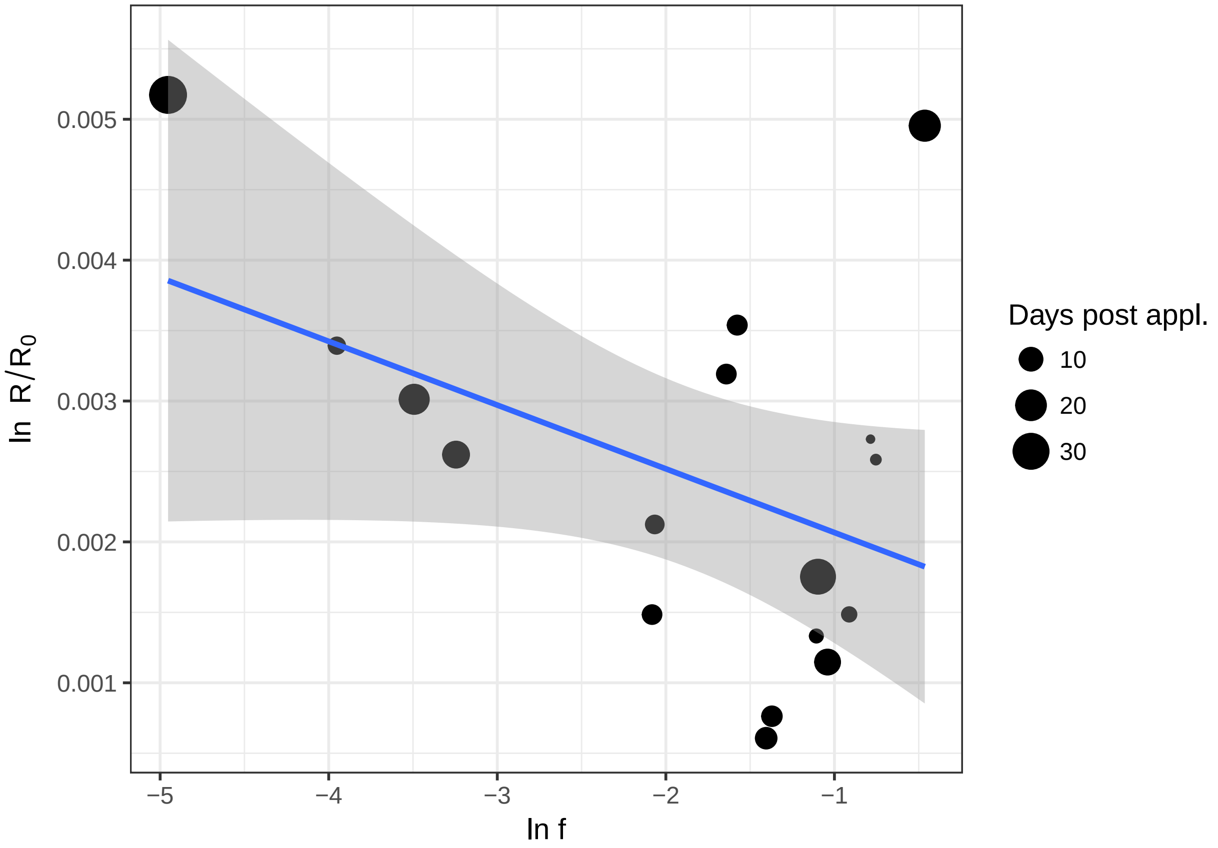

```r
#ggsave(waterIsoConc , filename = "DDvsConc_water.png", width = 8, height = 5, units = "in", scale = 1)
```

Water Rayleigh

```r
waterModel<-lm(yRaleigh~xRaleigh, data= waterClean)
summary(waterModel)
```

```
##
## Call:
## lm(formula = yRaleigh ~ xRaleigh, data = waterClean)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0019938 -0.0010556 -0.0002396  0.0008773  0.0029429
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.0018843  0.0004893   3.851 0.000866 ***
## xRaleigh    -0.0002738  0.0001629  -1.681 0.106903
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.001422 on 22 degrees of freedom
## Multiple R-squared:  0.1138, Adjusted R-squared:  0.07355
## F-statistic: 2.826 on 1 and 22 DF,  p-value: 0.1069
```

```r
minX <- confint(waterModel, "xRaleigh", level = 0.95)[1]*1000
maxX <- confint(waterModel, "xRaleigh", level = 0.95)[2]*1000

cofwater <- as.numeric(coef(waterModel)[2]*1000)
se <- summary(waterModel)$coef[[4]]*1000

CI95 = maxX - cofwater


waterRaleigh <- ggplot(data = subset(waterClean, (!is.na(yRaleigh) & xRaleigh > -7 & ngC.mean.diss > 5)
  geom_point(aes(size = timeSinceApp)) +
  theme_bw() +
  scale_size_continuous(range = c(1, 6)) +
  labs(size="Days post appl.") +
  xlab("ln f") +
  ylab("ln R/Ro") +
  ylab(expression(paste("ln  ",  R / R['0'] ))) +
  stat_smooth(data= subset(waterClean, (!is.na(yRaleigh) & xRaleigh > -7  & ngC.mean.diss > 5)), method

waterRaleigh
```




```r
# ggsave(waterRaleigh, filename = "lnDDvslnConc_water.png", width = 8, height = 5, units = "in", scale
# Date conversion correct:
sum(is.na(waters$Date.ti)) == 0
```

```
## [1] TRUE
```

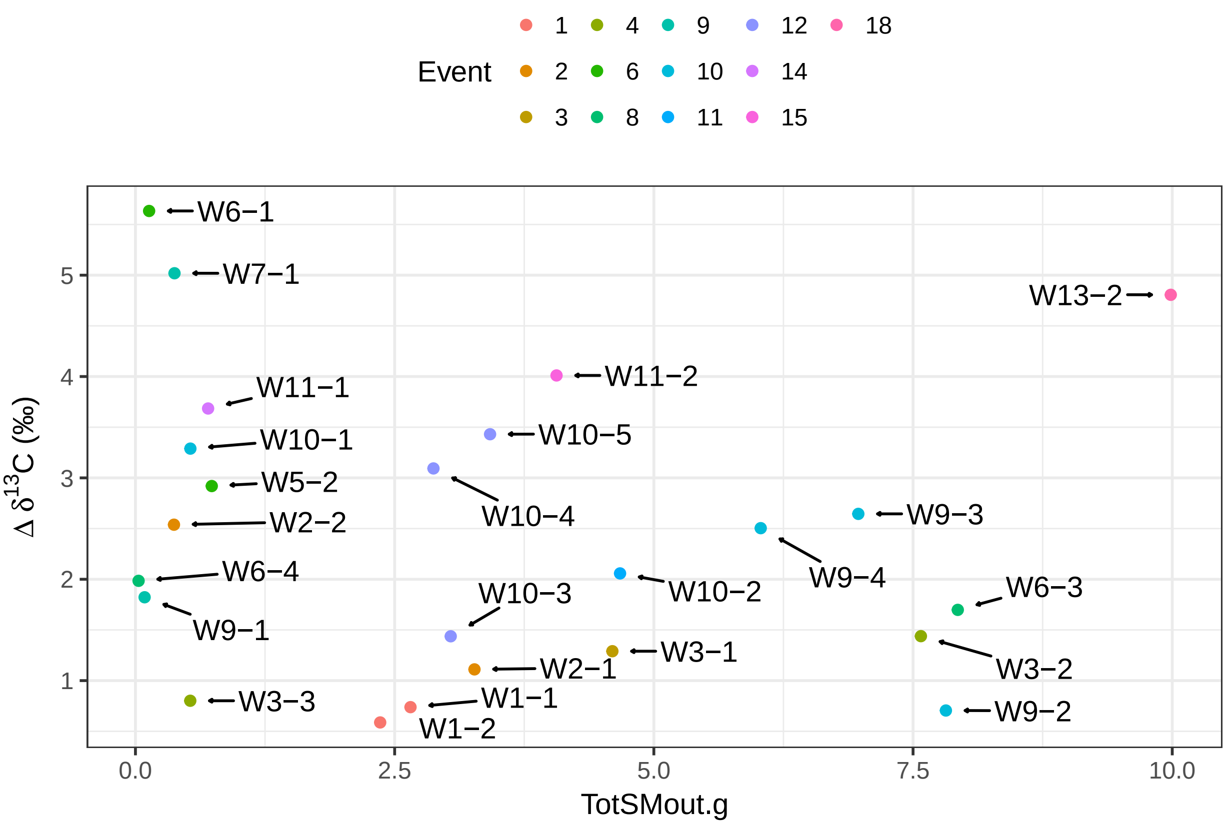
```r
str(waters)
```

```
## 'data.frame':	51 obs. of  96 variables:
##  $ Date.ti                : POSIXct, format: "2016-03-25 00:04:00" "2016-03-25 12:04:00" ...
##  $ WeekSubWeek            : Factor w/ 51 levels "W0-0x","W0-1",..: 1 2 3 4 5 6 26 27 28 29 ...
##  $ tf                     : Factor w/ 51 levels "2016-03-25 12:02:00",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ iflux                  : num  1.25 1.12 1.31 1.46 16.33 ...
##  $ fflux                  : num  1.13 1.31 1.46 16.45 15.18 ...
##  $ changeflux             : num  -0.119 0.189 0.148 14.989 -1.15 ...
##  $ maxQ                   : num  1.25 1.38 1.64 38.4 18.67 ...
##  $ minQ                   : num  1.118 1.082 0.929 1.449 13.201 ...
##  $ dryHrs                 : num  0.0167 6.0167 47.3 66.1333 1.65 ...
##  $ Duration.Hrs           : num  12 82.5 37.6 27.3 23.1 ...
##  $ chExtreme              : num  -0.13 0.256 0.33 36.944 -3.133 ...
##  $ Peak                   : int  NA NA NA 1 NA NA 2 NA NA 3 ...
##  $ Markers                : num  NA NA NA 16.9 NA ...
##  $ TimeDiff               : Factor w/ 18 levels "106","136","150",..: NA NA NA 10 NA NA 2 NA NA 11 ..
##  $ AveDischarge.m3.h      : num  1.2 1.21 1.28 14.32 15.53 ...
##  $ Volume.m3              : num  14.4 100.2 48.3 390.4 359.2 ...
##  $ Sampled.Hrs            : num  12 82.5 37.6 27.3 23.1 ...
##  $ Sampled                : Factor w/ 2 levels "Not Sampled",..: 1 2 1 2 2 1 2 2 1 2 ...
##  $ Conc.mug.L             : num  0.246 0.246 3.517 6.788 6.561 ...
##  $ Conc.SD                : num  0.0193 0.0193 0.1544 0.2894 0.1906 ...
##  $ OXA_mean               : num  4.82 4.82 17.68 30.53 32.49 ...
##  $ OXA_SD                 : num  1.141 1.141 5.663 10.185 0.243 ...
##  $ ESA_mean               : num  18.1 18.1 32 46 41.3 ...
##  $ ESA_SD                 : num  3.497 3.497 3.267 3.037 0.853 ...
##  $ N.x                    : int  NA NA NA 3 3 NA 3 3 NA 3 ...
##  $ diss.d13C              : num  NA NA NA -31.5 -31.7 ...
##  $ SD.d13C                : num  NA NA NA 0.106 0.151 ...
##  $ se.d13C                : num  NA NA NA 0.0612 0.0874 ...
##  $ N_ngC.diss             : int  NA NA NA 3 3 NA 3 3 NA 3 ...
##  $ ngC.mean.diss          : num  NA NA NA 42.7 54.7 ...
##  $ ngC.SD.diss            : num  NA NA NA 1.92 2.54 ...
##  $ MES.mg.L               : num  NA 53.4 NA 62.5 22.5 ...
##  $ MES.sd                 : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ MO.mg.L                : num  NA 0 NA 0.001 0.0001 NA 0.0001 0.0001 NA 0.0058 ...
##  $ Conc.Solids.mug.gMES   : num  0.645 0.645 0.385 0.126 0.436 ...
##  $ Conc.Solids.ug.gMES.SD: num  0.0232 0.0232 0.0252 0.0271 0.1232 ...
##  $ N.y                    : int  NA NA NA NA NA NA 3 3 NA NA ...
##  $ filt.d13C              : num  NA NA NA NA NA ...
##  $ filt.SD.d13C           : num  NA NA NA NA NA ...
##  $ filt.se.d13C           : num  NA NA NA NA NA ...
##  $ N_ngC.fl               : int  NA NA NA NA NA NA 3 3 NA NA ...
##  $ ngC.mean.fl            : num  NA NA NA NA NA ...
##  $ ngC.SD.fl              : num  NA NA NA NA NA ...
##  $ DD13C.diss             : num  NA NA NA 0.738 0.587 ...
##  $ DD13C.filt             : num  NA NA NA NA NA ...
##  $ NH4.mM                 : num  NA NA NA 0.05 NA NA NA NA NA NA ...
##  $ TIC.ppm.filt           : num  NA NA NA 51.8 44.8 NA 66.7 52.1 NA 69.4 ...
##  $ Cl.mM                  : num  NA NA NA 1.48 1574 ...
##  $ NO3...mM               : num  NA NA NA 616 778 ...
##  $ PO4..mM                : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ NPOC.ppm               : num  NA NA NA 4 4.4 NA 5.8 3.4 NA 9.1 ...
```

```
##  $ TIC.ppm.unfilt        : num  NA NA NA 44.8 26.4 NA 39 32.3 NA 54.8 ...
##  $ TOC.ppm.unfilt        : num  NA NA NA 4.7 5.4 NA 2.7 3.8 NA 3.9 ...
##  $ ExpMES.Kg             : num  5.35 5.35 14.88 24.4 8.08 ...
##  $ Appl.Mass.g           : num  17319 0 0 0 0 ...
##  $ timeSinceApp          : num  0.5 3.9 5.5 6.6 7.6 11.6 12.6 14 20.6 2.2 ...
##  $ Appl.Mass.g.NoSo      : num  17319 0 0 0 0 ...
##  $ timeSinceApp.NoSo     : num  0.5 3.9 5.5 6.6 7.6 11.6 12.6 14 20.6 2.2 ...
##  $ CumAppMass.g          : num  17319 17319 17319 17319 17319 ...
##  $ DissSmeto.mg          : num  3.54 24.6 170.04 2649.91 2357 ...
##  $ DissSmeto.mg.SD       : num  0.278 1.934 7.463 112.98 68.486 ...
##  $ DissSmeto.g           : num  0.00354 0.0246 0.17004 2.64991 2.357 ...
##  $ DissSmeto.g.SD        : num  0.000278 0.001934 0.007463 0.11298 0.068486 ...
##  $ DissOXA.mg            : num  69.5 483.2 854.7 11918.4 11672.7 ...
##  $ DissOXA.mg.SD         : num  16.5 114.3 273.8 3976 87.3 ...
##  $ DissOXA.g             : num  0.0695 0.4832 0.8547 11.9184 11.6727 ...
##  $ DissOXA.g.SD          : num  0.0165 0.1143 0.2738 3.976 0.0873 ...
##  $ DissESA.mg            : num  260 1808 1548 17951 14830 ...
##  $ DissESA.mg.SD         : num  50.4 350.3 158 1185.5 306.6 ...
##  $ DissESA.g             : num  0.26 1.81 1.55 17.95 14.83 ...
##  $ DissESA.g.SD          : num  0.0504 0.3503 0.158 1.1855 0.3066 ...
##  $ FiltSmeto.mg          : num  3.45 3.45 5.73 3.07 3.52 ...
##  $ FiltSmeto.mg.SD       : num  0.124 0.124 0.374 0.66 0.996 ...
##  $ FiltSmeto.g           : num  0.00345 0.00345 0.00573 0.00307 0.00352 ...
##  $ FiltSmeto.g.SD        : num  0.000124 0.000124 0.000374 0.00066 0.000996 ...
##  $ TotSMout.mg           : num  6.99 28.06 175.77 2652.98 2360.52 ...
##  $ TotSMout.mg.SD        : num  0.216 1.37 5.284 79.89 48.432 ...
##  $ TotSMout.g            : num  0.00699 0.02806 0.17577 2.65298 2.36052 ...
##  $ TotSMout.g.SD         : num  0.000216 0.00137 0.005284 0.07989 0.048432 ...
##  $ FracDiss              : num  0.506 0.877 0.967 0.999 0.999 ...
##  $ FracFilt              : num  0.49352 0.12301 0.03261 0.00116 0.00149 ...
##  $ MELsm.g               : num  0.302 2.078 2.379 30.241 27.008 ...
##  $ MELsm.g.SD            : num  0.0269 0.1868 0.1789 2.4062 0.1634 ...
##  $ CumOutDiss.g          : num  0.00354 0.02815 0.19818 2.84809 5.2051 ...
##  $ CumOutFilt.g          : num  0.00345 0.0069 0.01263 0.01571 0.01923 ...
##  $ CumOutSmeto.g         : num  0.00699 0.03505 0.21082 2.8638 5.22432 ...
##  $ CumOutMELsm.g         : num  0.302 2.38 4.76 35.001 62.009 ...
##  $ BalMassDisch.g        : num  17319 17317 17314 17284 17257 ...
##  $ prctMassOut           : num  4.98e-05 2.00e-04 1.25e-03 1.89e-02 1.68e-02 ...
##  $ FracDeltaOut          : num  0 0 0 -0.595 -0.532 ...
##  $ Events                : Factor w/ 51 levels "0-1","0-2","0-3",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ Weeks                 : Factor w/ 16 levels "W0","W1","W10",..: 1 1 1 2 2 2 9 9 9 10 ...
##  $ Event                 : Factor w/ 19 levels "0","1","2","3",..: 1 1 1 2 2 2 3 3 3 4 ...
##  $ yRaleigh              : num  NA NA NA 0.000763 0.000607 ...
##  $ xRaleigh              : num  -4.69 -4.69 -2.03 -1.37 -1.4 ...
##  $ DIa                   : num  1.5 1.68 2.1 549.76 289.92 ...
```

```r
ggplot(waterClean, aes(x=TotSMout.g, y=DD13C.diss))+
  geom_point(aes(group = Event, colour = Event))+
  theme_bw() +
  theme(legend.position="top"
        # axis.title.x = element_blank(),
        ) +
  guides(col = guide_legend(nrow =  3)) + #,
         # shape = guide_legend(nrow =  3)) +
```

```
  ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
  # xlab(expression(paste("Conc. S-Meto.  ", {({mu}*g / L)}))) +
  geom_text_repel(aes(label=WeekSubWeek),
                  arrow = arrow(length = unit(0.005, 'npc'), type = "closed"),
                  force = 1,
                  point.padding = unit(1.0, 'lines'),
                  max.iter = 2e3,
                  nudge_x = .2)
```

