

SI Graphs Water Research

PAZ

23 novembre 2017

Purpose

This produces a Hyetograph (rainfall and discharge data) based on 2 min intervals.

Input files:

- **groupAlteck2016_R** (Contains discharge and rainfall @ 2 min)

Output files:

- **nothing for now**

Libraries

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
## The following objects are masked from 'package:stats':
##
##   filter, lag
## The following objects are masked from 'package:base':
##
##   intersect, setdiff, setequal, union
```

```
library(tidyr)
```

```
library(zoo)
```

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

```
library(reshape)
```

```
##
## Attaching package: 'reshape'
## The following objects are masked from 'package:tidyr':
##
##   expand, smiths
## The following object is masked from 'package:dplyr':
##
##   rename
```

```

library(ggplot2)
library("ggrepel")

library("plotly")

##
## Attaching package: 'plotly'
## The following object is masked from 'package:ggplot2':
##
##     last_plot
## The following object is masked from 'package:reshape':
##
##     rename
## The following object is masked from 'package:stats':
##
##     filter
## The following object is masked from 'package:graphics':
##
##     layout
library("cowplot")

##
## Attaching package: 'cowplot'
## The following object is masked from 'package:ggplot2':
##
##     ggsave
library("gridExtra")

##
## Attaching package: 'gridExtra'
## The following object is masked from 'package:dplyr':
##
##     combine
library("Cairo")
library("GGally")

##
## Attaching package: 'GGally'
## The following object is masked from 'package:dplyr':
##
##     nasa
library("scales")

library("plotKML")

## plotKML version 0.5-6 (2016-05-02)
## URL: http://plotkml.r-forge.r-project.org/

```

```
# getwd()
# setwd("D:/Documents/these_pablo/Alteckendorf2016/HydrologicalMonitoring")
```

Data

```
# Discharge and 2 min rainfall
hydro = read.csv2("Data/groupAlteck2016_R.csv")
hydro$Date = as.POSIXct(strptime(hydro$DateCheck.S,
                                "%d/%m/%Y %H:%M", tz="EST") )

# names(hydro)
qra <- hydro[, c("Date", "Q.HW1", "Rain.mm")]

# Outlet Concentrations
aodf = read.csv2("Data/WeeklyHydroContam_R.csv")
# names(aodf)
c = aodf[, c("ti", "Conc.mug.L", "Conc.SD", "Event", "Events")]
c$ti <- as.POSIXct(strptime(c$ti, "%Y-%m-%d %H:%M", tz="EST"))
sum(is.na(c$ti)) == 0

## [1] TRUE

# Discharge and concentrations
ch = merge(qra, c, by.x = "Date", by.y="ti", all = T)

# Transect soils
weeklySoil = read.csv2("Data/WeeklySoils_Rng.csv", na.strings=c('#DIV/0!', '', 'NA'), header = TRUE)
weeklySoil$Date.ti <- as.POSIXct(strptime(weeklySoil$Date.ti, "%Y-%m-%d %H:%M", tz="EST"))
sum(is.na(weeklySoil$Date.ti))

## [1] 0

# weeklySoil$Conc.ComSoil.SD <-
# ifelse(weeklySoil$Conc.ComSoil.SD == as.character("#DIV/0!"), NA, as.numeric(as.character(weeklySoil$Conc.ComSoil.SD)))

# weeklySoil = weeklySoil %>%
#   group_by(Transect) %>%
#   arrange(Transect, Wnum)

# names(weeklySoil)
```

Conversions

Convert rainfall data [mm] to the same units as discharge [m^3/h]

```
ch$Rain.mm = ifelse(is.na(ch$Rain.mm), 0, ch$Rain.mm)
ch$Q.HW1 = ifelse(is.na(ch$Q.HW1), 0, ch$Q.HW1)

# Catchment area
area <- 47*10**4 # [m2]
ch$precip_m3 = ch$Rain.mm/10^3 * area

sum(is.na(ch$precip_m3))
```

```
## [1] 0
sum(is.na(ch$Q.HW1))

## [1] 0
# Calculate the range needed to avoid having your hyetograph and hydrograph overlap
maxRange <- 1*(max(ch$precip_m3) + max(ch$Q.HW1)) - 800

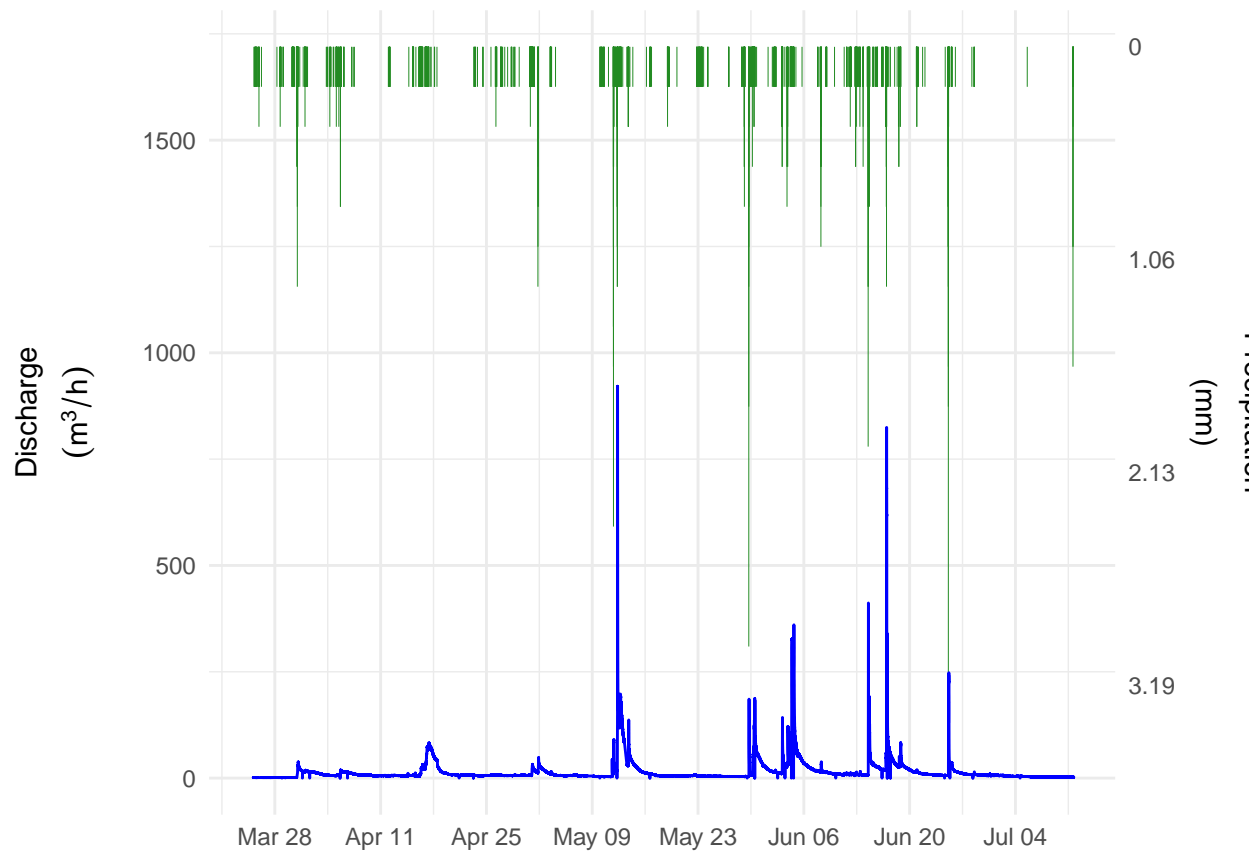
# Create a function to backtransform the axis labels for precipitation
precip_labels <- function(x) {round( ((x / area) * 10^3), digits = 2) } # X will be precip_m3 -> convert to cuft

lims <- as.POSIXct(strptime(c("2016-03-25 00:04:00", "2016-07-12 01:00:00"), format = "%Y-%m-%d %H:%M"))

# Plot the data
hy = ggplot(data = ch,
  aes(x = Date)) +
  theme_minimal() +
  # Use geom_tile to create the inverted hyetograph. geom_tile has a bug that displays a warning message
  geom_tile(aes(y = -1*(precip_m3/2-maxRange), # y = the center point of each bar, as geom_tile uses vertical center
    height = precip_m3,
    width = 1
  ),
  fill = "gray50",
  color = "forestgreen") +
  theme(# axis.text.x=element_text(angle = 45, hjust = 1)
    # axis.text.x=element_blank(),
    axis.title.x=element_blank()
    # legend.position="top"
  )+
  scale_x_datetime(limits = lims, breaks = date_breaks("2 weeks"), labels = date_format("%b %d")) +
  # Plot your discharge data
  geom_line(aes(y = Q.HW1),
    color = "blue") +
  # Create a second axis with sec_axis() and format the labels to display the original precipitation in cuft
  # ylab(expression(atop("Conc. S-met ", paste({{mu}*g / L} })))) +
  scale_y_continuous(name = expression(atop("Discharge", paste({{m^3}/h} })),
    sec.axis = sec_axis(trans = ~-1*(.-maxRange), # Equivalent to: y2 = -1*(y1 - maxRange)
      name = expression(atop("Precipitation", paste("(mm)")),
        labels = precip_labels)) # x here is = precip_cuft

## Warning: Ignoring unknown aesthetics: height, width
hy

## Warning: Removed 490 rows containing missing values (geom_tile).
## Warning: Removed 490 rows containing missing values (geom_path).
```



Concentrations

```
names(ch)
```

```
## [1] "Date"      "Q.HW1"     "Rain.mm"   "Conc.mug.L" "Conc.SD"
## [6] "Event"     "Events"    "precip_m3"
```

```
ch$Event = na.locf(ch$Event)
ch$Event = as.factor(ch$Event)
ch$Season = ifelse(ch$Date > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Late", "Early")
```

```
tags = FALSE
```

```
out_dates = ggplot(data = ch,
  aes(x = Date, y = Conc.mug.L)) +
  geom_errorbar(aes(ymin = Conc.mug.L - Conc.SD, ymax = Conc.mug.L + Conc.SD, colour = Season)) +
  geom_point(aes(group = Event, colour = Season)) +
  theme_minimal() +
  ylab(expression(atop("Conc. S-met ", paste({{mu}}*g / L} )))) +
  scale_y_continuous( breaks = c(28, 24, 20, 16, 12, 8, 4, 0), limits = c(0, 28) ) +
```

```
# Smooth linear models
```

```
geom_smooth(data=subset(ch[2203:43539, ]), method = "lm", formula = y ~ x, se = F, linetype="dashed")
geom_smooth(data=subset(ch[43539:nrow(ch)-1000, ]), method = "lm", formula = y ~ x, se= F, linetype=
```

```

scale_x_datetime(limits = lims, breaks = date_breaks("2 weeks"), labels = date_format("%b %d")) +
guides(col = guide_legend(nrow = 2, title.position = "top"))

out = out_dates +
  theme(# axis.text.x=element_text(angle = 45, hjust = 1) ,
        # axis.text.x=element_blank(),
        axis.title.x=element_blank(),
        legend.position="right"
        )

if (tags){
  out + geom_text_repel(aes(label=Events), # WeekSubWeek or Weeks
    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, show.legend = F)
}

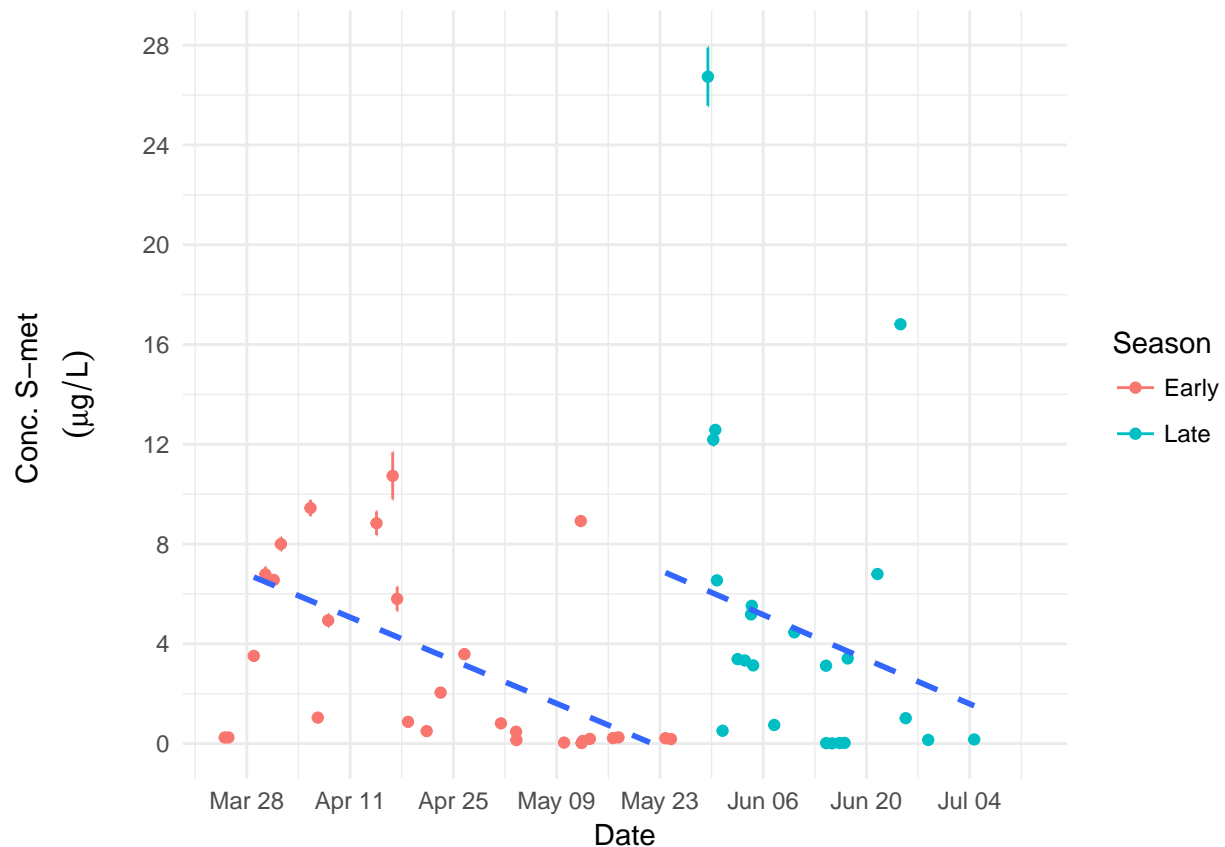
out_dates

```

```

## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).

```



Soil Concentrations

```

weeklySoil$Transect = as.character(weeklySoil$Transect)
weeklySoil$Transect = ifelse(weeklySoil$Transect == "N", "North",
                             ifelse(weeklySoil$Transect == "T", "Valley",
                                     ifelse(weeklySoil$Transect == "S", "South", NA)
                             )
)
weeklySoil$Transect <- factor(weeklySoil$Transect, levels = c("North", "Valley", "South"))
levels( weeklySoil$Transect)

```

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

```

#, fig.height=3, fig.width=3}
lb1a2 <- paste("App.")
lbW012 <- paste("App.W0/1/2")
lbW9 <- paste("App.W9")

```