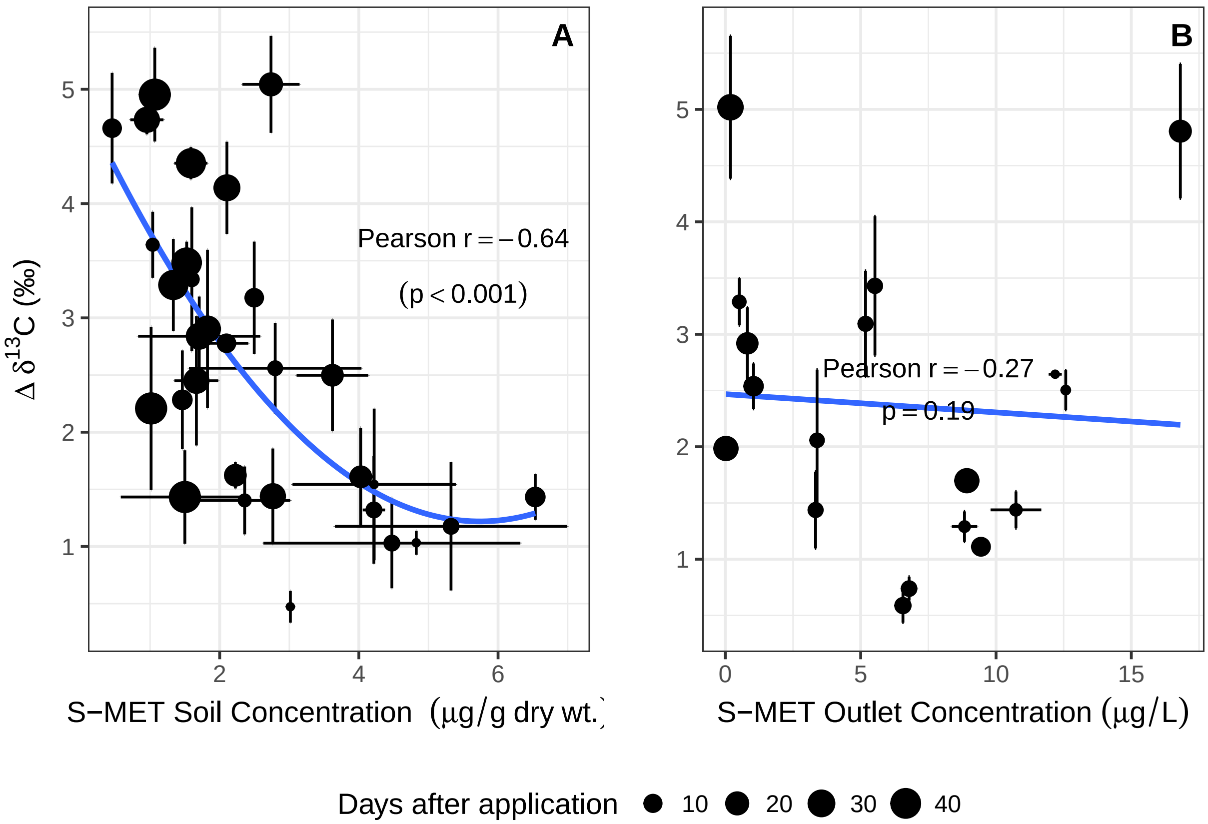


Join XY waters and soils

```
p_noLeg <- p + theme(legend.position = 'none')
p_Leg <- get_legend(p)

water_noLeg <- waterIsoConc + theme(legend.position = 'none')
water_Leg <- get_legend(waterIsoConc)

grid_xyConIso <- plot_grid(p_noLeg, water_noLeg,
                    ncol =2, nrow = 1, align ="v" #,
                    #labels = c("A", "B")
                    )

xyConcIso <- ggdraw() +
  draw_plot(grid_xyConIso, x=0., y=0.1, width =  1, height = .90) +
```

```
  #draw_plot(water_noLeg, x=0.5, y = 0.0, width = 0.4, height = 1) +
  draw_plot(p_Leg, x=0.48, y = 0.0, width = 0.1, height = 0.1) +
  draw_label("A", x= 0.47, y = .95, size = 12, fontface = "bold") +
  draw_label("B", x= 0.97, y = .95, size = 12, fontface = "bold")
```

```
xyConcIso
```




```
#ggsave(xyConcIso , filename = "waterSoil_DDvsConc.png", width = 8, height = 5, units = "in", scale = 1
```

Correlations Waters

```
cor.test(waters$Conc.mug.L, waters$diss.d13C)
```

```
##
##  Pearson's product-moment correlation
##
## data:  waters$Conc.mug.L and waters$diss.d13C
## t = -1.4068, df = 25, p-value = 0.1718
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.5901137  0.1217051
## sample estimates:
##        cor
## -0.2708348
```

```
#cor.test(waters$TotSMout.g, waters$diss.d13C)

#esaoxa <- waters$MELsm.g-waters$TotSMout.g
# cor.test(esaoxa, waters$diss.d13C)
```

Merge Soil and Water data frames

Objective is to plot both soils and water temporaly

Outlet Isotope Shifts (DD)

In the same plot consider this secondary axis, where the secondary axis is a formulat of the first:

ggplot(mpg, aes(displ, hwy)) + geom_point() + scale_y_continuous("mpg (US)", sec.axis = sec_axis(~ . * 1.20, name = "mpg (UK)"))

Or this: https://github.com/tidyverse/ggplot2/wiki/Align-two-plots-on-a-page

```
# SD min. selection line 914 (for dissolved)
waterClean_ng <- subset(waterClean, ngC.mean.diss > 0)
WaterSoils <- merge(waterClean_ng, soils, by = "Date.ti", all = T)

WaterSoils$BulkCatch.d13
```

```
##  [1]        NA        NA        NA        NA        NA        NA -30.90999
##  [8]        NA        NA -31.06420        NA        NA -31.08437        NA
## [15]        NA -30.18066        NA        NA -29.92248 -28.79611        NA
## [22]        NA        NA        NA        NA -28.77000        NA -29.07242
## [29]        NA        NA        NA        NA -29.60902        NA        NA
## [36]        NA        NA        NA -29.30065        NA        NA -29.14126
## [43]        NA        NA        NA        NA -27.21000        NA        NA
## [50] -29.50000 -28.60148        NA
```

```
WaterSoils$DD13.Bulk
```

```
##  [1]       NA       NA       NA       NA       NA       NA 1.343015
##  [8]       NA       NA 1.188803       NA       NA 1.168629       NA
## [15]       NA 2.072338       NA       NA 2.330516 3.456895       NA
## [22]       NA       NA       NA       NA 3.483000       NA 3.180585
## [29]       NA       NA       NA       NA 2.643984       NA       NA
## [36]       NA       NA       NA 2.952355       NA       NA 3.111739
## [43]       NA       NA       NA       NA 5.043000       NA       NA
## [50] 2.753000 3.651518       NA
```

```
names(WaterSoils)
```

```
##   [1] "Date.ti"                  "WeekSubWeek"
##   [3] "tf"                       "iflux"
##   [5] "fflux"                    "changeflux"
##   [7] "maxQ"                     "minQ"
##   [9] "dryHrs"                   "Duration.Hrs"
##  [11] "chExtreme"                "Peak"
##  [13] "Markers"                  "TimeDiff"
##  [15] "AveDischarge.m3.h"        "Volume.m3"
```

```
##  [17] "Sampled.Hrs"            "Sampled"
##  [19] "Conc.mug.L"             "Conc.SD"
##  [21] "OXA_mean"               "OXA_SD"
##  [23] "ESA_mean"               "ESA_SD"
##  [25] "N.x"                    "diss.d13C.x"
##  [27] "SD.d13C.x"              "se.d13C"
##  [29] "N_ngC.diss"             "ngC.mean.diss"
##  [31] "ngC.SD.diss"            "MES.mg.L"
##  [33] "MES.sd"                 "MO.mg.L"
##  [35] "Conc.Solids.mug.gMES"   "Conc.Solids.ug.gMES.SD"
##  [37] "N.y"                    "filt.d13C"
##  [39] "filt.SD.d13C"           "filt.se.d13C"
##  [41] "N_ngC.fl"               "ngC.mean.fl"
##  [43] "ngC.SD.fl"              "DD13C.diss"
##  [45] "DD13C.filt"             "NH4.mM"
##  [47] "TIC.ppm.filt"           "Cl.mM"
##  [49] "NO3...mM"               "PO4..mM"
##  [51] "NPOC.ppm"               "TIC.ppm.unfilt"
##  [53] "TOC.ppm.unfilt"         "ExpMES.Kg"
##  [55] "Appl.Mass.g"            "timeSinceApp.x"
##  [57] "Appl.Mass.g.NoSo"       "timeSinceApp.NoSo.x"
##  [59] "CumAppMass.g.x"         "DissSmeto.mg"
##  [61] "DissSmeto.mg.SD"        "DissSmeto.g"
##  [63] "DissSmeto.g.SD"         "DissOXA.mg"
##  [65] "DissOXA.mg.SD"          "DissOXA.g"
##  [67] "DissOXA.g.SD"           "DissESA.mg"
##  [69] "DissESA.mg.SD"          "DissESA.g"
##  [71] "DissESA.g.SD"           "FiltSmeto.mg"
##  [73] "FiltSmeto.mg.SD"        "FiltSmeto.g"
##  [75] "FiltSmeto.g.SD"         "TotSMout.mg"
##  [77] "TotSMout.mg.SD"         "TotSMout.g"
##  [79] "TotSMout.g.SD"          "FracDiss"
##  [81] "FracFilt"               "MELsm.g"
##  [83] "MELsm.g.SD"             "CumOutDiss.g"
##  [85] "CumOutFilt.g"           "CumOutSmeto.g"
##  [87] "CumOutMELsm.g"          "BalMassDisch.g"
##  [89] "prctMassOut"            "FracDeltaOut"
##  [91] "Events"                 "Weeks"
##  [93] "Event.x"                "yRaleigh"
##  [95] "xRaleigh"               "DIa"
##  [97] "Event.y"                "timeSinceApp.y"
##  [99] "timeSinceApp.NoSo.y"    "diss.d13C.y"
## [101] "SD.d13C.y"              "CumAppMass.g.y"
## [103] "MassSoil.g.North"       "MassSoil.g.SD.North"
## [105] "Conc.mug.g.dry.soil.N"  "comp.d13C.North"
## [107] "comp.d13C.SD.North"     "ID.N"
## [109] "MassSoil.g.Talweg"      "MassSoil.g.SD.Talweg"
## [111] "Conc.mug.g.dry.soil.T"  "comp.d13C.Talweg"
## [113] "comp.d13C.SD.Talweg"    "MassSoil.g.South"
## [115] "MassSoil.g.SD.South"    "Conc.mug.g.dry.soil.S"
## [117] "comp.d13C.South"        "comp.d13C.SD.South"
## [119] "ID.S"                   "DD13C.North"
## [121] "DD13C.Talweg"           "DD13C.South"
## [123] "CatchMassSoil.g"        "CatchMassSoil.g.SD"
```

```
## [125] "BulkCatch.d13"          "BulkCatch.d13.SD"
## [127] "DD13.Bulk"              "Area.Catchment"
## [129] "BulkCatch.Conc"
```

```r
keepWS <- c("Date.ti", "WeekSubWeek", "ID.N", "Event.x",
            "maxQ", "AveDischarge.m3.h",
            "DD13C.diss", "SD.d13C.x",
            "DD13C.filt", "filt.SD.d13C",
            "DD13C.Talweg", "comp.d13C.SD.Talweg",
            "DD13C.South", "comp.d13C.SD.South",
            "DD13C.North", "comp.d13C.SD.North",
            "DD13.Bulk", "BulkCatch.d13.SD"
            #"timeSinceApp.x", "Event.x", "Events"
            )
wsSmall <- WaterSoils[ , (names(WaterSoils) %in% keepWS)]

names(wsSmall)
```

```
##  [1] "Date.ti"             "WeekSubWeek"         "maxQ"
##  [4] "AveDischarge.m3.h"   "SD.d13C.x"           "filt.SD.d13C"
##  [7] "DD13C.diss"          "DD13C.filt"          "Event.x"
## [10] "comp.d13C.SD.North"  "ID.N"                "comp.d13C.SD.Talweg"
## [13] "comp.d13C.SD.South"  "DD13C.North"         "DD13C.Talweg"
## [16] "DD13C.South"         "BulkCatch.d13.SD"    "DD13.Bulk"
```

```r
wsSmall <- wsSmall[c("Date.ti", "WeekSubWeek", "ID.N", "Event.x",
                     "maxQ", "AveDischarge.m3.h",
            "DD13C.diss", "SD.d13C.x",
            "DD13C.filt", "filt.SD.d13C" ,
            "DD13C.Talweg", "comp.d13C.SD.Talweg",
            "DD13C.South", "comp.d13C.SD.South",
            "DD13C.North", "comp.d13C.SD.North",
            "DD13.Bulk", "BulkCatch.d13.SD")]

keepCorrTest <- c("DD13C.diss",
                  "DD13C.Talweg",
                  "DD13C.South",
                  "DD13C.North",
                  "DD13.Bulk")

wsTest <- wsSmall[ , (names(wsSmall) %in% keepCorrTest)]

names(wsSmall) <- c("Date", "Week", "IDSoil", "Event",
                    "Qmax", "Qmean",
            "diss.measure", "diss.SD",
            "filt.measure", "filt.SD",
            "Talweg.measure", "Talweg.SD",
            "South.measure", "South.SD",
            "North.measure", "North.SD",
            "BulkDD.measure", "BulkDD.SD"
            )

wsTest <- wsTest[7:length(wsTest$DD13C.diss) , ]
wsTest$DD13.Bulk <- na.locf(wsTest$DD13.Bulk)
wsTest$DD13C.Talweg <- na.locf(wsTest$DD13C.Talweg)
```

```r
wsTest$DD13C.South <- na.locf(wsTest$DD13C.South)
wsTest$DD13C.North <- na.locf(wsTest$DD13C.North)

cor.test(wsTest$DD13.Bulk, wsTest$DD13C.diss, method = "pearson", use = "pairwise.complete.obs")
```

```
##
##  Pearson's product-moment correlation
##
## data:  wsTest$DD13.Bulk and wsTest$DD13C.diss
## t = 2.639, df = 19, p-value = 0.01618
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1110408 0.7760796
## sample estimates:
##      cor
## 0.517902
```

```r
cor.test(wsTest$DD13C.Talweg, wsTest$DD13C.diss, method = "pearson", use = "pairwise.complete.obs")
```

```
##
##  Pearson's product-moment correlation
##
## data:  wsTest$DD13C.Talweg and wsTest$DD13C.diss
## t = 2.9441, df = 19, p-value = 0.00833
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1688081 0.7984696
## sample estimates:
##       cor
## 0.5597077
```

```r
cor.test(wsTest$DD13C.North, wsTest$DD13C.diss, method = "pearson", use = "pairwise.complete.obs")
```

```
##
##  Pearson's product-moment correlation
##
## data:  wsTest$DD13C.North and wsTest$DD13C.diss
## t = 4.8762, df = 19, p-value = 0.0001049
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4628101 0.8905996
## sample estimates:
##       cor
## 0.7455452
```

```r
cor.test(wsTest$DD13C.South, wsTest$DD13C.diss, method = "pearson", use = "pairwise.complete.obs")
```

```
##
##  Pearson's product-moment correlation
##
## data:  wsTest$DD13C.South and wsTest$DD13C.diss
## t = 0.76082, df = 19, p-value = 0.4561
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.2805674  0.5619222
## sample estimates:
```

```
##       cor
## 0.1719448
```

```r
# Conventional way of melting won't work if we need SDs.
# ws <- melt(wsSmall, id=c("Date.ti", "timeSinceApp.x", "Events", "Event.x"))

# Need to rename the columns so that I can use separate and spread from the package tidyr
#names(wsSmall)[-1][seq(2, length(names(wsSmall)) - 1, 2)] <-
#  paste0(names(wsSmall)[-1][seq(1, length(names(wsSmall)) - 1, 2)], "-SD")
#names(wsSmall)[-1][seq(1, length(names(wsSmall)) - 1, 2)] <-
#  paste0(names(wsSmall)[-1][seq(1, length(names(wsSmall)) - 1, 2)], "-measure")

wstidier <- wsSmall %>%
  gather(measure, value, -Date, -IDSoil, -Event, -Week, -Qmax, -Qmean) %>% # Melts data frame
  separate(measure, into = c("Location", "temporary_var")) %>% # parses the sep = "." into...
  spread(temporary_var, value)

wstidier$Type <- ifelse(wstidier$Location == "diss", "Dissolved",
                  ifelse(wstidier$Location == "filt", "Sediment",
                        "Top Soil"))

wstidier$Source <- ifelse(wstidier$Location == "diss", "Outlet",
                  ifelse(wstidier$Location == "filt", "Outlet",
                         ifelse(wstidier$Location == "South", "South",
                               ifelse(wstidier$Location == "Talweg", "Valley",
                                       ifelse(wstidier$Location == "BulkDD", "Bulk",
                                       "North"))) ))

wstidier$Source <- as.factor(wstidier$Source)
wstidier$Type <- as.factor(wstidier$Type)
wstidier$IDSoil <- as.factor(wstidier$IDSoil)
wstidier$Event <- as.numeric(wstidier$Event)

# Copy all data
wstidierAll <- wstidier

levels(wstidier$Source)
```

```
## [1] "Bulk"   "North"  "Outlet" "South"  "Valley"
```

```r
levels(wstidier$Type)
```

```
## [1] "Dissolved" "Sediment"  "Top Soil"
```