```

limits_conc_soil <- aes(ymin=Conc.mug.g.dry.soil-Conc.ComSoil.SD, ymax=Conc.mug.g.dry.soil+Conc.ComSoil.SD)
#limits_conc_soil <- aes(ymin=mean-0.5, ymax=mean+0.5)

```

```
pd <- position_dodge(0.5) # move them .05 to the left and right
```

```
# xlims = xlim(as.POSIXct('2016-03-25 00:04:00', tz = 'EST'), as.POSIXct('2016-07-12 01:00:00', tz = 'EST'))
```

```
tags = FALSE
```

```

co = ggplot(weeklySoil[4:48, ],
            aes(x=Date.ti, y=Conc.mug.g.dry.soil, colour=Transect, group = Transect)) +

  geom_point() +
  geom_line() +

  # Error bars
  geom_errorbar(limits_conc_soil, width=.1, position=pd) +
  # scale_y_continuous(limits=c(0,10), oob = rescale_none) +

  # Themes and axes
  theme_minimal() +
  theme(legend.position = "right",
        # axis.text.x=element_text(angle = 45, hjust = 1),
        # axis.text.x=element_blank(),
        axis.title.x=element_blank()
        ) +

  ylab(expression(atop("Conc. S-met ", paste({{mu}}*g / g.soil.dry)} ))) +
  # facet_wrap(~Transect, nrow = 3) +
  # xlab("Date") +
  # theme() +
  # scale_x_datetime(breaks = date_breaks("1 weeks"), labels = date_format("%b %d")) +

  # Smooth linear models
  # stat_smooth(method = "lm", formula = y ~ poly(x, 2)) +
  # stat_smooth(method = "lm") +

  # Text
  # W0 Application
  # annotate("text", x = as.POSIXct('2016-03-25 08:04:00'), y = 4, label = lb1a2, parse = T, size = 3.0)
  geom_segment(aes(x = as.POSIXct('2016-04-14 08:04:00'),
                    y = 0.5,
                    xend = as.POSIXct('2016-03-26 01:04:00'), yend = -0), color = "black",
               arrow = arrow(length = unit(0.2, "cm")))) +

  # W1 Application
  #geom_segment(aes(x = as.POSIXct('2016-04-14 08:04:00'), y = 0.5,
  #               xend = as.POSIXct('2016-04-05 08:04:00'), yend = 0), color = "black",
  #            arrow = arrow(length = unit(0.2, "cm")))) +
  # W2 Application
  annotate("text", x = as.POSIXct('2016-04-15 08:04:00'), y = 1, label = lb1a2, parse = T, size = 3.0)
  geom_segment(aes(x = as.POSIXct('2016-04-14 08:04:00'), y = 0.5,
                    xend = as.POSIXct('2016-04-13 08:04:00'), yend = 0), color = "black",
               arrow = arrow(length = unit(0.2, "cm")))) +

  # W9 Application
  annotate("text", x = as.POSIXct('2016-05-26 08:04:00'), y = 4.5, label = lb1a2, parse = T, size = 3.0)
  geom_segment(aes(x = as.POSIXct('2016-05-26 08:04:00'), y = 4,
                    xend = as.POSIXct('2016-05-26 08:04:00'), yend = 0), color = "black",
               arrow = arrow(length = unit(0.2, "cm")))) +
  guides(col = guide_legend(nrow = 3, title.position = "top")) +
  scale_x_datetime(limits = lims, breaks = date_breaks("2 weeks"), labels = date_format("%b %d"))

```

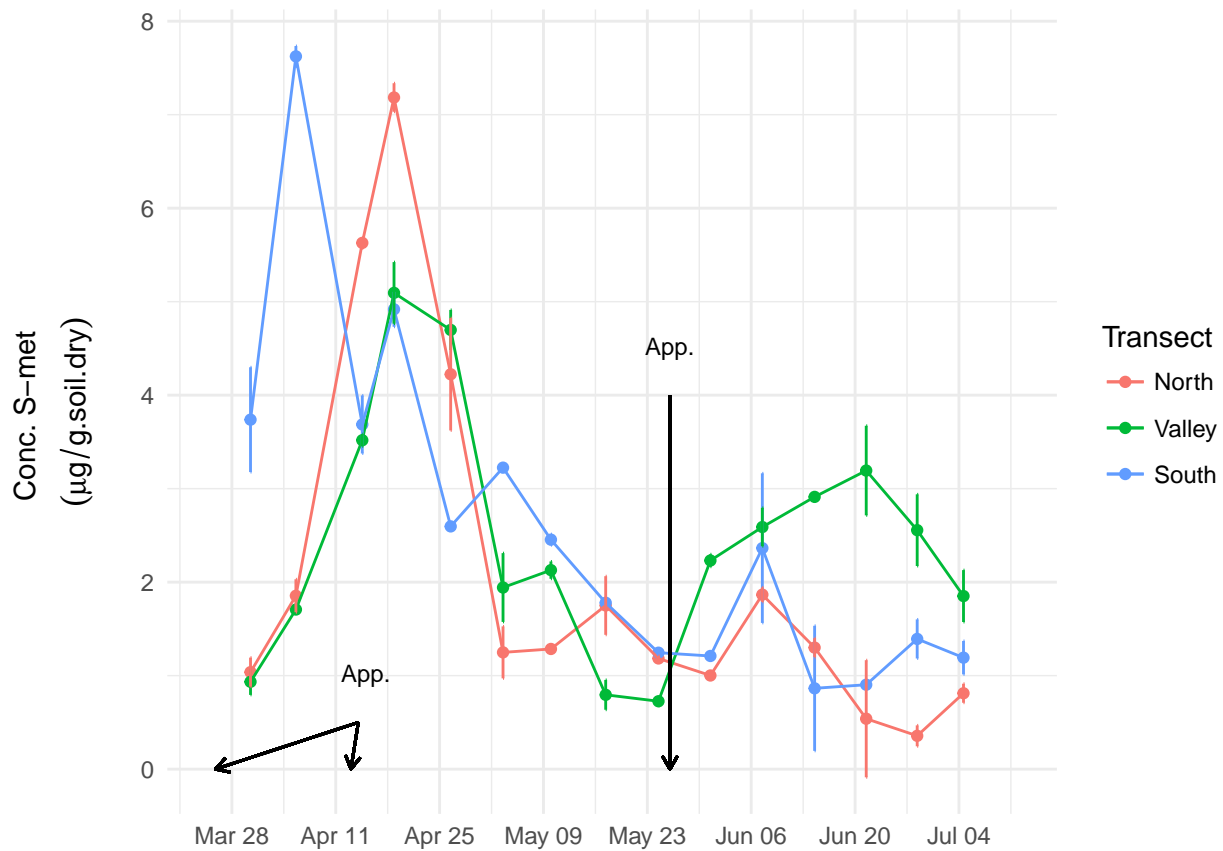


```

if (tags){
  co + geom_text_repel(aes(label=as.factor(Wnum)),
    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,
    show.legend = F)
}

co

```



```

# Linear model
# ggsave(co, filename = "CompositeConcLM.png", width = 7, height = 5, units = "in", scale = 1)

## ggsave(co, filename = "CompositeConcLM.tiff", height = 10, width = 8.7, units = 'cm')

# No linear model
# ggsave(co, filename = "CompositeConc.png", width = 7, height = 5, units = "in", scale = 1)

```

Draw D*/B* factors