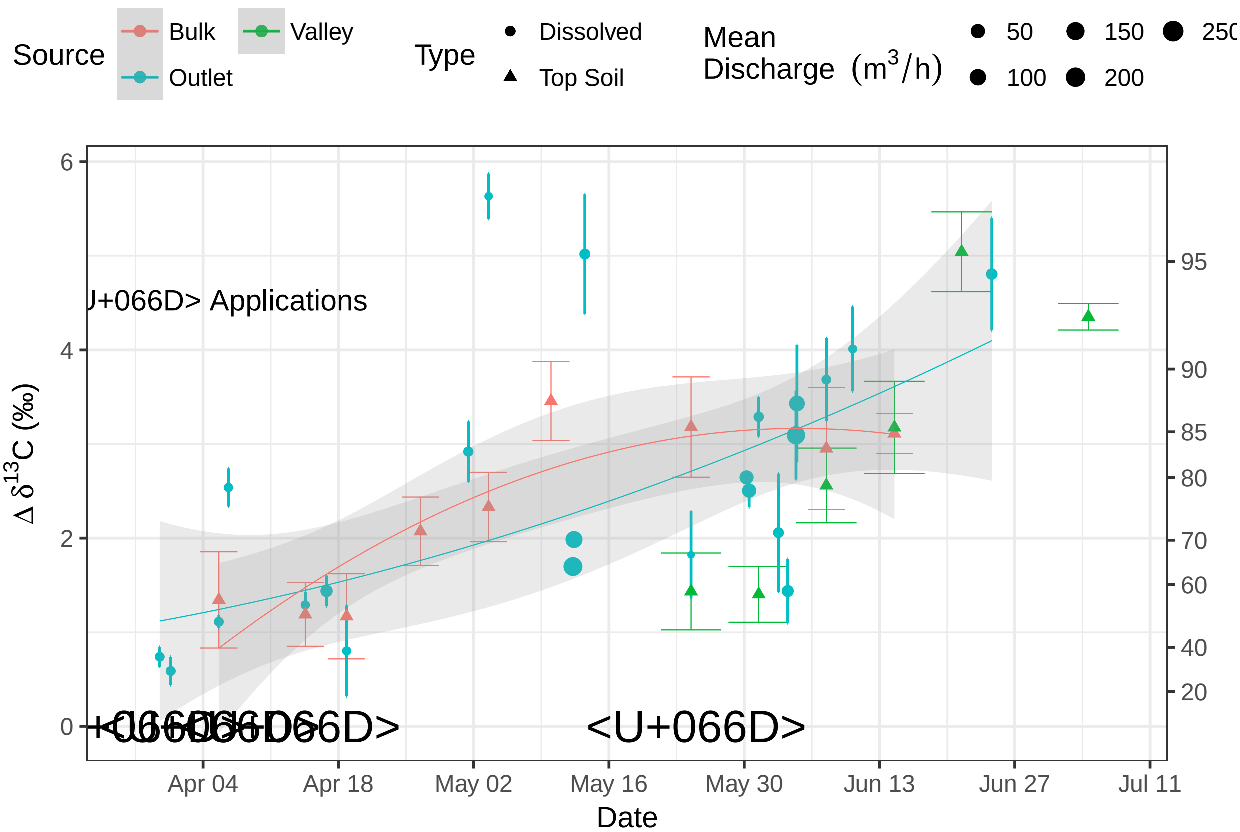
```r
#wstidier$Source <- factor(wstidier$Source, levels = c("Bulk", "Plateau","Valley", "Outlet"))
wstidier$Source <- factor(wstidier$Source, levels = c("Bulk", "North", "Valley", "South", "Outlet"))
wstidier$Type <- factor(wstidier$Type, levels = c("Top Soil", "Dissolved", "Sediment" ))


# epsilon
#epsilon_field
#initialDelta

#wstidier$DegField <- (1-((1000 + d13Co + wstidier$measure)/(1000+d13Co))^(1000/epsilon_field))*100
#wstidier$DegLab <- (1-((1000 + d13Co + wstidier$measure)/(1000+d13Co))^(1000/epsilon_lab))*100
```

```
#wstidier$DegDiff <- (wstidier$DegField - wstidier$DegLab)

wstidier$Location <- as.factor(wstidier$Location)
#wstidier$Week <- as.factor(wstidier$Week)

#library(dplyr)
#detach("package:plyr")
#sumary <- na.omit(wstidier) %>%
#  group_by(Type) %>%
#  summarise(mean = mean(DegDiff))

limits_DdC <- aes(ymin=measure-SD, ymax=measure+SD, colour = Source)


# Dissolved has been selected, but not soils or filters
wstidier2 = subset(wstidier, SD <= 0.75) #& Source != "Bulk"  ) #& Date < as.POSIXct('2016-06-14 08:04:
NoBASE <- subset(wstidier2, Week != "W6-1" )

pd <- position_dodge(width = 0.4)
wsALL_lab <- ggplot(data = wstidier2, aes(x = Date, y = measure, group = Source) )+
  geom_errorbar(data=subset(wstidier2, Source == 'Bulk'), limits_DdC, size=0.2) +
  geom_errorbar(data=subset(wstidier2, Source == 'Valley' &
                              Date > as.POSIXct('2016-05-14 08:04:00')), limits_DdC, size=0.2) +
  geom_errorbar(data=subset(wstidier2, Source == 'Outlet'), limits_DdC) +
  #geom_point(data=subset(wstidier2, Source == 'Outlet'), aes(shape = Type, colour = Source, size = Qma
  geom_point(data=subset(wstidier2, Source == 'Outlet'), aes(shape = Type, colour = Source, size = Qmean
  geom_point(data=subset(wstidier2, Source == 'Bulk'), aes(shape = Type, colour = Source)) +
  geom_point(data=subset(wstidier2, Source == 'Valley' &
                           Date > as.POSIXct('2016-05-14 08:04:00')), aes(shape = Type, colour = Source)

  #stat_smooth(data=subset(wstidier,
  #                          (Source == "Valley" & Event > 8 )),
  #            method = "lm", formula = y ~ poly(x, 2), se = F, colour = 'darkgreen' , alpha = 0.1, siz
  #stat_smooth(data=subset(wstidier,
  #                          (Source != "Outlet" & Source != "Valley" & Event < 20 )),
  #            method = "lm", formula = y ~  poly(x, 2), se = F, alpha = 0.1, size=0.2) +

  # Water
  stat_smooth(data=subset(NoBASE,
                          (Source == "Outlet" & Event > 1 & Type == "Dissolved")),
              method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'Outlet'), alpha = 0.2, size
  # North
  stat_smooth(data=subset(wstidier2,
                          (Source == "Bulk" )), #| Source == "South" )),
              method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'Bulk'), alpha = 0.2, size=
  #stat_smooth(data=subset(wstidier2,
  #                          (Source == "South")),
  #            method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'South'), alpha = 0.2, siz
  theme_bw() +
  # Applics
  annotate("text", x = as.POSIXct('2016-03-28 08:04:00'), y = 0,
           label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  annotate("text", x = as.POSIXct('2016-04-05 00:04:00'), y = 0,
```

```
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  annotate("text", x = as.POSIXct('2016-04-13 08:04:00'), y = 0,
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  annotate("text", x = as.POSIXct('2016-05-25 08:04:00'), y = 0,
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  # Title applics
  annotate("text", x = as.POSIXct('2016-04-05 08:04:00'), y = 4.5,
         label = as.character(expression(paste( "\u066D", " Applications"))), parse = T, size = 4.0) +
  scale_x_datetime(breaks = date_breaks("1 month"), labels = date_format("%b %d")) +
  #scale_x_datetime(breaks = date_breaks("2 weeks"), labels = date_format("%b %d")) +
  theme(legend.position="top"
      # axis.title.x = element_blank(),
      # axis.text.x=element_text(angle = 45, hjust = 1)
      ) +
  # geom_smooth(data=subset(ws, Source != "Outlet"), method = "lm", formula = y ~ poly(x, 2)) +
  xlab("Date") +
  #ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
  scale_y_continuous(
    expression(paste({Delta~delta}^"13","C", ' (\u2030)')),
    sec.axis = sec_axis(trans = ~ (1-((1000 + d13Co + .)/(1000+d13Co))^(1000/epsilon_lab))*100 ,
                    name = "Degradation (%)",
                    #name = element_blank(),
                    breaks=c(20, 40, 60, 70, 80, 85, 90, 95) )# breaks=seq(20, 120, 15))
  )  +
  scale_color_manual(name= "Source",
                   values = c("#F8766D", "#00BFC4", "#00BA38", "#B79F00", "#619CFF", "#F564E3",
                              "#D55E00", "darkgreen", "dodgerblue")
                  ) +
  scale_size_continuous(range = c(1, 3)) #




wsALL_field <- ggplot(data = wstidier2, aes(x = Date, y = measure, group = Source) )+
  geom_errorbar(data=subset(wstidier2, Source == 'Bulk'), limits_DdC, size=0.2) +
  geom_errorbar(data=subset(wstidier2, Source == 'Valley' &
                              Date > as.POSIXct('2016-05-14 08:04:00')), limits_DdC, size=0.2) +
  geom_errorbar(data=subset(wstidier2, Source == 'Outlet'), limits_DdC) +
  #geom_point(data=subset(wstidier2, Source == 'Outlet'), aes(shape = Type, colour = Source, size = Qma
  geom_point(data=subset(wstidier2, Source == 'Outlet'), aes(shape = Type, colour = Source, size = Qmear
  geom_point(data=subset(wstidier2, Source == 'Bulk'), aes(shape = Type, colour = Source)) +
  geom_point(data=subset(wstidier2, Source == 'Valley' &
                           Date > as.POSIXct('2016-05-14 08:04:00')), aes(shape = Type, colour = Source

  #stat_smooth(data=subset(wstidier,
  #                          (Source == "Valley" & Event > 8 )),
  #            method = "lm", formula = y ~ poly(x, 2), se = F, colour = 'darkgreen' , alpha = 0.1, siz
  #stat_smooth(data=subset(wstidier,
  #                          (Source != "Outlet" & Source != "Valley" & Event < 20 )),
  #            method = "lm", formula = y ~  poly(x, 2), se = F, alpha = 0.1, size=0.2) +

  # Water
  stat_smooth(data=subset(NoBASE, #wstidier2, #NoBASE,
```

```
                          (Source == "Outlet" & Event > 1 & Type == "Dissolved")),
            method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'Outlet'), alpha = 0.2, size
# North
stat_smooth(data=subset(wstidier2,
                          (Source == "Bulk" )), #| Source == "South" )),
            method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'Bulk'), alpha = 0.2, size=
#stat_smooth(data=subset(wstidier2,
#                          (Source == "South")),
#            method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'South'), alpha = 0.2, siz
theme_bw() +
# Applics
annotate("text", x = as.POSIXct('2016-03-28 08:04:00'), y = 0,
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
annotate("text", x = as.POSIXct('2016-04-05 00:04:00'), y = 0,
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
annotate("text", x = as.POSIXct('2016-04-13 08:04:00'), y = 0,
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
annotate("text", x = as.POSIXct('2016-05-25 08:04:00'), y = 0,
         label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
# Title applics
annotate("text", x = as.POSIXct('2016-04-05 08:04:00'), y = 4.5,
         label = as.character(expression(paste( "\u066D", " Applications"))), parse = T, size = 4.0)
scale_x_datetime(breaks = date_breaks("2 weeks"), labels = date_format("%b %d")) +
#scale_x_datetime(breaks = date_breaks("1 month"), labels = date_format("%b %d")) +
theme(legend.position="top"
      # axis.title.x = element_blank()
      # axis.text.x=element_text(angle = 45, hjust = 1)
      ) +
# geom_smooth(data=subset(ws, Source != "Outlet"), method = "lm", formula = y ~ poly(x, 2)) +
xlab("Date") +
#ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
scale_y_continuous(
  expression(paste({Delta~delta}^"13","C", ' (\u2030)')),
  sec.axis = sec_axis(trans = ~ (1-((1000 + d13Co + .)/(1000+d13Co))^(1000/epsilon_field))*100 ,
                      name = element_blank(),
                      #name = "Degradation (%)",
                      breaks=c(20, 40, 60, 70, 80, 85, 90, 95) )# breaks=seq(20, 120, 15))
)  +
scale_color_manual(name= "Source",
                    values = c("#F8766D", "#00BFC4", "#00BA38", "#B79F00", "#619CFF", "#F564E3",
                               "#D55E00", "darkgreen", "dodgerblue")
                   ) +
scale_size_continuous(range = c(1, 3)) +
guides(col = guide_legend(order = 1,
                          #title=expression("Source"),
                          #title.vjust = -1,
                          nrow = 2,
                          title.position = "left"
                          ),
       shape=guide_legend(#title=expression("Type"),
                          order = 2,
                          nrow=2,
                          title.position = "left",
```

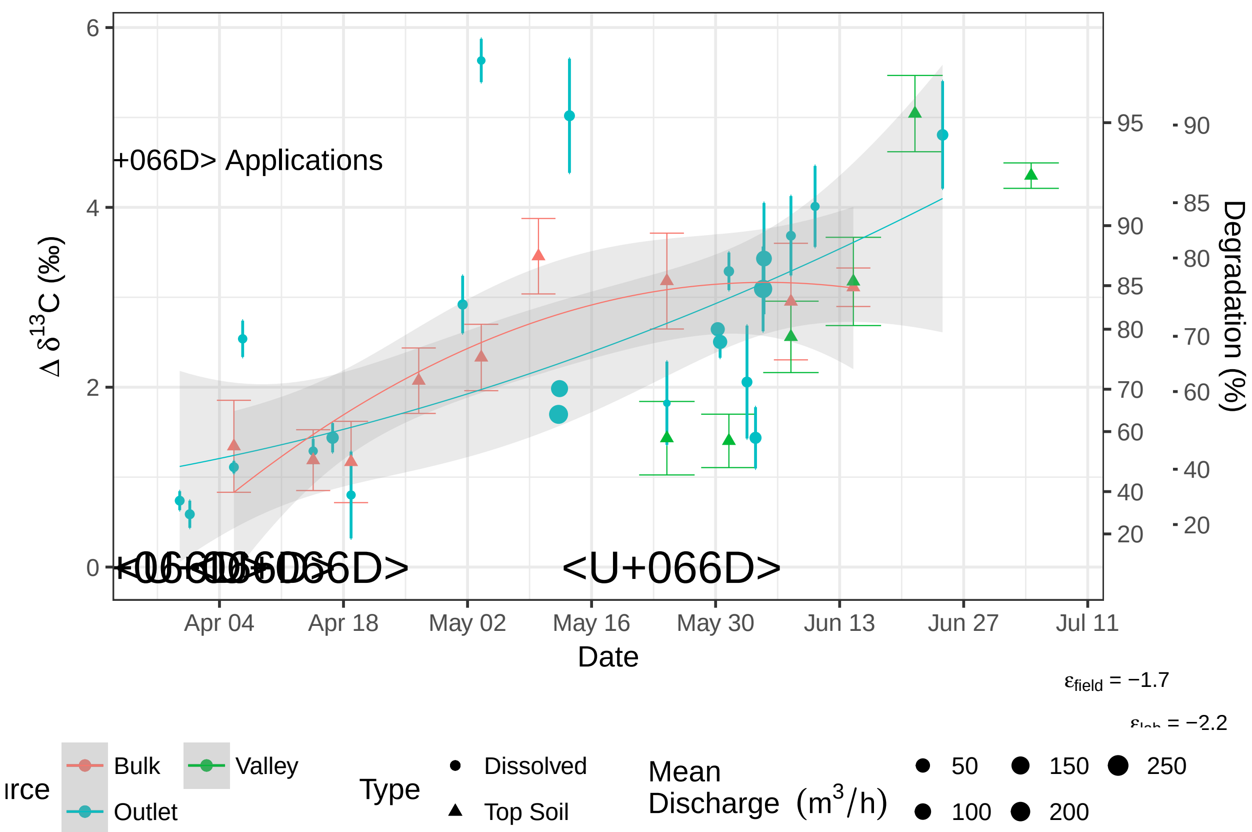
```
                          keyheight = NULL, title.vjust = NULL, label.vjust = NULL),
         size = guide_legend(order = 3,
                             title=expression("Mean\nDischarge " ~ (m^3 / h) ),
                             nrow=2, title.position = "left", title.vjust = .26
                              ))# +
  # scale_shape_manual(name= )

#ggplotly(wsALL_field)
wsALL_field
```



Join all figures

```
#wsALL_lab
#wsALL_field
#wsPlot
# ggsave(wsALL, filename = "WaterSoilvsTime.png", width = 8, height = 5, units = "in", scale = 1)
# ggsave(wsALL, filename = "WaterBulkvsTime.png", width = 8, height = 5, units = "in", scale = 1)

wsALL_field_noLeg <- wsALL_field + theme(legend.position='none')
wsALL_lab_noLeg <- wsALL_lab + theme(legend.position='none')
wsAll_field_Leg  <- get_legend(wsALL_field)
```

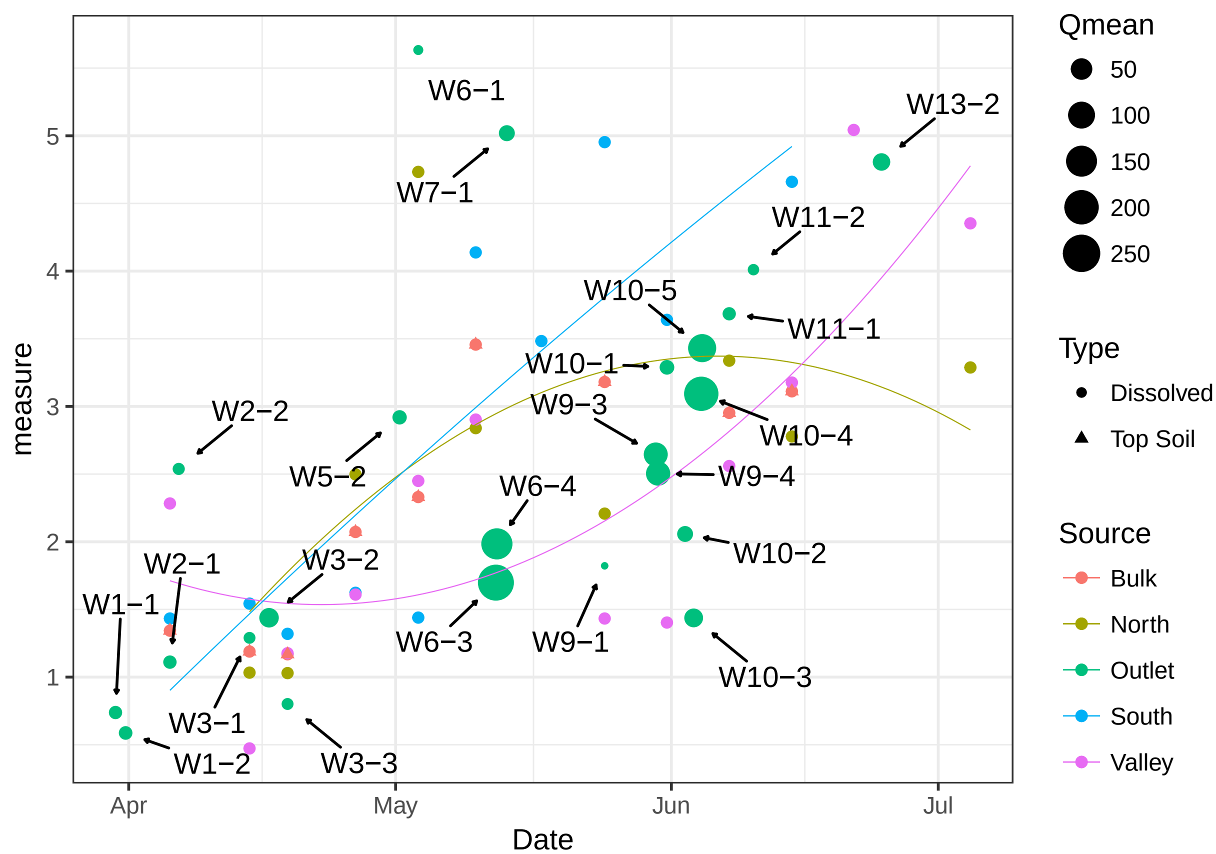
```
label <- substitute(paste(epsilon, " = ", epsilon_f, ", Field", epsilon, " = " , epsilon_l),
                    list(epsilon_f = signif(epsilon_field, 2), epsilon_l = signif(epsilon_lab, 2) ))

label2 <- substitute(paste(epsilon ["field"] , " = ", epsilon_f),
                     list(epsilon_f = signif(epsilon_field, 3)))

label3 <- substitute(paste(epsilon ["lab"] , " = ", epsilon_l),
                     list(epsilon_l = signif(epsilon_lab, 3)))
# adding label via ggdraw, in the ggdraw coordinates


wsALL <- ggdraw() +
  draw_plot(wsALL_lab_noLeg, x=0, y = 0.2, width = 1, height = 0.8) + # bottom
  draw_plot(wsALL_field_noLeg, x=0, y=.2, width = 0.935, height = .8) + # top
  draw_label(label2, x= .89, y = .2, size = 8) +
  draw_label(label3, x= .94, y = .15, size = 8) +
  draw_plot(wsAll_field_Leg, x=0.2, y=0.0, width = 0.50, height = 0.15)

wsALL
```




```
#ggsave(wsALL, filename = "WaterSoilvsTime.png", width = 8, height = 5, units = "in", scale = 1)
```

Check Soils

```
wstidier2$IDSoil <- as.character(wstidier2$IDSoil)
split <- strsplit(wstidier2$IDSoil, "-", fixed = TRUE)
wstidier2$Soil.ID <- sapply(split, "[", 3)
wstidier2$Soil.ID <- as.factor(wstidier2$Soil.ID)

ggplot(data = wstidier2, aes(x = Date, y = measure, group = Source) )+
  theme_bw() +
  #geom_errorbar(data=subset(wstidier2, Type == 'Top Soil'), limits_DdC, size=0.2) +

  #geom_errorbar(data=subset(wstidier2, Source == 'Valley' &
  #                           Date > as.POSIXct('2016-05-14 08:04:00')), limits_DdC, size=0.2) +
  #geom_errorbar(data=subset(wstidier2, Source == 'Outlet'), limits_DdC) +
  #geom_point(data=subset(wstidier2, Source == 'Outlet'), aes(shape = Type, colour = Source, size = Qma
  geom_point(data=subset(wstidier2, Type == 'Dissolved'), aes(shape = Type, colour = Source, size = Qmea
  geom_point(data=subset(wstidier2, Type == 'Top Soil'), aes(colour = Source)) +

  stat_smooth(data=subset(wstidier2,
                          (Source == "North" )), #| Source == "South" )),
              method = "lm", formula = y ~ poly(x, 2), se = F, aes(colour = Source), alpha = 0.2, size=0
  stat_smooth(data=subset(wstidier2,
                          (Source == "Valley" )), #| Source == "South" )),
              method = "lm", formula = y ~ poly(x, 2), se = F, aes(colour = Source), alpha = 0.2, size=0
  stat_smooth(data=subset(wstidier2,
                          (Source == "South" )), #| Source == "South" )),
              method = "lm", formula = y ~ poly(x, 2), se = F, aes(colour = Source), alpha = 0.2, size=0
  geom_point(data=subset(wstidier2, Source == 'Bulk'), aes(shape = Type, colour = Source)) +
  #geom_point(data=subset(wstidier2, Source == 'Valley' &
  #                         Date > as.POSIXct('2016-05-14 08:04:00')), aes(shape = Type, colour = Sourc
  #geom_text_repel(data=subset(wstidier2, Source == 'Bulk'), aes(label=Soil.ID),
  #                arrow = arrow(length = unit(0.005, 'npc'), type = "closed"),
  #                force = 1,
  #                point.padding = unit(1.0, 'lines'),
  #                max.iter = 2e3,
  #               nudge_x = .2) +
  #geom_text_repel(data=subset(wstidier2, Source != 'Outlet'), aes(label=Soil.ID),
  geom_text_repel(data=subset(wstidier2, Source == 'Outlet'), aes(label=Week),
                 arrow = arrow(length = unit(0.005, 'npc'), type = "closed"),
                 force = 1,
                 point.padding = unit(1.0, 'lines'),
                 max.iter = 2e3,
                 nudge_x = .2)
```




```r
sum(wstidier2$Location == "North")  # 10
```

```
## [1] 9
```

```r
sum(wstidier2$Location == "South")  # 12
```

```
## [1] 10
```

```r
sum(wstidier2$Location == "Talweg")  # 12
```

```
## [1] 12
```

```r
sum(wstidier2$Source == "Bulk")  # 9
```

```
## [1] 9
```

Comparison to Lutz et al. (2013)