```
moltenSoil = read.csv2("Data/moltenDB_R.csv", header = TRUE, sep = ",", dec = ".")
moltenSoil$Date = as.POSIXct(moltenSoil$Date, "%Y-%m-%d %H:%M", tz = "EST")

moltenSoil$DB_max = ifelse(moltenSoil$DB_max < 0, NA, moltenSoil$DB_max)
moltenSoil$DB_max = ifelse(moltenSoil$DB_max > 1, NA, moltenSoil$DB_max)
mSoils = melt(moltenSoil, id=c("Date", "Transect"))

mSoils$Transect = as.character(mSoils$Transect)
mSoils$Transect = ifelse(mSoils$Transect == "N", "North",
                        ifelse(mSoils$Transect == "T", "Valley",
                              ifelse(mSoils$Transect == "S", "South", NA)
                             )
                       )
)
mSoils$Transect <- factor(mSoils$Transect, levels = c("North", "Valley", "South"))
levels( mSoils$Transect)

## [1] "North" "Valley" "South"

DBLeg = ggplot(data = mSoils , aes(x=Date, y=value, shape=variable))+
  geom_point(data=subset(mSoils, variable == 'DB_lab')) +
  geom_point(data=subset(mSoils, variable == 'DB_max')) +
  theme_minimal() +
  guides(shape=guide_legend(title=("D*/B*"),
                            order = 2,
                            nrow=2,
                            title.position = "top" #,
                            # keyheight = 1.5,
                            # title.vjust = NULL, label.vjust = NULL
                          )) +
  ylab(expression(atop("D*/B*"))) +
  # facet_wrap(~Transect, nrow = 3) +
  xlab("Date") +
  scale_x_datetime(limits = lims, breaks = date_breaks("2 weeks"), labels = date_format("%b %d"))

db_leg = get_legend(DBLeg)

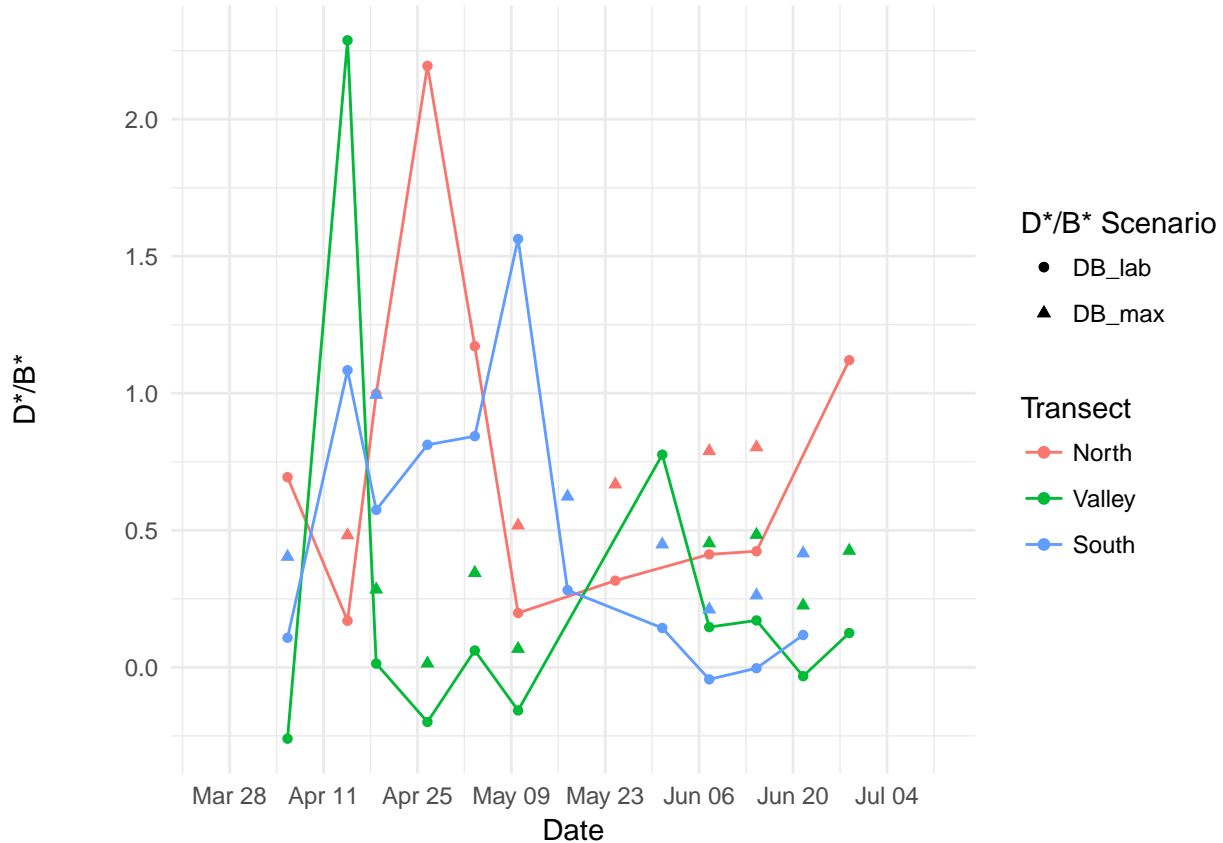
## Warning: Removed 12 rows containing missing values (geom_point).

DB = ggplot(data = mSoils , aes(x=Date, y=value, colour=Transect, shape=variable))+
  geom_line(data=subset(mSoils, variable == 'DB_lab')) +
  geom_point(data=subset(mSoils, variable == 'DB_lab')) +
  geom_point(data=subset(mSoils, variable == 'DB_max')) +
  theme_minimal() +
  guides(shape=guide_legend(title=("D*/B* Scenario"),
                            order = 2,
                            nrow=2,
                            title.position = "top" #,
                            # keyheight = 1.5,
                            # title.vjust = NULL, label.vjust = NULL
                          )) +
  ylab(expression(atop("D*/B*"))) +
  # facet_wrap(~Transect, nrow = 3) +
  xlab("Date") +
```

```
scale_x_datetime(limits = lims, breaks = date_breaks("2 weeks"), labels = date_format("%b %d"))
```

DB

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



Merge hyetograph, outlet and soil concentrations

```
hy_noLeg <- hy + theme(legend.position = 'none')
out_noLeg = out + theme(legend.position = 'none')
co_noLeg = co + theme(legend.position = 'none')
```