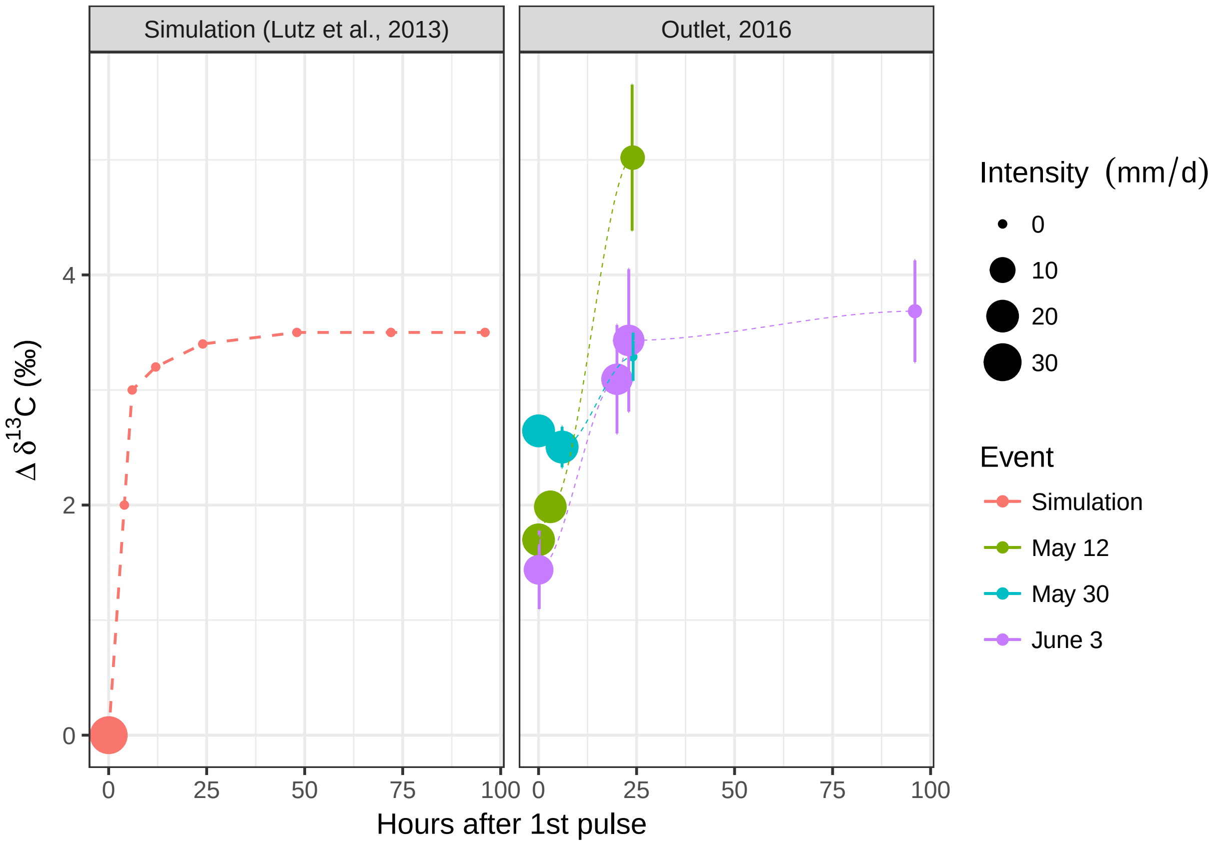
```r
rainDay = read.csv2("Data/WaterDay_R.csv", header = T)
rainDay$DayMoYr <-as.character(rainDay$DayMoYr)
rainDay$Month <-as.character(rainDay$Month)
split2 <- strsplit(rainDay$DayMoYr, "-", fixed = TRUE)
rainDay$Day <- as.numeric(sapply(split2, "[", 3))

# Subset only dissolved measures and select events
dissolved <- subset(wstidier2, Location == "diss" &
                    Date >= as.POSIXct("2016-05-12 06:34:00", tz = "EST") &
```

```r
                    Date <= as.POSIXct("2016-06-07 12:00:00", tz = "EST"))
dissolved <- subset(dissolved, Date != as.POSIXct("2016-05-24 12:00:00", tz = "EST"))

# May 12 event
eventMay12 <- subset(dissolved, Date >= as.POSIXct("2016-05-12 06:34:00", tz = "EST") &
                       Date <= as.POSIXct("2016-05-13 12:06:00", tz = "EST"))

# Inspect the required mm / day
rainMay12 <- subset(rainDay, Month == "May" & (Day == 12 | Day == 13))
eventMay12$Intensity <- c(20.0, 20.0, 8.4)
eventMay12$Time <- c(0, 3, 24)
eventMay12$Event <- rep("May 12", 3)
eventMay12$Approach <- rep("Outlet, 2016", 3)

# May 30 event
eventMay30 <- subset(dissolved, Date >= as.POSIXct("2016-05-30 05:48:00", tz = "EST") &
                       Date <= as.POSIXct("2016-05-31 12:00:00", tz = "EST"))

rainMay30 <- subset(rainDay, Month == "May" & (Day == 30 | Day == 31))
eventMay30$Intensity <- c(20.4, 20.4, 0)
eventMay30$Time <- c(0, 6, 24)
eventMay30$Event <- rep("May 30", 3)
eventMay30$Approach <- rep("Outlet, 2016", 3)

# June 2 event
eventJune2 <- subset(dissolved, Date >= as.POSIXct("2016-06-02 12:58:00", tz = "EST") &
                       Date < as.POSIXct("2016-06-03 12:06:00", tz = "EST"))

rainJune2 <- subset(rainDay, Month == "June" & Day == 2)
eventJune2$Intensity <- c(5)
eventJune2$Time <- c(0)
eventJune2$Event <- rep("June 2", 1)
eventJune2$Approach <- rep("Outlet, 2016", 1)

eventJune3 <- subset(dissolved, Date >= as.POSIXct("2016-06-03 12:06:00", tz = "EST") &
                       Date <= as.POSIXct("2016-06-07 12:00:00", tz = "EST"))

rainJune3 <- subset(rainDay, Month == "June" & (Day > 2 & Day <= 7 ))
eventJune3$Intensity <- c(15.2, 18.0, 18.0, 0.8)
eventJune3$Time <- c(0, 20, 23, 96)
eventJune3$Event <- rep("June 3", 4)
eventJune3$Approach <- rep("Outlet, 2016", 4)

eventsField <- rbind(eventMay12, eventMay30, eventJune3) # eventJune2,

names(eventsField)
```

```
##  [1] "Date"      "Week"      "IDSoil"    "Event"     "Qmax"
##  [6] "Qmean"     "Location"  "measure"   "SD"        "Type"
## [11] "Source"    "Soil.ID"   "Intensity" "Time"      "Approach"
```

```r
eventsField <- eventsField[c("Time", "Intensity", "measure", "SD" ,  "Event", "Approach")]
```

```
Time <- c(0, 4, 6, 12, 24, 48, 72, 96)
Intensity <- c(30, 0, 0, 0, 0, 0, 0, 0)
measure <- c(0, 2, 3, 3.2, 3.4, 3.5, 3.5, 3.5)
SD <- rep(NA, 8)
Event <- rep("Simulation", 8)
Approach <- rep("Simulation (Lutz et al., 2013)", 8)

events <- data.frame(Time, Intensity, measure, SD, Event, Approach)

allEvents <- rbind (events, eventsField)

LutzEvents <- ggplot(data = allEvents, aes(x= Time, y=measure, colour = Event))+
  theme_bw() +
  geom_point(aes(size = Intensity)) +
  geom_line(data = subset(allEvents, Event == "Simulation"), aes(colour = Event), linetype = "dashed") +
  geom_errorbar(data = allEvents, aes(ymin = measure-SD, ymax = measure+SD),
                 width=.2 , # ) + #,                    # Width of the error bars
                  position=position_dodge(.5)) +
  geom_smooth(data=subset(allEvents, Event != "Simulation"), aes(group = Event, colour = Event) ,
              se = F, alpha = 0.2, size=0.2, span = 0.74, linetype = "dashed") +
  ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
  xlab("Hours after 1st pulse") +
  guides(size = guide_legend(order = 4,
                             title=expression("Intensity " ~ (mm/d) ),
                             ncol=1, title.position = "top", title.vjust = .26
                              )) +
  #theme(axis.title.x = element_blank() ) +
  facet_wrap(~ Approach)#, scale="free")

LutzEvents
```

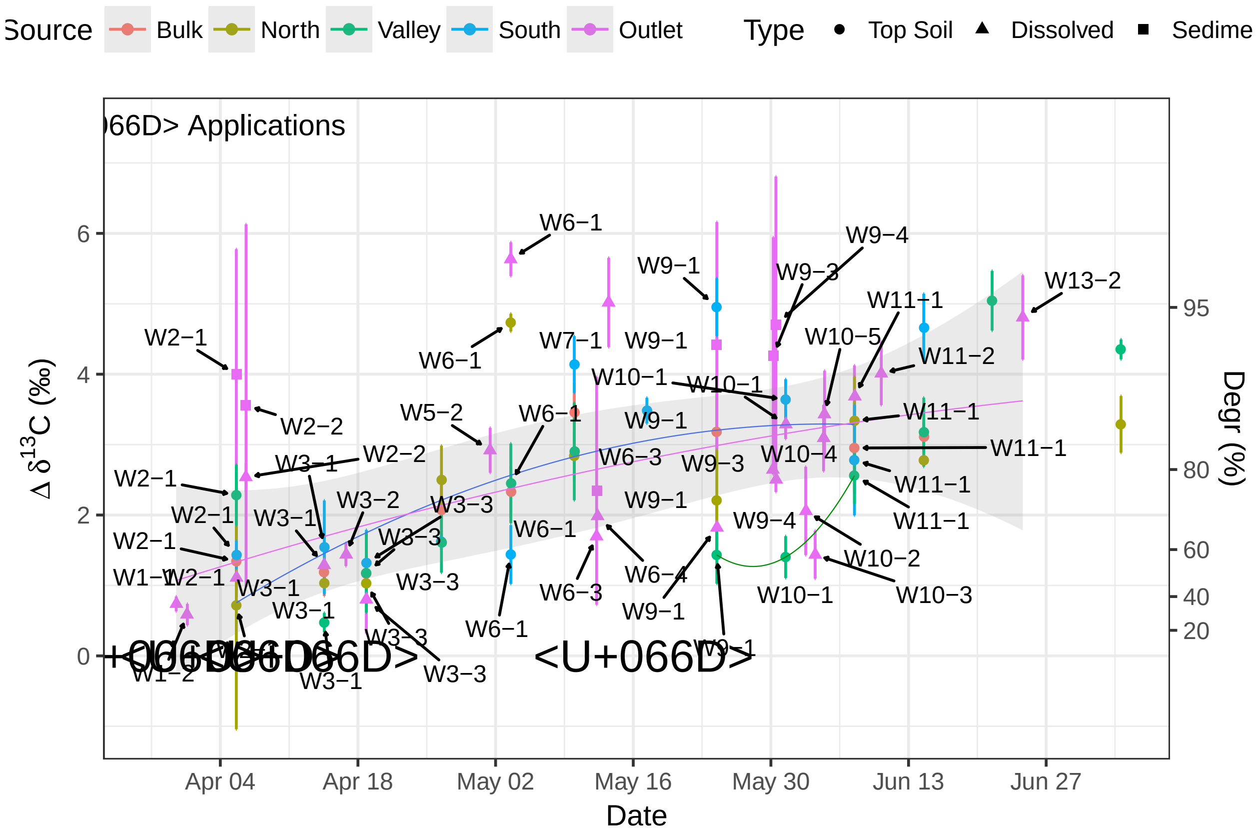



```
# ggsave(LutzEvents, filename = "LutzEvents.png", width = 8, height = 5, units = "in", scale = 1)
```

Soils and Water with labels (inspection)

```
# Data without the Plateau
#wsNoPlat <- subset(wstidierAll, Source != "Plateau")
wsNoPlat <- subset(wstidier, SD < 4)
#wsNoPlat$Source <- factor(wsNoPlat$Source, levels = c("Bulk", "Valley", "Outlet"))
#levels(wsNoPlat$Source)

# Subset the data to values with SD < 1
#wsNoPlat2 = subset(wsNoPlat, SD < 1.50)


limits_DdC <- aes(ymin=measure-SD, ymax=measure+SD, colour = Source)

wsPlot <- ggplot(data = wsNoPlat, aes(x = Date, y = measure)) +
  geom_errorbar(limits_DdC) +
  geom_jitter(aes(shape = Type, colour = Source)) +
  stat_smooth(data=subset(wsNoPlat,
                        (Source == "Valley" & Event > 8 )),
              method = "lm", formula = y ~ poly(x, 2), se = F, colour = 'green4' , alpha = 0.1, size=0.
  stat_smooth(data=subset(wsNoPlat,
                        (Source != "Outlet" & Source != "Valley" & Event < 20 )),
```

```
              method = "lm", formula = y ~  poly(x, 2), se = F, alpha = 0.1, size=0.2) +
  stat_smooth(data=subset(wsNoPlat,
                          (Source == "Outlet" & Event > 1 & Type == "Dissolved")),
              method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'Outlet'), alpha = 0.2, size
  #stat_smooth(data=subset(wsNoPlat,
  #                         (Source == "Bulk")),
  #             method = "lm", formula = y ~ poly(x, 2), se = T, aes(colour = 'Bulk'), alpha = 0.2, size
  theme_bw() +
  # Applics
  annotate("text", x = as.POSIXct('2016-03-28 08:04:00'), y = 0,
           label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  annotate("text", x = as.POSIXct('2016-04-05 08:04:00'), y = 0,
           label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  annotate("text", x = as.POSIXct('2016-04-13 08:04:00'), y = 0,
           label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  annotate("text", x = as.POSIXct('2016-05-17 08:04:00'), y = 0,
           label = as.character(expression(paste( "\u066D"))), parse = T, size = 6.0) +
  # Title applics
  annotate("text", x = as.POSIXct('2016-04-01 08:04:00'), y = 7.5,
           label = as.character(expression(paste( "\u066D", " Applications"))), parse = T, size = 4.0) +

  scale_x_datetime(breaks = date_breaks("2 weeks"), labels = date_format("%b %d")) +
  theme(legend.position="top"
        # axis.title.x = element_blank(),
        # axis.text.x=element_text(angle = 45, hjust = 1)
        ) +
  # geom_smooth(data=subset(ws, Source != "Outlet"), method = "lm", formula = y ~ poly(x, 2)) +
  xlab("Date") +
  #ylab(expression(paste({Delta~delta}^"13","C", ' (\u2030)'))) +
  scale_y_continuous(
    expression(paste({Delta~delta}^"13","C", ' (\u2030)')),
    sec.axis = sec_axis(trans = ~ (1-((1000 + d13Co + .)/(1000+d13Co))^(1000/epsilon_field))*100 ,
                        name = "Degr (%)", breaks=c(20, 40, 60, 80, 95) )# breaks=seq(20, 120, 15))
  ) +
  geom_text_repel(aes(label=as.factor(Week)),
                  size = 3,
                   arrow = arrow(length = unit(0.005, 'npc'), type = "closed"),
                   force = 0.5,
                   point.padding = unit(0.5, 'lines'),
                  max.iter = 2e3,
                 nudge_x = .05)

# +
  #scale_color_manual(name= "Source",
  #                     values = c("black", "dodgerblue", "green", "red")
  #                    ) +
  # scale_shape_manual(name= )

wsPlot
```



Testing difference in $\Delta\delta$ between groups

Based on ANOVA tests, there is:

- No significant difference between soils and water

```
names(WaterSoils)
```

```
##  [1] "Date.ti"                 "WeekSubWeek"
##  [3] "tf"                      "iflux"
##  [5] "fflux"                   "changeflux"
##  [7] "maxQ"                    "minQ"
##  [9] "dryHrs"                  "Duration.Hrs"
## [11] "chExtreme"               "Peak"
## [13] "Markers"                 "TimeDiff"
## [15] "AveDischarge.m3.h"       "Volume.m3"
## [17] "Sampled.Hrs"             "Sampled"
## [19] "Conc.mug.L"              "Conc.SD"
## [21] "OXA_mean"                "OXA_SD"
## [23] "ESA_mean"                "ESA_SD"
## [25] "N.x"                     "diss.d13C.x"
## [27] "SD.d13C.x"               "se.d13C"
## [29] "N_ngC.diss"              "ngC.mean.diss"
## [31] "ngC.SD.diss"             "MES.mg.L"
## [33] "MES.sd"                  "MO.mg.L"
## [35] "Conc.Solids.mug.gMES"    "Conc.Solids.ug.gMES.SD"
```

```
##  [37] "N.y"                      "filt.d13C"
##  [39] "filt.SD.d13C"             "filt.se.d13C"
##  [41] "N_ngC.fl"                 "ngC.mean.fl"
##  [43] "ngC.SD.fl"                "DD13C.diss"
##  [45] "DD13C.filt"               "NH4.mM"
##  [47] "TIC.ppm.filt"             "Cl.mM"
##  [49] "NO3...mM"                 "PO4..mM"
##  [51] "NPOC.ppm"                 "TIC.ppm.unfilt"
##  [53] "TOC.ppm.unfilt"           "ExpMES.Kg"
##  [55] "Appl.Mass.g"              "timeSinceApp.x"
##  [57] "Appl.Mass.g.NoSo"         "timeSinceApp.NoSo.x"
##  [59] "CumAppMass.g.x"           "DissSmeto.mg"
##  [61] "DissSmeto.mg.SD"          "DissSmeto.g"
##  [63] "DissSmeto.g.SD"           "DissOXA.mg"
##  [65] "DissOXA.mg.SD"            "DissOXA.g"
##  [67] "DissOXA.g.SD"             "DissESA.mg"
##  [69] "DissESA.mg.SD"            "DissESA.g"
##  [71] "DissESA.g.SD"             "FiltSmeto.mg"
##  [73] "FiltSmeto.mg.SD"          "FiltSmeto.g"
##  [75] "FiltSmeto.g.SD"           "TotSMout.mg"
##  [77] "TotSMout.mg.SD"           "TotSMout.g"
##  [79] "TotSMout.g.SD"            "FracDiss"
##  [81] "FracFilt"                 "MELsm.g"
##  [83] "MELsm.g.SD"               "CumOutDiss.g"
##  [85] "CumOutFilt.g"             "CumOutSmeto.g"
##  [87] "CumOutMELsm.g"            "BalMassDisch.g"
##  [89] "prctMassOut"              "FracDeltaOut"
##  [91] "Events"                   "Weeks"
##  [93] "Event.x"                  "yRaleigh"
##  [95] "xRaleigh"                 "DIa"
##  [97] "Event.y"                  "timeSinceApp.y"
##  [99] "timeSinceApp.NoSo.y"      "diss.d13C.y"
## [101] "SD.d13C.y"                "CumAppMass.g.y"
## [103] "MassSoil.g.North"         "MassSoil.g.SD.North"
## [105] "Conc.mug.g.dry.soil.N"    "comp.d13C.North"
## [107] "comp.d13C.SD.North"       "ID.N"
## [109] "MassSoil.g.Talweg"        "MassSoil.g.SD.Talweg"
## [111] "Conc.mug.g.dry.soil.T"    "comp.d13C.Talweg"
## [113] "comp.d13C.SD.Talweg"      "MassSoil.g.South"
## [115] "MassSoil.g.SD.South"      "Conc.mug.g.dry.soil.S"
## [117] "comp.d13C.South"          "comp.d13C.SD.South"
## [119] "ID.S"                     "DD13C.North"
## [121] "DD13C.Talweg"             "DD13C.South"
## [123] "CatchMassSoil.g"          "CatchMassSoil.g.SD"
## [125] "BulkCatch.d13"            "BulkCatch.d13.SD"
## [127] "DD13.Bulk"                "Area.Catchment"
## [129] "BulkCatch.Conc"
```

```r
keepDDtest <- c(
  "Date.ti",
  "diss.d13C.x", # "DD13C.diss",
  "comp.d13C.North", "comp.d13C.Talweg", "comp.d13C.South" #,
  #"DD13C.North", "DD13C.Talweg", "DD13C.South"
)
```

```
wsStatTest <- WaterSoils[, colnames(WaterSoils) %in% keepDDtest]

mwsStatTest <- melt(wsStatTest, id="Date.ti")
mwsStatTest$Group1 <- ifelse(mwsStatTest$variable == "diss.d13C.x", "Outlet", "Soil")
mwsStatTest$Group2 <- ifelse(mwsStatTest$variable == "diss.d13C.x", "Outlet",
                             ifelse(mwsStatTest$variable == "comp.d13C.Talweg", "Valley", "Plateau"))
mwsStatTest$Group3 <- ifelse(mwsStatTest$variable == "diss.d13C.x" &
                               mwsStatTest$Date.ti > as.POSIXct('2016-06-05 00:06:00', tz = 'EST'), "Ou
                      ifelse(mwsStatTest$variable == "diss.d13C.x" &
                               mwsStatTest$Date.ti <= as.POSIXct('2016-06-05 00:06:00', tz = 'EST'), "Ou
                      ifelse(mwsStatTest$variable == "comp.d13C.Talweg" &
                               mwsStatTest$Date.ti > as.POSIXct('2016-06-05 00:06:00', tz = 'EST'), "Val
                      ifelse(mwsStatTest$variable == "comp.d13C.Talweg" &
                               mwsStatTest$Date.ti <= as.POSIXct('2016-06-05 00:06:00', tz = 'EST'), "Va
                      ifelse( (mwsStatTest$variable == "comp.d13C.North" | mwsStatTest$variable == "comp
                               mwsStatTest$Date.ti <= as.POSIXct('2016-06-05 00:06:00', tz = 'EST'), "Pl
                      ifelse( (mwsStatTest$variable == "comp.d13C.North" | mwsStatTest$variable == "comp
                               mwsStatTest$Date.ti > as.POSIXct('2016-06-05 00:06:00', tz = 'EST'), "Pla
                              ))))))

Gr1 <- na.omit(mwsStatTest[, colnames(mwsStatTest) %in% c("value", "Group1")])
Gr2 <- na.omit(mwsStatTest[, colnames(mwsStatTest) %in% c("value", "Group2")])
Gr3 <- na.omit(mwsStatTest[, colnames(mwsStatTest) %in% c("value", "Group3")])


# Test for homogeneity of variance
# Large p-value means no confirmation of homogeneity of variance
bartlett.test(value ~ as.factor(Group3), data = Gr3)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  value by as.factor(Group3)
## Bartlett's K-squared = 3.7036, df = 5, p-value = 0.5928
```

```
# Non-parameteric
# Reject Ho that pop. means are the same if low p-value
res.krs.Grp3 <- kruskal.test(value ~ as.factor(Group3), data = Gr3)
res.krs.Grp3
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  value by as.factor(Group3)
## Kruskal-Wallis chi-squared = 17.372, df = 5, p-value = 0.003846
```

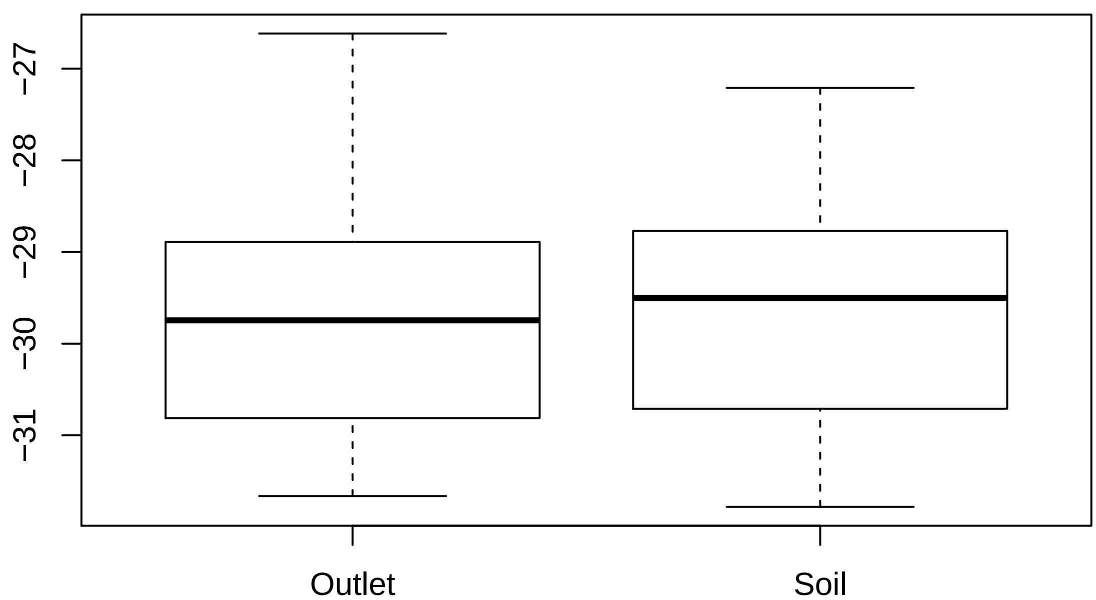
```
# Want a TukeyHSD function, but this only works with
# parametric data. So, will pass the ranks of the data instead of the actual values
Gr3.ranks <- rank( Gr3$value )
Gr3.groups <- Gr3$Group3
group3.aov <- aov(Gr3.ranks ~ Gr3.groups)
res.grp3 <- TukeyHSD(group3.aov, ordered = T)
aov.res.grp3.df <- as.data.frame(res.grp3$Gr3.groups)
aov.res.grp3.df$P <- round(aov.res.grp3.df$`p adj`, 3)
# High p-value indicates no significant difference
```

```r
write.csv(aov.res.grp3.df, "aovResISOs_ranked.csv", row.names = T)
```

ANOVA and ANOSIM

Not actually used, as Grouping 3 does not have homegenity of variance

```r
# Simple ANOVA tests
# (high p-value indicates lack of difference)
# Big P-value no significant difference
boxplot(Gr1$value ~ Gr1$Group1)
```




```r
summary(aov(Gr1$value ~ Gr1$Group1))
```

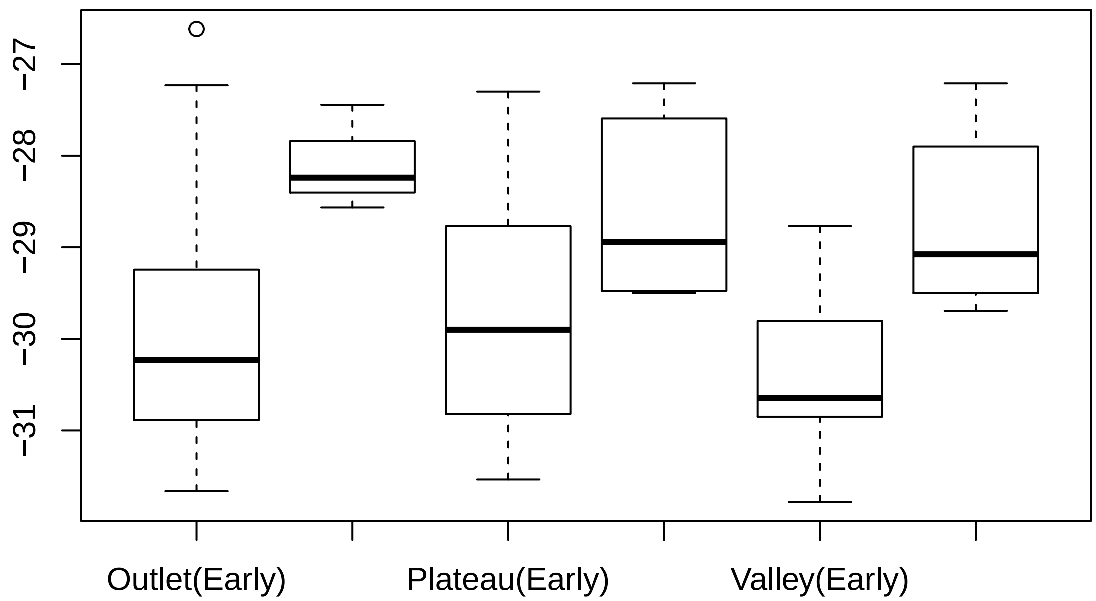
```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Gr1$Group1   1   0.68   0.677   0.379  0.541
## Residuals   63 112.65   1.788
```

```r
TukeyHSD(aov(Gr1$value ~ Gr1$Group1))
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Gr1$value ~ Gr1$Group1)
##
## $`Gr1$Group1`
##                 diff        lwr       upr     p adj
```

```
## Soil-Outlet 0.213441 -0.4797029 0.9065848 0.5405386
```

```
boxplot(Gr3$value ~ Gr3$Group3)
```




```
group3.aov <- aov(Gr3$value ~ Gr3$Group3)
summary(group3.aov)
```

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## Gr3$Group3   5  28.46   5.692   3.957 0.00367 **
## Residuals   59  84.86   1.438
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Transform data and compute dissimilarity
Gr1.hell <- decostand(Gr1[ , 1], "hellinger", na.rm=T, MARGIN = 2) # Transform/Standardize
Gr1.hell.daisy = daisy(Gr1.hell, "euclidean") # Dissimilarity
attach(Gr1)
anosim.group1 <- anosim(Gr1.hell.daisy, grouping = Group1)
summary(anosim.group1)
```

```
##
## Call:
## anosim(dat = Gr1.hell.daisy, grouping = Group1)
## Dissimilarity:
##
## ANOSIM statistic R: -0.002704
##       Significance: 0.457
##
```

```
## Permutation: free
## Number of permutations: 999
##
## Upper quantiles of permutations (null model):
##    90%    95%  97.5%    99%
## 0.0491 0.0695 0.0883 0.1176
##
## Dissimilarity ranks between and within classes:
##           0%    25%    50%    75% 100%   N
## Between 11.0 514.75 1034.0 1560.5 2080 966
## Outlet  12.0 558.00 1068.0 1617.0 2079 253
## Soil     5.5 516.00 1036.5 1545.0 2071 861
```

```
Gr2.hell <- decostand(Gr2[ , 1], "hellinger", na.rm=T, MARGIN = 2) # Transform/Standardize
Gr2.hell.daisy = daisy(Gr2.hell, "euclidean") # Dissimilarity
attach(Gr2)
anosim.group2 <- anosim(Gr2.hell.daisy, grouping = Group2)
summary(anosim.group2)
```

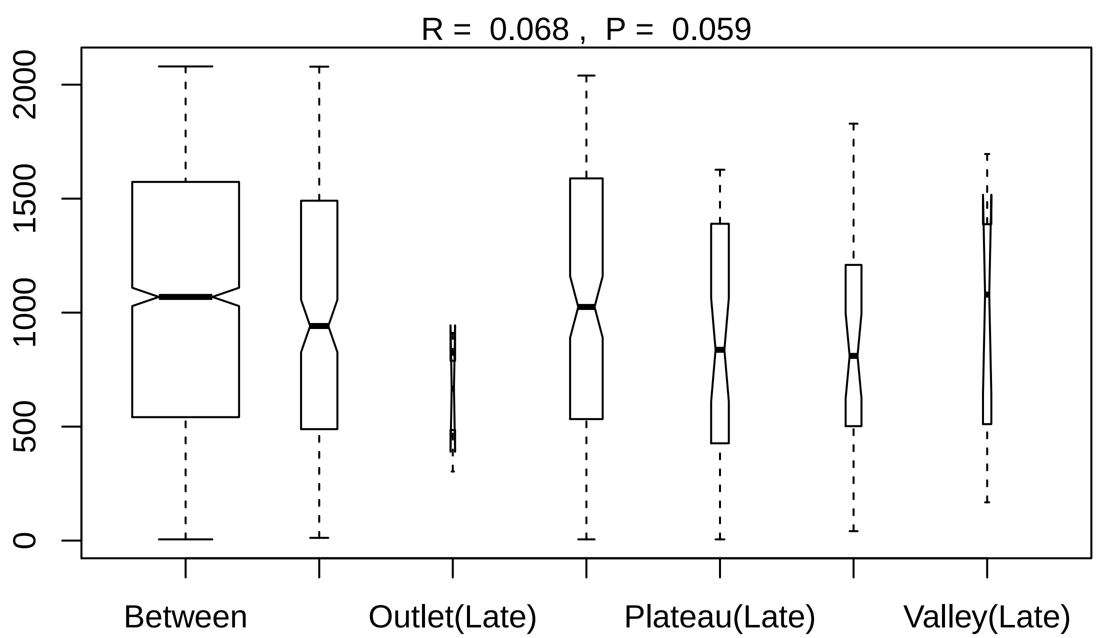
```
##
## Call:
## anosim(dat = Gr2.hell.daisy, grouping = Group2)
## Dissimilarity:
##
## ANOSIM statistic R: -0.02921
##       Significance: 0.853
##
## Permutation: free
## Number of permutations: 999
##
## Upper quantiles of permutations (null model):
##    90%    95%  97.5%    99%
## 0.0395 0.0573 0.0744 0.0833
##
## Dissimilarity ranks between and within classes:
##           0%   25%    50%     75% 100%    N
## Between  5.5 506.5 1028.5 1552.75 2080 1358
## Outlet  12.0 558.0 1068.0 1617.00 2079  253
## Plateau  5.5 541.0 1069.5 1564.75 2058  378
## Valley  41.5 577.0  976.0 1475.75 2071   91
```

```
Gr3.hell <- decostand(Gr3[ , 1], "hellinger", na.rm=T, MARGIN = 2) # Transform/Standardize
Gr3.hell.daisy = daisy(Gr3.hell, "euclidean") # Dissimilarity
attach(Gr3)
anosim.group3 <- anosim(Gr3.hell.daisy, grouping = Group3)
summary(anosim.group3)
```

```
##
## Call:
## anosim(dat = Gr3.hell.daisy, grouping = Group3)
## Dissimilarity:
##
## ANOSIM statistic R: 0.0679
##       Significance: 0.059
##
```