```
out_leg <- get_legend(out)
```

```
## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
```

```
## Warning: Removed 78732 rows containing missing values (geom_point).
```

```
## Warning: Removed 4 rows containing missing values (geom_smooth).
```

```
co_leg <- get_legend(co)
```

```
grid1 = plot_grid(
```

```

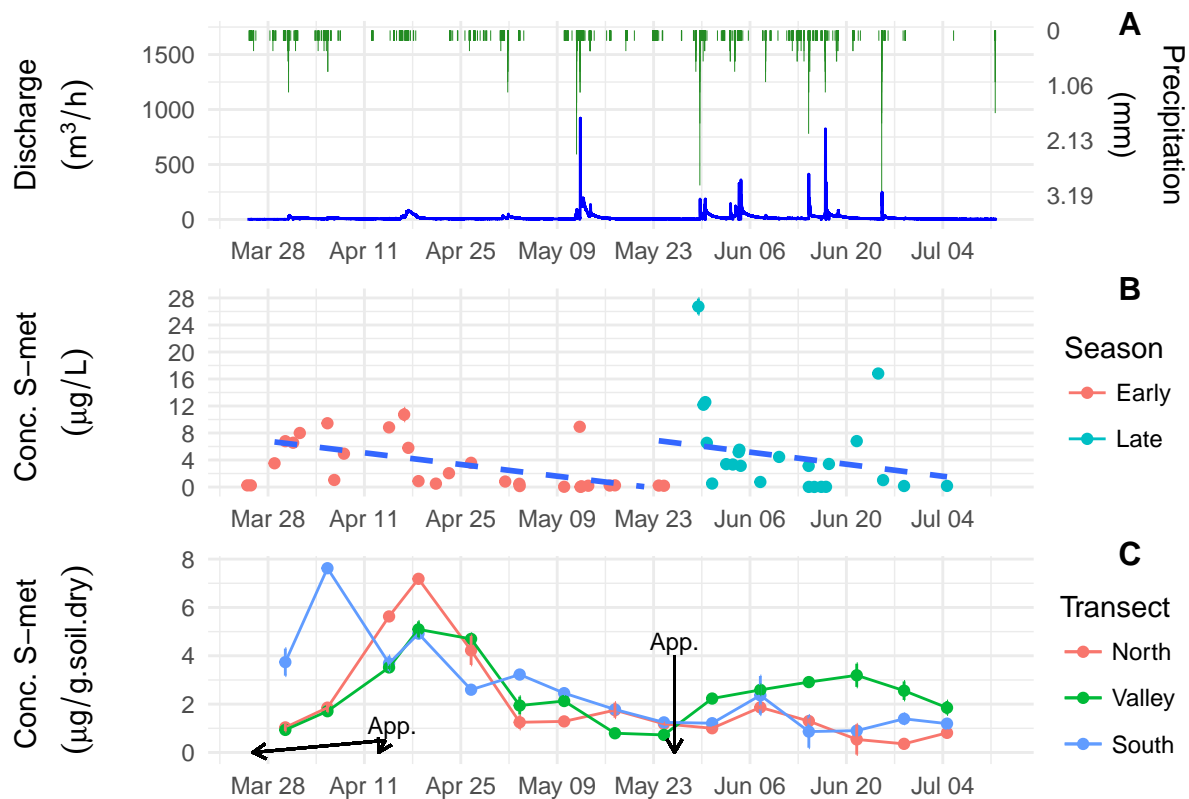
hy_noLeg,
out_noLeg,
co_noLeg,
ncol = 1,
align = 'hv')

## Warning: Removed 490 rows containing missing values (geom_tile).
## Warning: Removed 490 rows containing missing values (geom_path).
## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).

ml = ggdraw() +
  draw_plot(grid1, x=0.02, y = 0.0, width = 0.95, height = .95) +
  draw_plot(out_leg, x=(0.53 ), y = 0.44, width = .8, height = 0.1) +
  draw_plot(co_leg, x=(0.53) , y = 0.11, width = .8, height = 0.1) +

  draw_label("A", x= 0.94, y = .93, size = 12, fontface = "bold") +
  draw_label("B", x= 0.94, y = .62, size = 12, fontface = "bold") +
  draw_label("C", x= 0.94, y = .31, size = 12, fontface = "bold")
ml

```



```

SAVE = F
PC = F

```

```

if (SAVE){
  if (PC){
    ggsave(m1,
      filename = "D:/Documents/these_pablo/WriteUp/WaterResearch/images/multilevel.pdf",
      device = "pdf", dpi = 600, scale = 1, # )# ,
      width = 7, height = 11)
  } else {
    ggsave(m1,
      filename = "/Users/DayTightChunks/Documents/PhD/Writeups/Journals/WaterResearch/images/multilevel.pdf",
      device="pdf", dpi = 600, scale = 1, # )# ,
      width = 7, height = 11)
  }
}

```

Grid arrange

```

# ggsave(balAllplot, filename = "images/MB_CSIA_Bars.png", width = 8, height = 5, units = "in", scale = 1)
## convert plots to gtable objects
library(gtable)
library(grid) # low-level grid functions are required
g1 <- ggplotGrob(hy_noLeg)

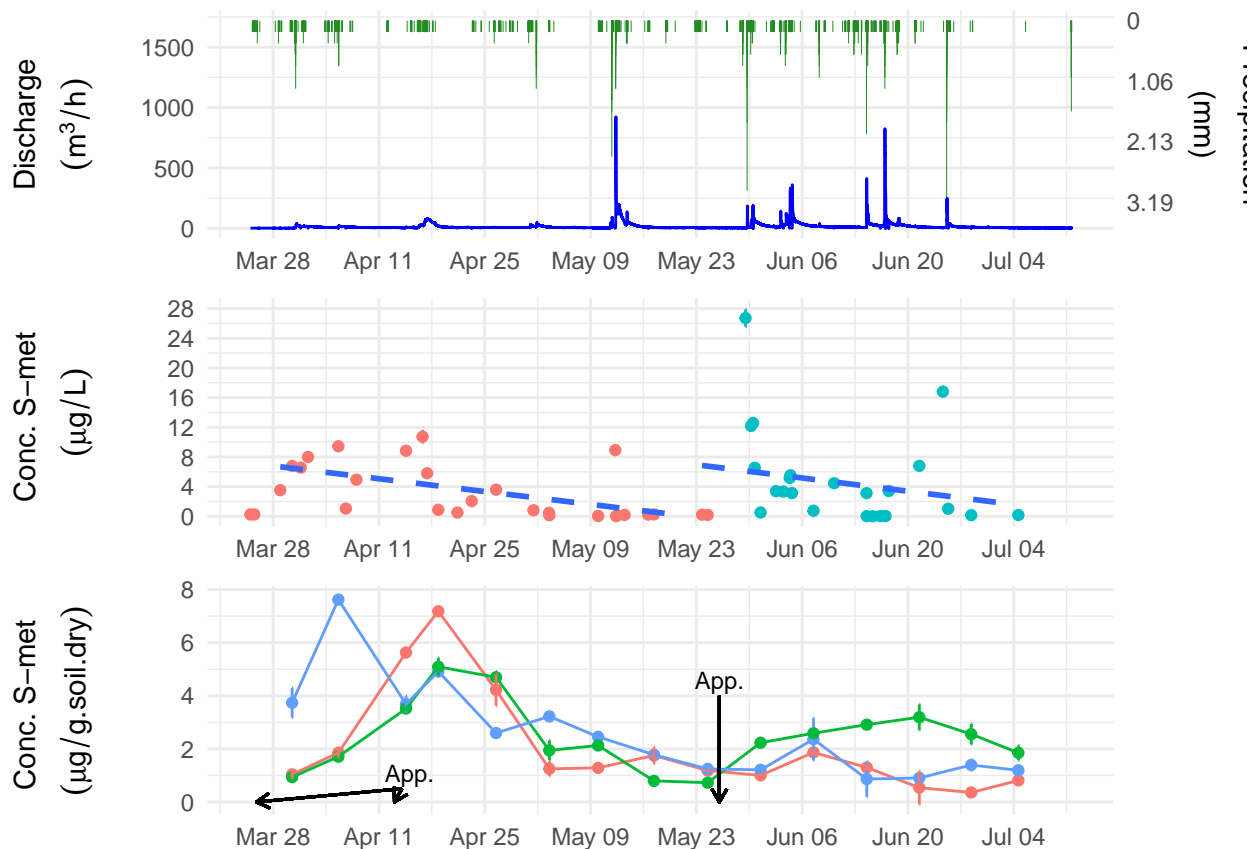
## Warning: Removed 490 rows containing missing values (geom_tile).
## Warning: Removed 490 rows containing missing values (geom_path).

# g1 <- gtable_add_cols(g1, unit(0,"mm")) # add a column for missing legend
g2 <- ggplotGrob(out_noLeg)

## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).

g3 <- ggplotGrob(co_noLeg)
# g <- rbind(g2, g3, size="first") # stack the two plots
g <- rbind(g1, g2, g3, size="first") # stack the two plots
g$widths <- unit.pmax(g1$widths, g2$widths, g3$widths) # use the largest widths
# center the legend vertically
# g$layout[grepl("guide", g$layout$name),c("t","b")] <- c(1,nrow(g))
grid.newpage()
grid.draw(g)

```



Plot grid option, embedding different plot_grid 's

```
library(cowplot)
```

```
theme_set(theme_minimal())
```

```
embeds <-  
  plot_grid(  
    plot_grid(  
      hy_noLeg,  
      out_noLeg,  
      co_noLeg,  
      ncol = 1,  
      align = 'hv'),  
    plot_grid(  
      ggplot(),  
      out_leg,  
      co_leg,  
      ncol = 1  
    ), rel_widths = c(9,1)  
  )
```

```
## Warning: Removed 490 rows containing missing values (geom_tile).
```

```
## Warning: Removed 490 rows containing missing values (geom_path).
```

```
## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).
```

Sources (Plot with map)

```
# Water and soils transposed data
WaterSoils <- read.csv2("Data/WaterSoils_R.csv")
WaterSoils$Date.ti = as.POSIXct(strptime(WaterSoils$Date.ti,
                                         "%Y-%m-%d %H:%M", tz="EST") )
sum(is.na(WaterSoils$Date.ti))

## [1] 0

# View(WaterSoils)
# Concnetrations to plot as box plot
keepDDtest <- c(
  "Date.ti",
  "diss.d13C.x", # "DD13C.diss",
  "comp.d13C.North", "comp.d13C.Talweg", "comp.d13C.South" #,
  #"DD13C.North", "DD13C.Talweg", "DD13C.South"
)

ws <- WaterSoils[, colnames(WaterSoils) %in% keepDDtest]
ws <- melt(ws, id="Date.ti")

ws$Source <- ifelse(ws$variable == "diss.d13C.x" , "Outlet",
  ifelse(ws$variable == "comp.d13C.South", "South",
    ifelse(ws$variable == "comp.d13C.Talweg", "Valley",
      ifelse(ws$variable == "comp.d13C.North", "North", NA
    )))

ws$Season = ifelse(ws$Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Late", "Early")

ws$Group4 <- ifelse(ws$variable == "diss.d13C.x" & # Outlet
  ws$Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Outlet(E
  ifelse(ws$variable == "diss.d13C.x" &
  ws$Date.ti <= as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Outlet
# South
  ifelse(ws$variable == "comp.d13C.South" &
  ws$Date.ti < as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "South(E
  ifelse(ws$variable == "comp.d13C.South" &
  ws$Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "South
# Valley
  ifelse(ws$variable == "comp.d13C.Talweg" &
  ws$Date.ti < as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Valley(E
  ifelse(ws$variable == "comp.d13C.Talweg" &
  ws$Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Valley
# North
  ifelse(ws$variable == "comp.d13C.North" &
  ws$Date.ti < as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "North(E
  ifelse(ws$variable == "comp.d13C.North" &
```

```

ws$Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "North
))))))

ws$Source = factor(ws$Source, levels = c( "Outlet", "Valley", "North", "South"))
levels(ws$Source)

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

ws$Source = as.factor(ws$Source)

sources <- ggplot(ws, aes(Source, value)) +
  geom_boxplot(aes(colour=Season)) +
  theme_minimal() +

  # guides(col = guide_legend(nrow = 2)) +
  #theme(axis.text.x=element_text(angle = 45, hjust = 1) ,
  #axis.text.x=element_blank(),
  #axis.title.x=element_blank(),
  # legend.position="bottom"
  #
  # )+
  # ylab(expression(paste('S-met ', {delta}~"13", "C", ' (\u2030)'))
  ylab(expression(atop(paste({delta}~"13", "C", ' S-met '), paste({' (\u2030)' } ))))

sources_big = sources + theme(text = element_text(size=17))

sources

## Warning: Removed 149 rows containing non-finite values (stat_boxplot).
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :

```



```

## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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```

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```

```

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

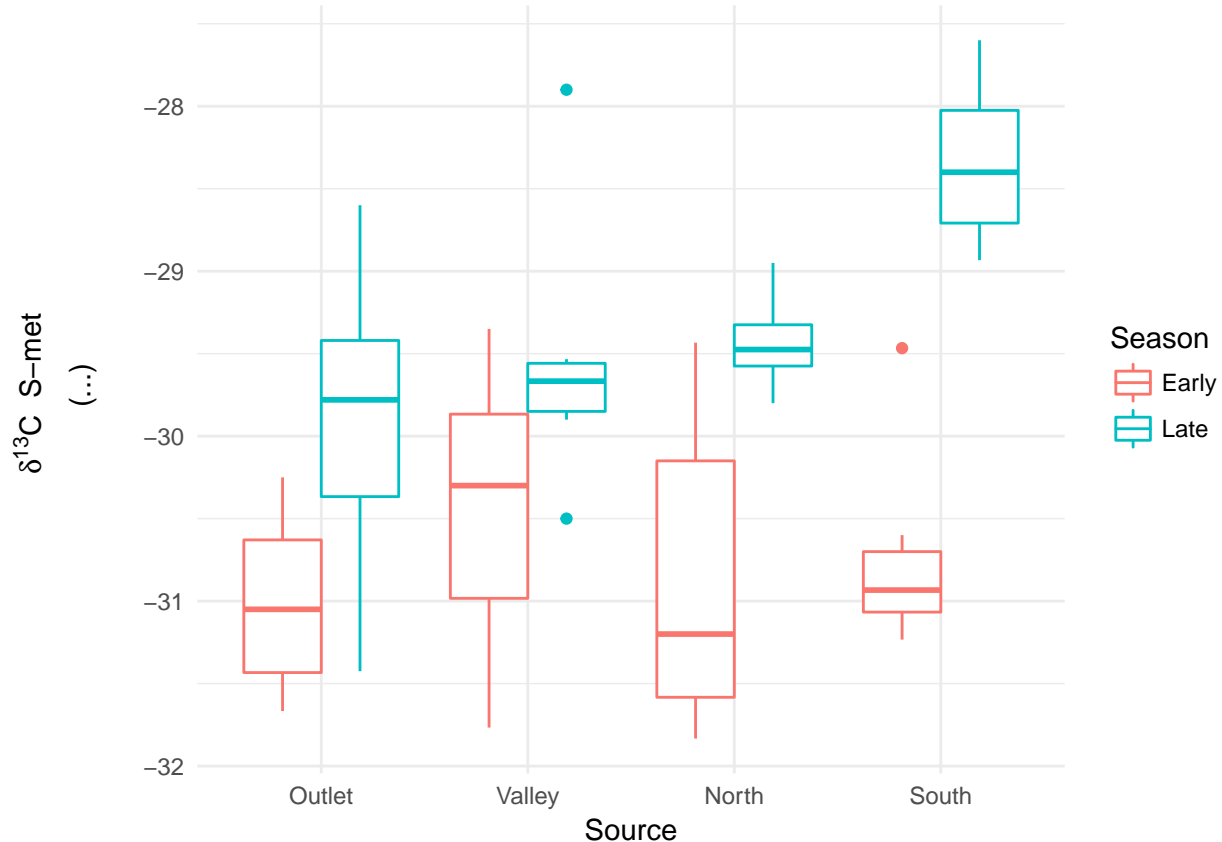
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for