```
## Permutation: free
## Number of permutations: 999
##
## Upper quantiles of permutations (null model):
##    90%    95%  97.5%    99%
## 0.0542 0.0699 0.0815 0.1028
##
## Dissimilarity ranks between and within classes:
##                    0%    25%     50%     75% 100%    N
## Between           5.5 541.50 1069.00 1573.50 2080 1643
## Outlet(Early)    12.0 491.25  941.50 1481.25 2079  190
## Outlet(Late)    303.0 485.00  667.00  789.00  911    3
## Plateau(Early)    5.5 533.00 1025.00 1589.00 2040  153
## Plateau(Late)     5.5 427.00  837.00 1390.00 1627   45
## Valley(Early)    41.5 507.50  810.25 1177.75 1829   36
## Valley(Late)    168.0 531.50 1079.00 1374.25 1696   10
```

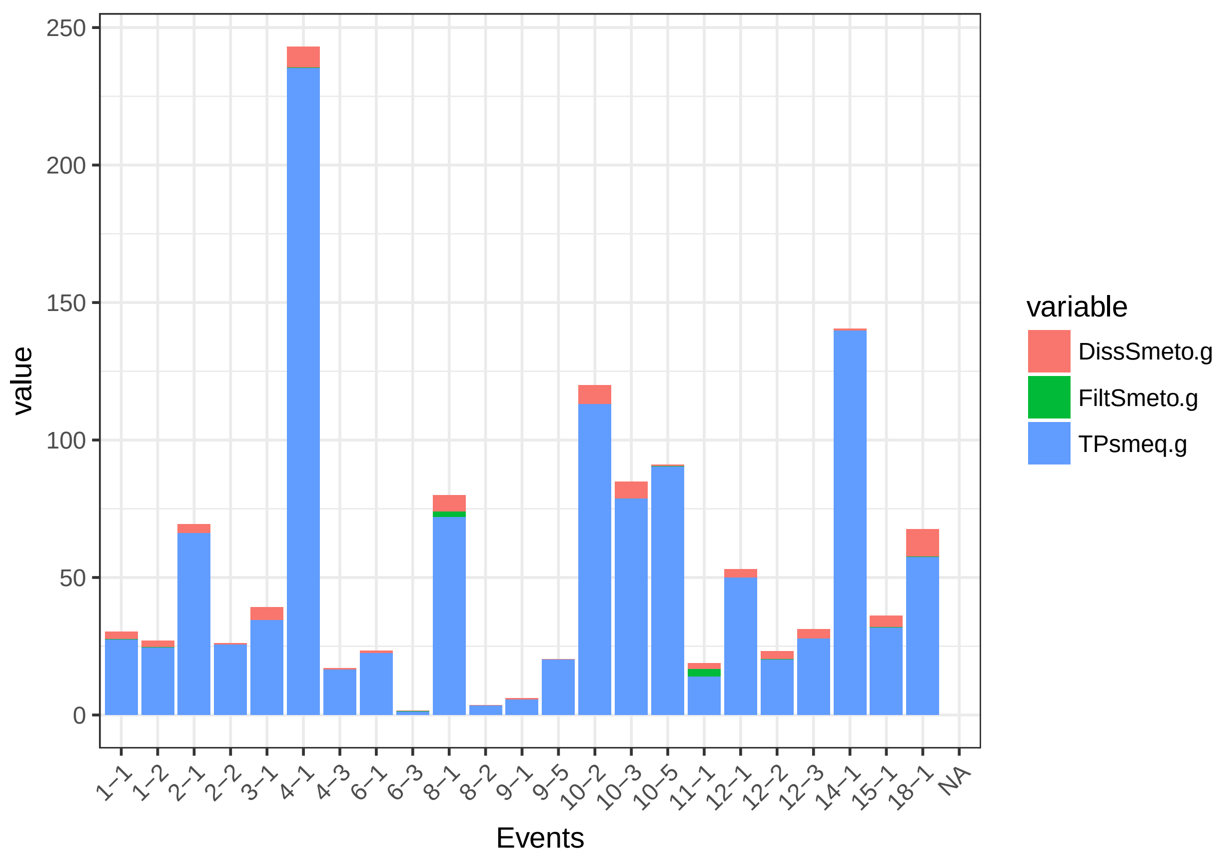
```r
plot(anosim.group3)
```



Loadings

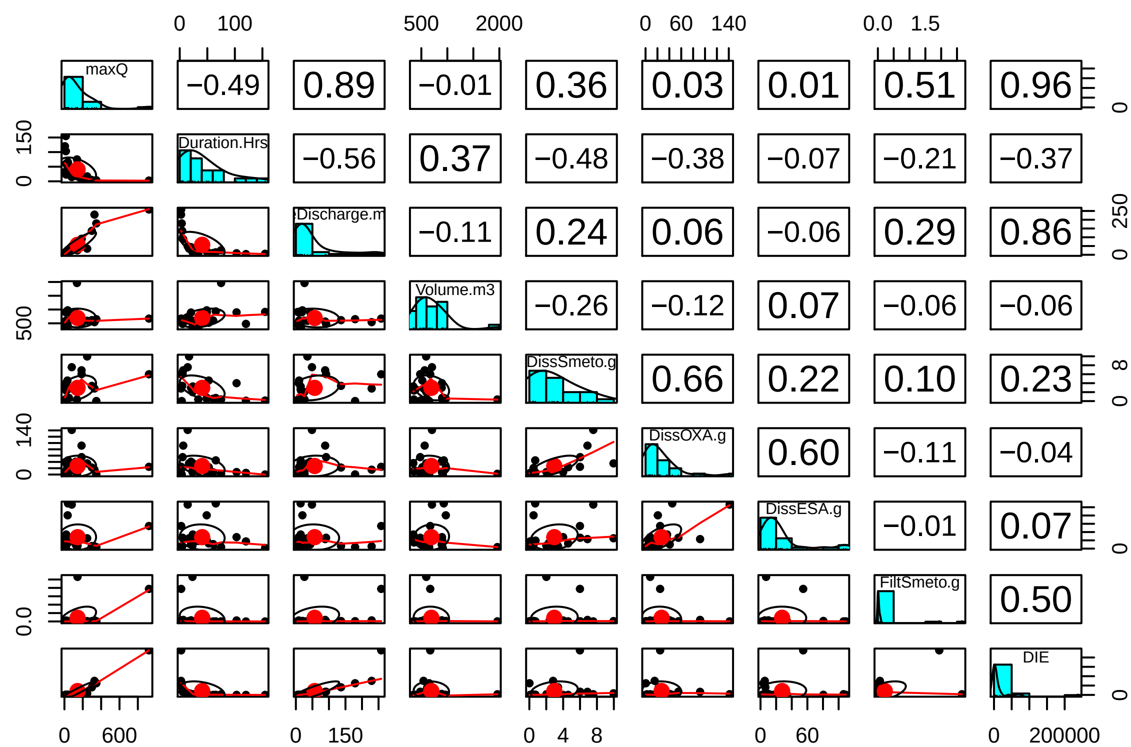
```r
keepLoads <- c("Date.ti",
            "DissOXA.g", "DissESA.g", "DissSmeto.g", "FiltSmeto.g",
            "Event.x", "Events")
wsLoads <- WaterSoils[ , (names(WaterSoils) %in% keepLoads)]
```

```r
mw.SM <- 283.796 # g/mol
mw.MOXA <- 279.33 # g/ml
mw.MESA <- 329.1 # g/mol
wsLoads$TPsmeq.g <-
  wsLoads$DissOXA.g * (mw.SM/mw.MOXA) +
  wsLoads$DissESA.g * (mw.SM/mw.MESA)

wsLoads <- wsLoads[ , !(names(wsLoads) %in% c("DissOXA.g", "DissESA.g"))]

loads <- melt(wsLoads, id=c("Date.ti", "Events", "Event.x"))

ggplot(data = loads , aes(x=Events, y=value, fill = variable))+
  theme_bw() +
  geom_bar(stat = "identity") +
  theme(# legend.position="top"
        # axis.title.x = element_blank(),
        axis.text.x=element_text(angle = 45, hjust = 1)
        )
```

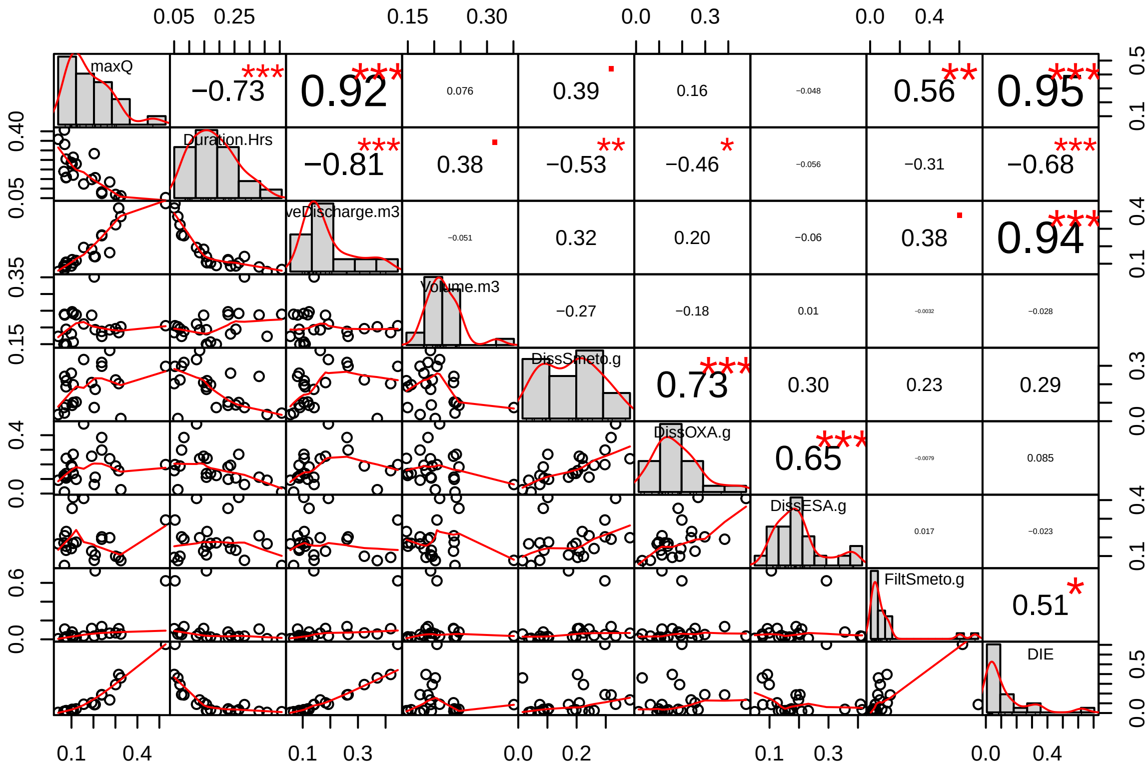



```r
  # geom_bar(stat = "identity", position = position_dodge())

WaterSoils$DIE <- WaterSoils$maxQ*WaterSoils$Volume.m3/WaterSoils$Duration.Hrs

keepCor <- c("maxQ", "Duration.Hrs", "AveDischarge.m3.h", "Volume.m3", "DIE",
            "DissOXA.g", "DissESA.g", "DissSmeto.g", "FiltSmeto.g" #,
            #"NH4.mM", "TIC.ppm.filt", "Cl.mM", "NO3..mM", "PO4..mM", "NPOC.ppm",
```

```r
            #"TIC.ppm.unfilt", "TOC.ppm.unfilt"
            )

corData <- WaterSoils[ , (names(WaterSoils) %in% keepCor)]

# Transform / normalize
corData.hell <- decostand(corData, "hellinger", na.rm=T, MARGIN = 2)

library(psych)
pairs.panels(corData)
```




```r
library(PerformanceAnalytics)
chart.Correlation(corData.hell)
```




```
keepLoads <- c("Date.ti",
               "DissOXA.g", "DissESA.g", "DissSmeto.g", "FiltSmeto.g",
               "Event.x", "Events")
wsLoads <- WaterSoils[ , (names(WaterSoils) %in% keepLoads)]
```

Outliers

```
# Test function
g_param = 1.5
# g_param = 2.2  #  (Hoaglin et al.,1986; Hoaglin & Iglewicz, 1987)
is_outlier <- function(x) {
  return(x < quantile(x, 0.25) - g_param * IQR(x) | x > quantile(x, 0.75) + g_param * IQR(x))
}
```

Soil concentrations

Correlation will be made after variable transformation. Options tested:

a) Z-scoring transformation by translation and expansion is done to create unit-free variables with means of zero and standard deviations of one. Standardised values differ from one another in units of standard deviation. The mean of each variable is subtracted from the original values and the difference divided by the variable's standard deviation and is given by:

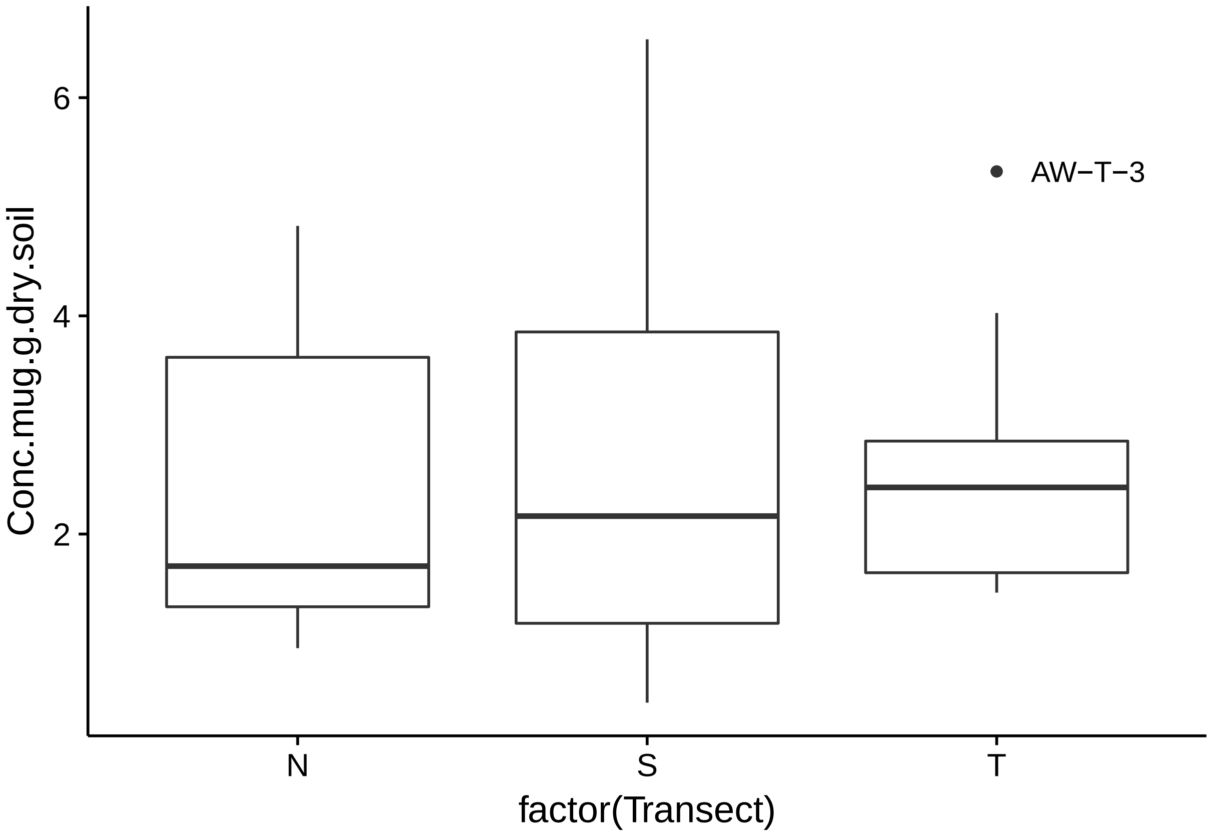
$$z_i = \frac{y_i - \bar{y}}{s_y}$$

Z-scoring did not change correlation results, nor outlier reduction.

b) Scaling by expansion where all values are divided by the maximum observation.

Outliers before transformation

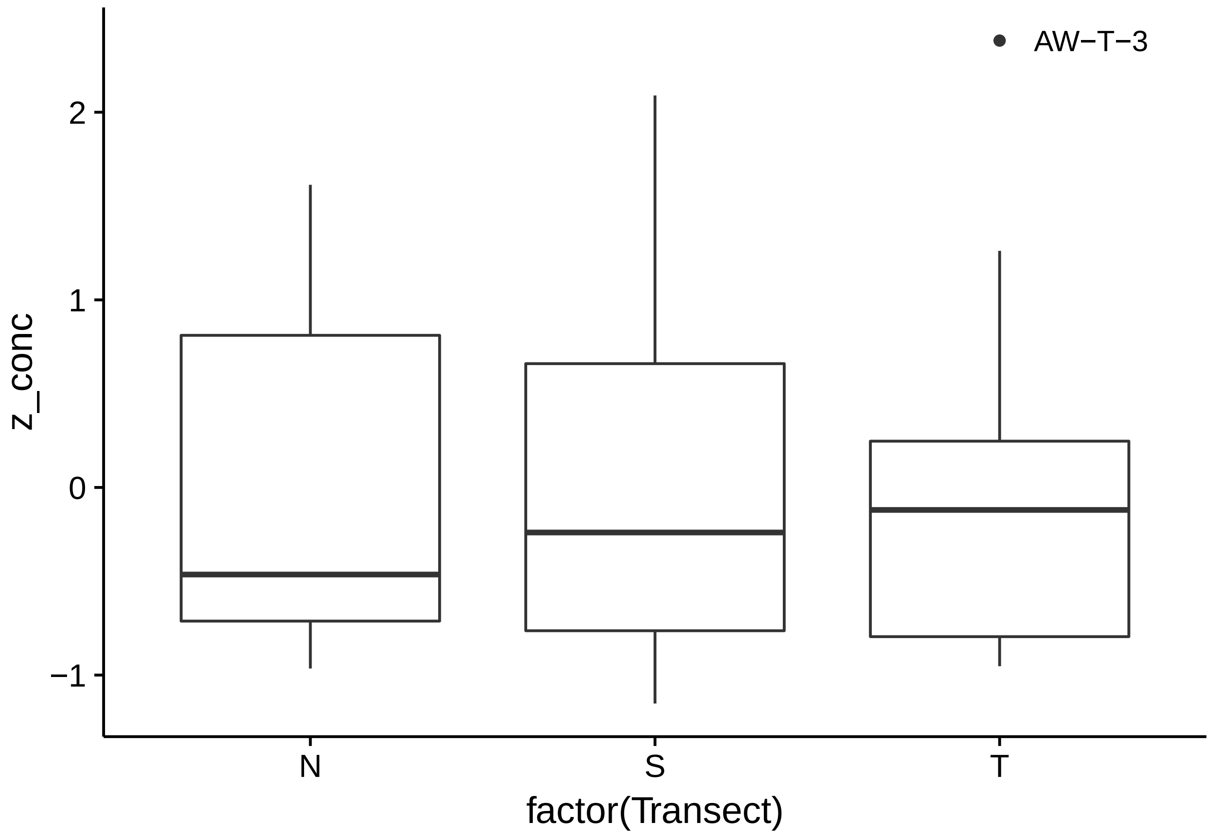
```
# Concentrations
soilGroups %>%
  group_by(Transect) %>%
  mutate(outlier = ifelse(is_outlier(Conc.mug.g.dry.soil), as.character(ID), NA)) %>%
  ggplot(., aes(x = factor(Transect), y = Conc.mug.g.dry.soil)) +
    geom_boxplot() +
    geom_text(aes(label = outlier), na.rm = TRUE, hjust = -0.3)
```



Outliers after transformation

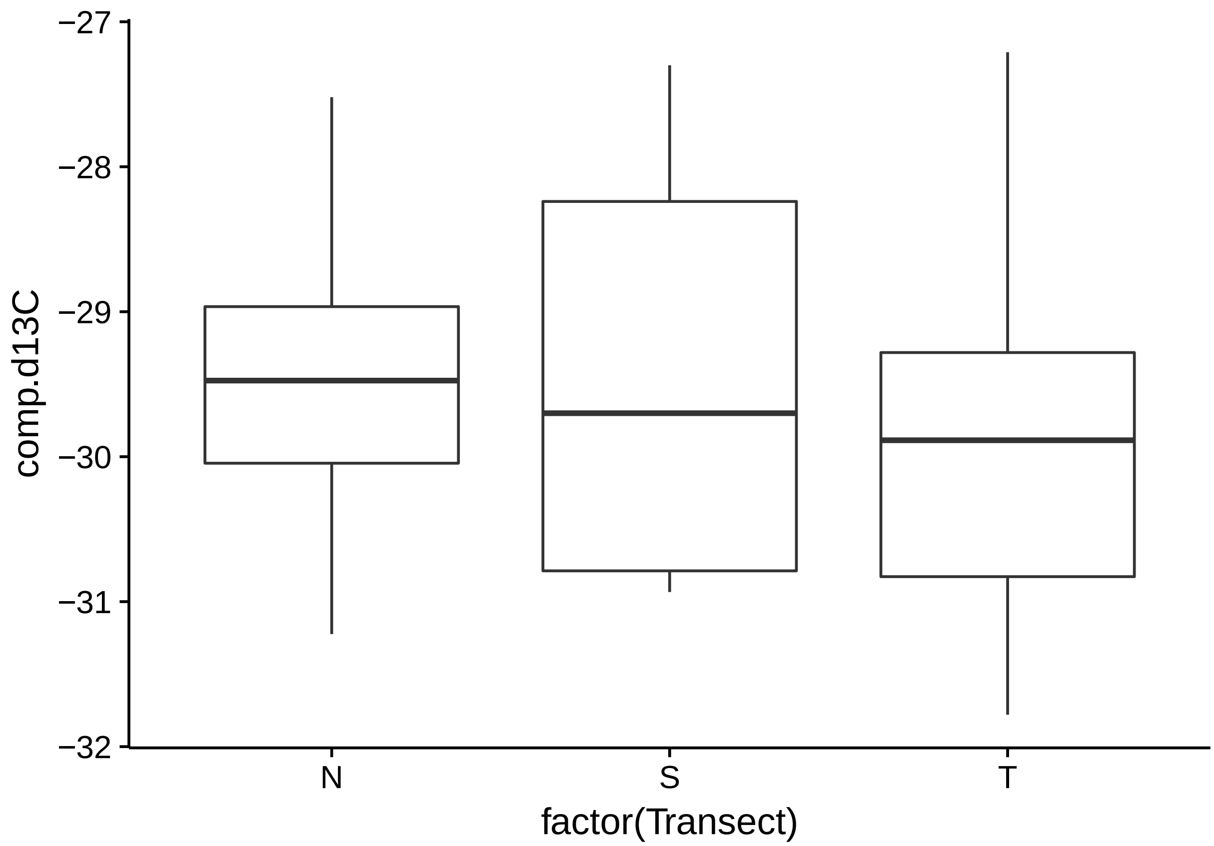
```
soilGroups <- soilGroups %>%
  group_by(Transect) %>%
  mutate(z_conc = (Conc.mug.g.dry.soil-mean(Conc.mug.g.dry.soil))/sd(Conc.mug.g.dry.soil))
```