```

```
## <e2>
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>
```



```
late = subset(ws, Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'))
early = subset(ws, Date.ti <= as.POSIXct('2016-05-25 00:06:00', tz = 'EST'))
```

```
# Non-parametric
```

```
# Reject Ho that pop. means are the same if low p-value
```

```
earlyGr4 <- kruskal.test(value ~ as.factor(Group4), data = early)
```

```
earlyGr4 # result is high p value, thus cannot reject that pop. are the same (therefore, no difference)
```

```
##
## Kruskal-Wallis rank sum test
##
## data: value by as.factor(Group4)
## Kruskal-Wallis chi-squared = 2.3098, df = 3, p-value = 0.5107
lateGr4 <- kruskal.test(value ~ as.factor(Group4), data = late)
lateGr4 # Low p-value, therefore reject Ho that groups are the same.

##
## Kruskal-Wallis rank sum test
##
## data: value by as.factor(Group4)
## Kruskal-Wallis chi-squared = 9.1142, df = 3, p-value = 0.02781
SAVE = F
PC = F
if (SAVE){
  if (PC){
    ggsave(sources,
            filename = "D:/Documents/these_pablo/WriteUp/WaterResearch/images/boxplot.pdf",
            device = "pdf", dpi = 600, scale = 1, # )# ,
            width = 8.7, height = 4)
  } else {
    ggsave(sources,
            filename = "/Users/DayTightChunks/Documents/PhD/Writeups/Journals/WaterResearch/images/boxplot",
            device=cairo_pdf, dpi = 600, scale = 1, # )# ,
            width = 8.7, height = 4)
  }
}
```

Grid with sources

```
out_dates_noLeg = out_dates + theme(legend.position = 'none')

sources_noLeg = sources + theme(legend.position = 'none')
so_leg = get_legend(sources)

## Warning: Removed 149 rows containing non-finite values (stat_boxplot).
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
```



```

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

grid2 = plot_grid(
  hy_noLeg,
  out_dates_noLeg,
  sources_noLeg,
  ncol = 1,
  align = 'v')

## Warning: Removed 490 rows containing missing values (geom_tile).
## Warning: Removed 490 rows containing missing values (geom_path).
## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).
## Warning: Removed 149 rows containing non-finite values (stat_boxplot).
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

m12 = ggdraw() +
  draw_plot(grid2, x=0.02, y = 0.0, width = 0.95, height = .95) +
  draw_plot(out_leg, x=(0.53 ), y = 0.44, width = .8, height = 0.1) +
  draw_plot(so_leg, x=(0.53) , y = 0.11, width = .8, height = 0.1) +

  draw_label("A", x= 0.94, y = .93, size = 12, fontface = "bold") +
  draw_label("B", x= 0.94, y = .62, size = 12, fontface = "bold") +
  draw_label("C", x= 0.94, y = .31, size = 12, fontface = "bold")
m12

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

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## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for

```

```
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

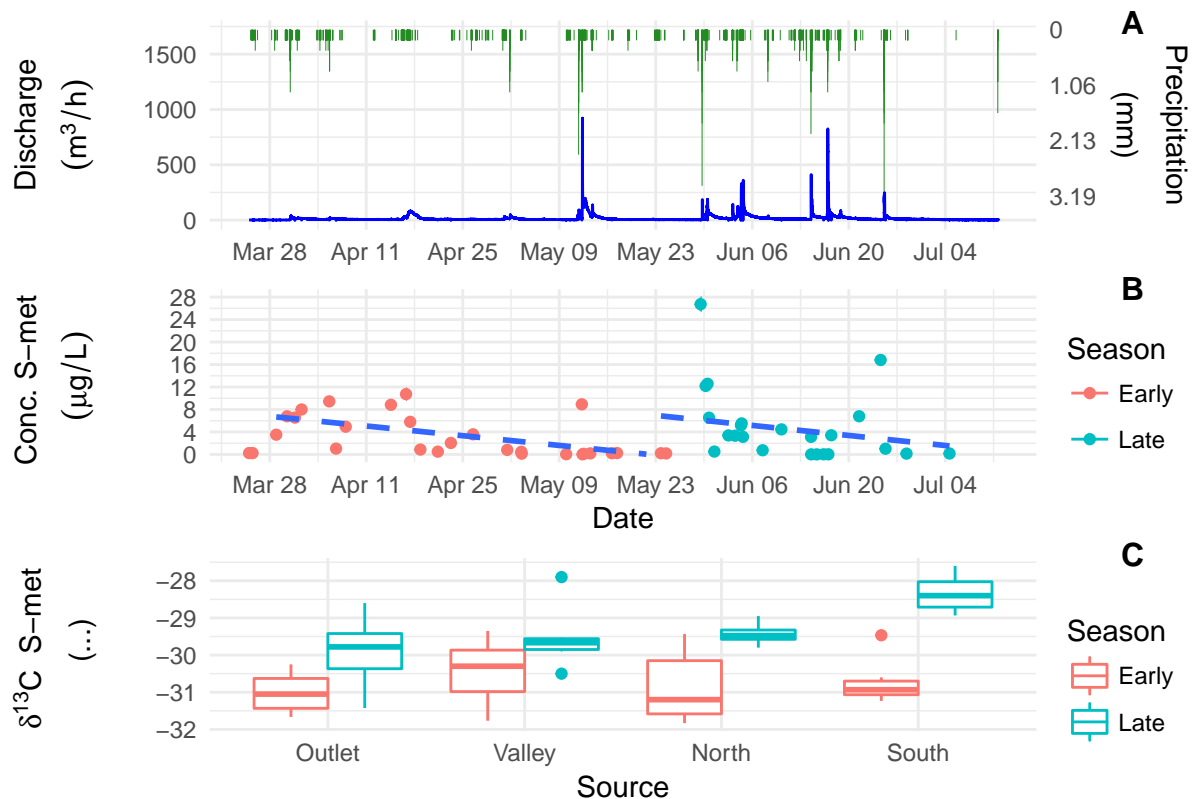
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>
```