```
soilGroups %>%
  group_by(Transect) %>%
  mutate(outlier = ifelse(is_outlier(z_conc), as.character(ID), NA)) %>%
  ggplot(., aes(x = factor(Transect), y = z_conc)) +
    geom_boxplot() +
    geom_text(aes(label = outlier), na.rm = TRUE, hjust = -0.3)
```



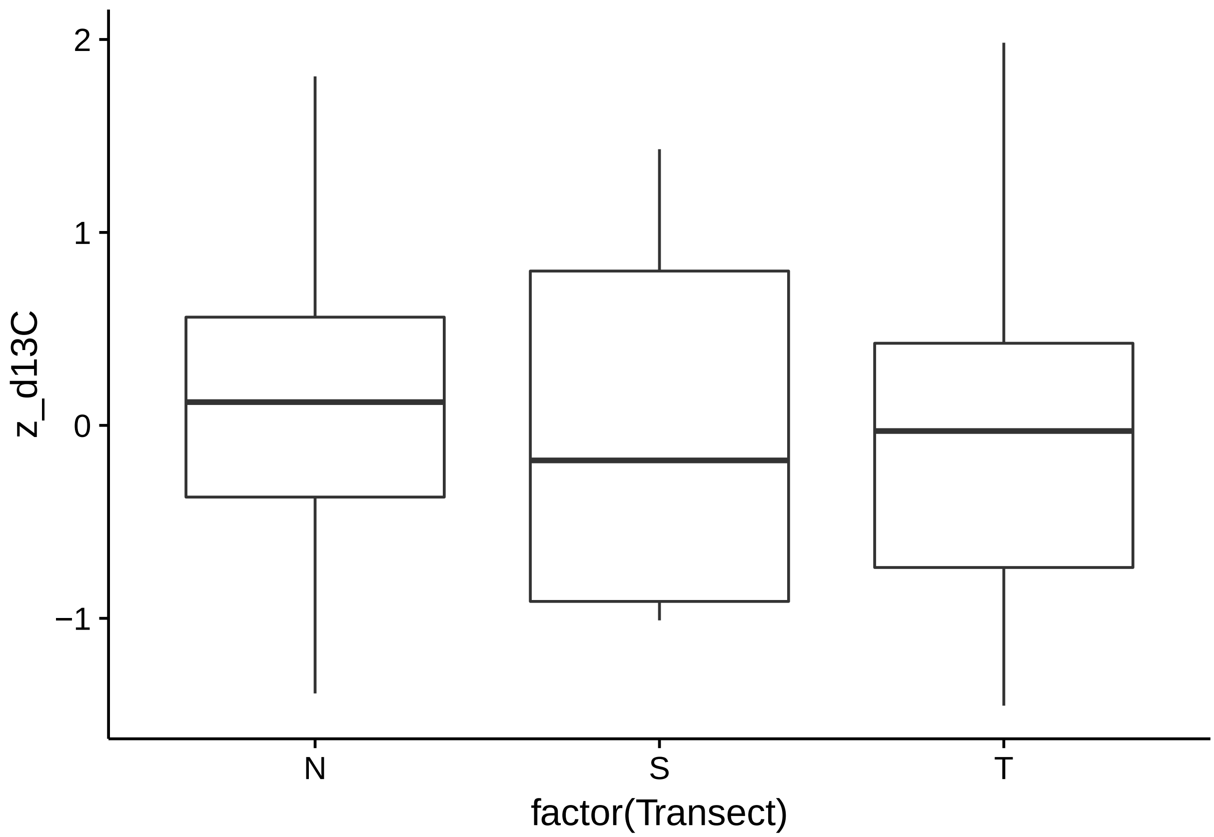
Soil Isotopes

```
# Isotopes

temp <- na.omit(soilGroups)

temp %>%
  group_by(Transect) %>%
  mutate(outlier = ifelse(is_outlier(comp.d13C), as.character(ID), NA)) %>%
  ggplot(., aes(x = factor(Transect), y = comp.d13C)) +
    geom_boxplot() +
    geom_text(aes(label = outlier), na.rm = TRUE, hjust = -0.3)
```



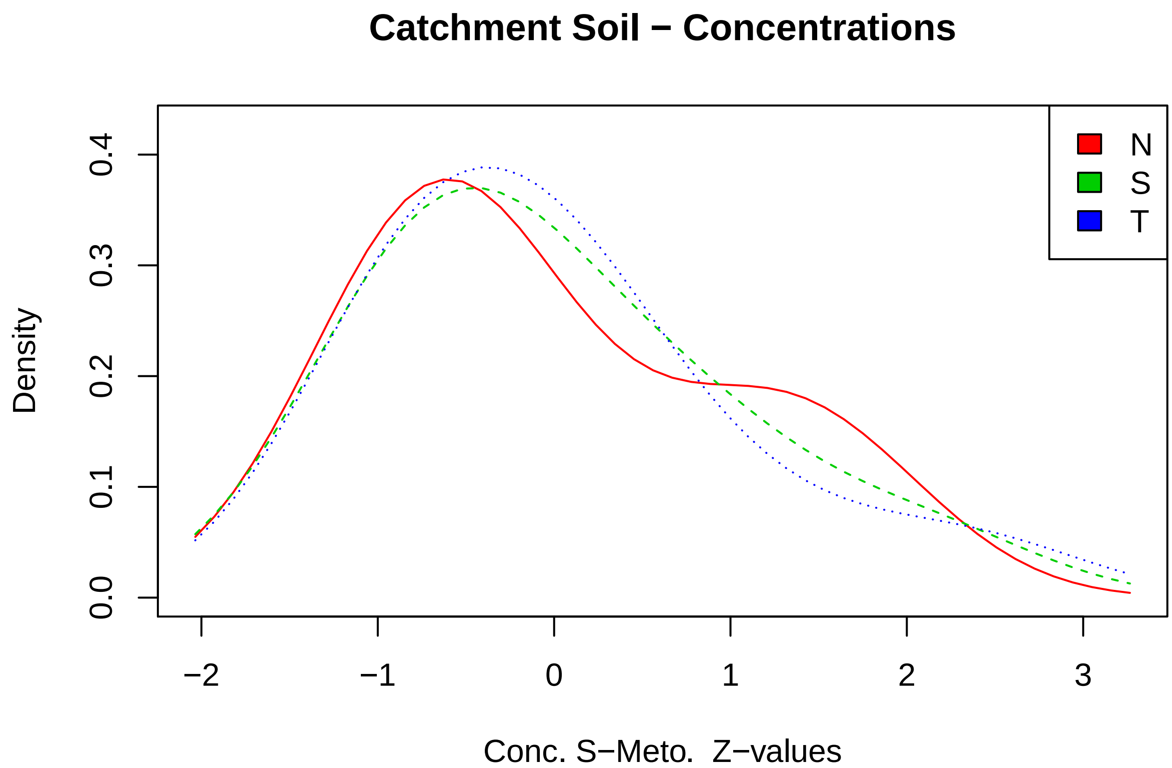
Looks like 7 potential outliers in concentrations and 1 for isotopes. Removing NA's for isotopes and re-computing outliers, reduces the number of outliers to 2 in concentrations and 1 for isotopes.

```
temp <- temp %>%
  group_by(Transect) %>%
  mutate(z_d13C = (comp.d13C-mean(comp.d13C))/sd(comp.d13C))

temp %>%
  group_by(Transect) %>%
  mutate(outlier = ifelse(is_outlier(z_d13C), as.character(ID), NA)) %>%
  ggplot(., aes(x = factor(Transect), y = z_d13C)) +
    geom_boxplot() +
    geom_text(aes(label = outlier), na.rm = TRUE, hjust = -0.3)
```



Distribution of z values (same as non-transformed)

```
# plot densities
#sm.density.compare(temp$z_conc, temp$Transect, xlab=expression(paste("Conc. S-Meto.  ", {({mu}*g / g.s
sm.density.compare(temp$z_conc, temp$Transect, xlab=expression(paste("Conc. S-Meto.  Z-values")))
title(main="Catchment Soil - Concentrations")
legend("topright", levels( soilGroups$Transect), fill=2+(0:nlevels(soilGroups$Transect)))
```

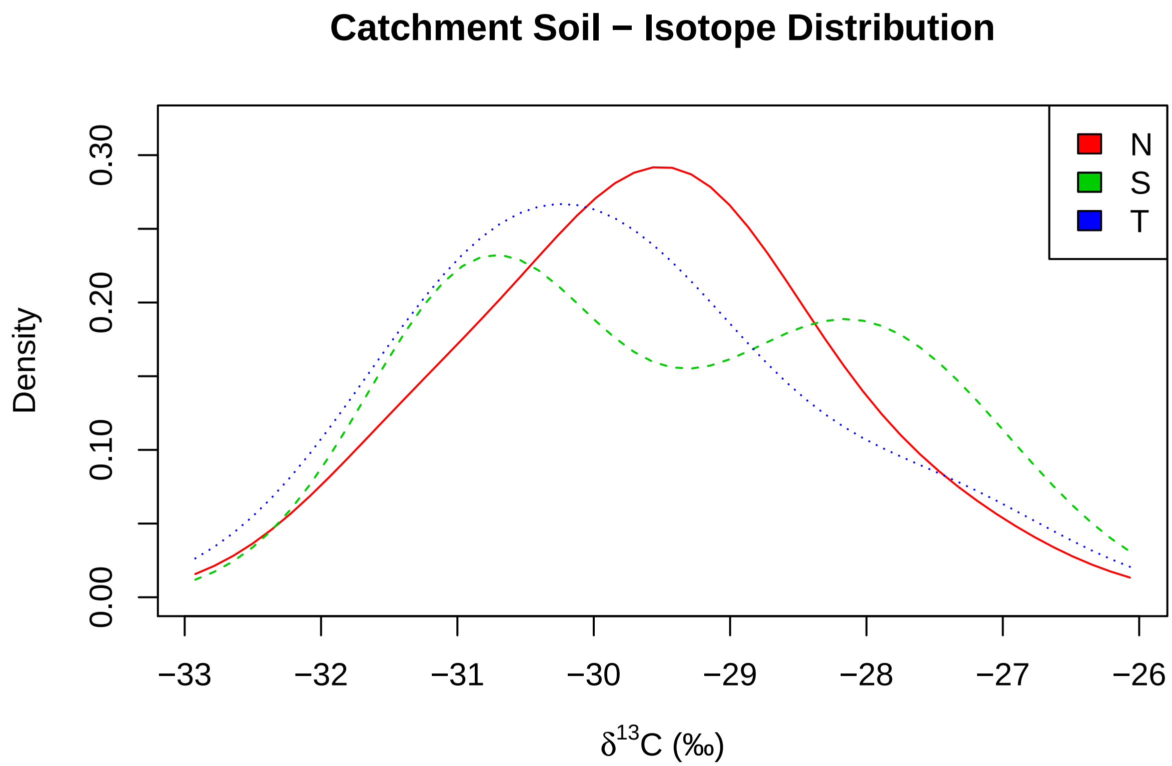



```r
#vioplot(soilGroups$Conc.mug.g.dry.soil,  names = "Catchment")
#title(expression(paste("Conc. S-Meto.  ", {({mu}*g / g.soil.dry)})))
```

Soil Isotopes

```r
#vioplot(na.omit(soilGroups$comp.d13C),  names = "Catchment")
#title(expression(paste({delta}^"13","C", ' (\u2030)')))
```

```r
temp <- na.omit(soilGroups)
sm.density.compare(temp$comp.d13C, temp$Transect,
                   xlab=expression(paste({delta}^"13","C", ' (\u2030)')))
title(main="Catchment Soil - Isotope Distribution")
legend("topright", levels( soilGroups$Transect), fill=2+(0:nlevels(soilGroups$Transect)))
```


Catchment Soil − Isotope Distribution
Density
0.00
0.10
0.20
0.30
−33
−32
−31
−30
−29
−28
−27
−26
δ13C (‰)
N
S
T