All four graphs together

```
hy_noLeg <- hy + theme(legend.position = 'none')
out_noLeg = out + theme(legend.position = 'none')
co_noLeg = co + theme(legend.position = 'none')

out_leg <- get_legend(out)

## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).

co_leg <- get_legend(co)

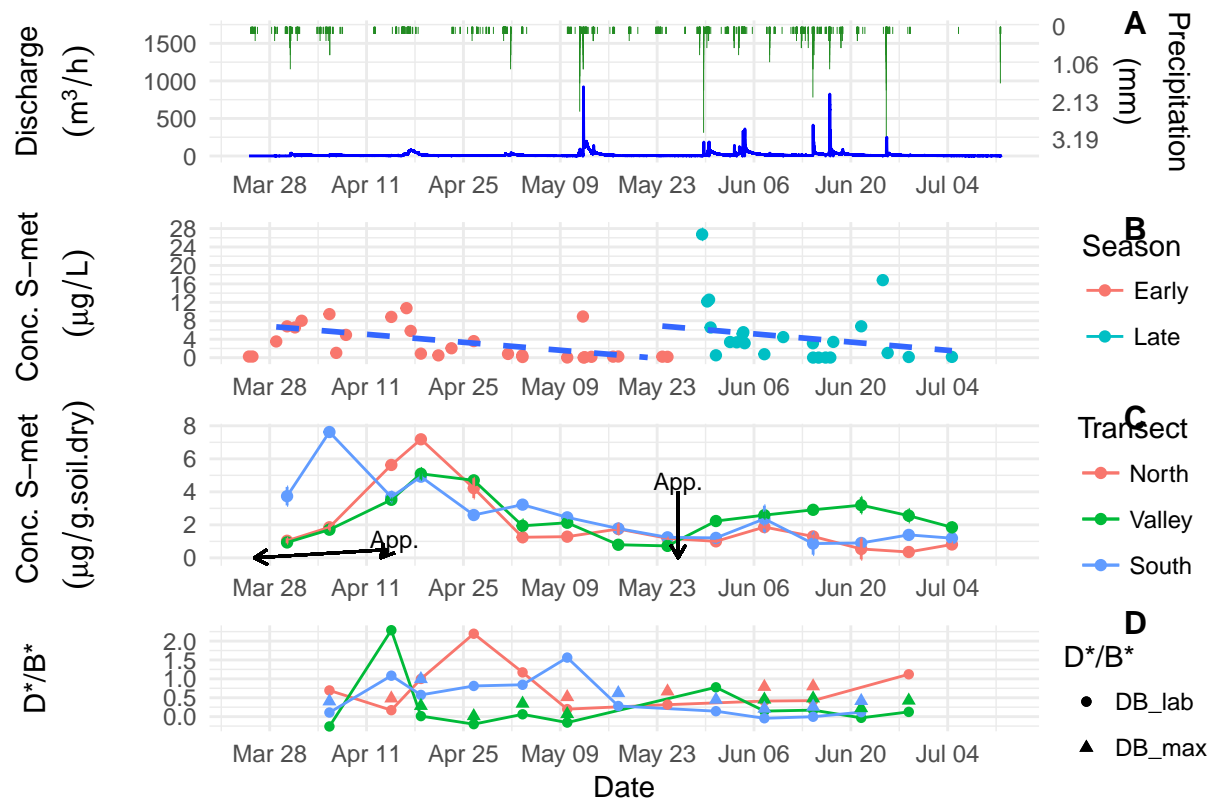
db_noLeg = DB + theme(legend.position = 'none')

grid3 = plot_grid(
  hy_noLeg,
  out_noLeg,
  co_noLeg,
  db_noLeg,
  # sources_noLeg,
  ncol = 1,
  align = 'v')

## Warning: Removed 490 rows containing missing values (geom_tile).
## Warning: Removed 490 rows containing missing values (geom_path).
## Warning: Removed 41311 rows containing non-finite values (stat_smooth).
## Warning: Removed 35220 rows containing non-finite values (stat_smooth).
## Warning: Removed 78736 rows containing missing values (geom_errorbar).
## Warning: Removed 78732 rows containing missing values (geom_point).
## Warning: Removed 4 rows containing missing values (geom_smooth).
## Warning: Removed 12 rows containing missing values (geom_point).

ml3 = ggdraw() +
  draw_plot(grid3, x=0.02, y = 0.0, width = 0.95, height = .95) +
  draw_plot(out_leg, x=(0.54 ), y = 0.56, width = .8, height = 0.1) +
  draw_plot(co_leg, x=(0.54 ), y = 0.32, width = .8, height = 0.1) +
  draw_plot(db_leg, x=(0.54) , y = 0.08, width = .8, height = 0.1) +

  draw_label("A", x= 0.94, y = .93, size = 12, fontface = "bold") +
  draw_label("B", x= 0.94, y = .69, size = 12, fontface = "bold") +
  draw_label("C", x= 0.94, y = .47, size = 12, fontface = "bold") +
  draw_label("D", x= 0.94, y = .23, size = 12, fontface = "bold")
ml3
```



Save

SAVE = F

PC = F

```
if (SAVE){
```

```
  if (PC){
```

```
    ggsave(ml3,
```

```
      filename = "D:/Documents/these_pablo/WriteUp/WaterResearch/images/multilevel4.pdf",
```

```
      device = "pdf", dpi = 600, scale = 1, # )# ,
```

```
      width = 7, height = 10)
```

```
  } else {
```

```
    ggsave(ml3,
```

```
      filename = "/Users/DayTightChunks/Documents/PhD/Writeups/Journals/WaterResearch/images/multilevel4.pdf",
```

```
      device=cairo_pdf, dpi = 600, scale = 1, # )# ,
```

```
      width = 7, height = 10)
```

```
  }
```

```
}
```

Double isotope graph

```
oDual = WaterSoils[ , c("Date.ti", "WeekSubWeek", "diss.d13C.x", "SD.d13C.x")]
```

```
oDual$WeekSubWeek = as.character(oDual$WeekSubWeek)
```

```
oDual$WeekSubWeek = ifelse(oDual$Date.ti == as.POSIXct("2016-03-25 00:04:00", tz= "EST"), "Product", oDual$WeekSubWeek)
```

```
oDual$diss.d13C.x = ifelse(oDual$Date.ti == as.POSIXct("2016-03-25 00:04:00", tz= "EST"), -32.2, oDual$diss.d13C.x)
```

```
oDual$SD.d13C.x = ifelse(oDual$Date.ti == as.POSIXct("2016-03-25 00:04:00", tz= "EST"), 0.4, oDual$SD.d13C.x)
```

```

n = read.csv2("Data/NitrogenIRMS.csv", dec = ".")
n$WeekSubWeek = as.character(n$WeekSubWeek)
n[nrow(n)+1,] = c("Product", as.numeric(1.9), as.numeric(0.5))

#row = c("Product", as.numeric(1.9), as.numeric(0.5))
#n = rbind(n, row)
#str(n)
oDual = merge(oDual, n, by = "WeekSubWeek", all = F)
oDual$diss.d15N = as.numeric(oDual$diss.d15N)
oDual$SD.d15N = as.numeric(oDual$SD.d15N)

oDual$Month = ifelse(oDual$Date.ti >= as.POSIXct("2016-03-24 00:30:00", tz = "EST") &
  oDual$Date.ti < as.POSIXct("2016-04-01 00:00:00", tz = "EST"), "April",
  ifelse(oDual$Date.ti >= as.POSIXct("2016-04-01 00:00:00", tz = "EST") &
    oDual$Date.ti < as.POSIXct("2016-05-01 00:00:00", tz = "EST"), "April",
    ifelse(oDual$Date.ti >= as.POSIXct("2016-05-01 00:00:00", tz = "EST") &
      oDual$Date.ti < as.POSIXct("2016-06-01 00:00:00", tz = "EST"), "May",
      ifelse(oDual$Date.ti >= as.POSIXct("2016-06-01 00:00:00", tz = "EST") &
        oDual$Date.ti < as.POSIXct("2016-07-01 00:00:00", tz = "EST"), "June",
        )
      )
    )
  )

oDual$Season = ifelse(oDual$Date.ti > as.POSIXct('2016-05-25 00:06:00', tz = 'EST'), "Late", "Early")

y = oDual$diss.d15N
y.sd = oDual$SD.d15N

x = oDual$diss.d13C.x
x.sd = oDual$SD.d13C.x

d = ggplot(data = oDual, aes(x=x, y=y, group = Month, colour = Month, shape = Month))+
  theme_minimal() +
  geom_errorbar(aes(ymin = y - y.sd, ymax = y + y.sd)) +
  geom_errorbarh(aes(xmin = x - x.sd, xmax = x + x.sd)) +
  geom_point() +
  ylab(expression(paste({delta}^"15", "N", ' (\u2030)')) +
  xlab(expression(paste({delta}^"13", "C", ' (\u2030)')) +
  theme(text = element_text(size=17))

# View(subset(oDual, WeekSubWeek == "Product" ))

tags = T
oDual$Label = ifelse(oDual$WeekSubWeek != "Product", NA, "Product") # as.factor(oDual$WeekSubWeek)
if (tags){
d = d + geom_label_repel(data = subset(oDual), aes(label=Label),
  arrow = arrow(length = unit(0.005, 'npc'), type = "closed"),
  force = 0.1,
  point.padding = unit(1, 'lines'),
  max.iter = 2e3,
  nudge_x = .1, nudge_y = -0.2, show.legend = F)
}

```

```
d = d + scale_x_continuous(breaks = seq(-33, -29, by=0.5) )
```

```
d
```

```
## Warning: Removed 7 rows containing missing values (geom_label_repel).
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): font
## metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_stringMetric, as.graphicsAnnot(x$label)): conversion
## failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>
## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>
```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

```



```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

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## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

```

```

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## font metrics unknown for Unicode character U+2030

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(L_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : font metrics unknown for Unicode character U+2030

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <80>

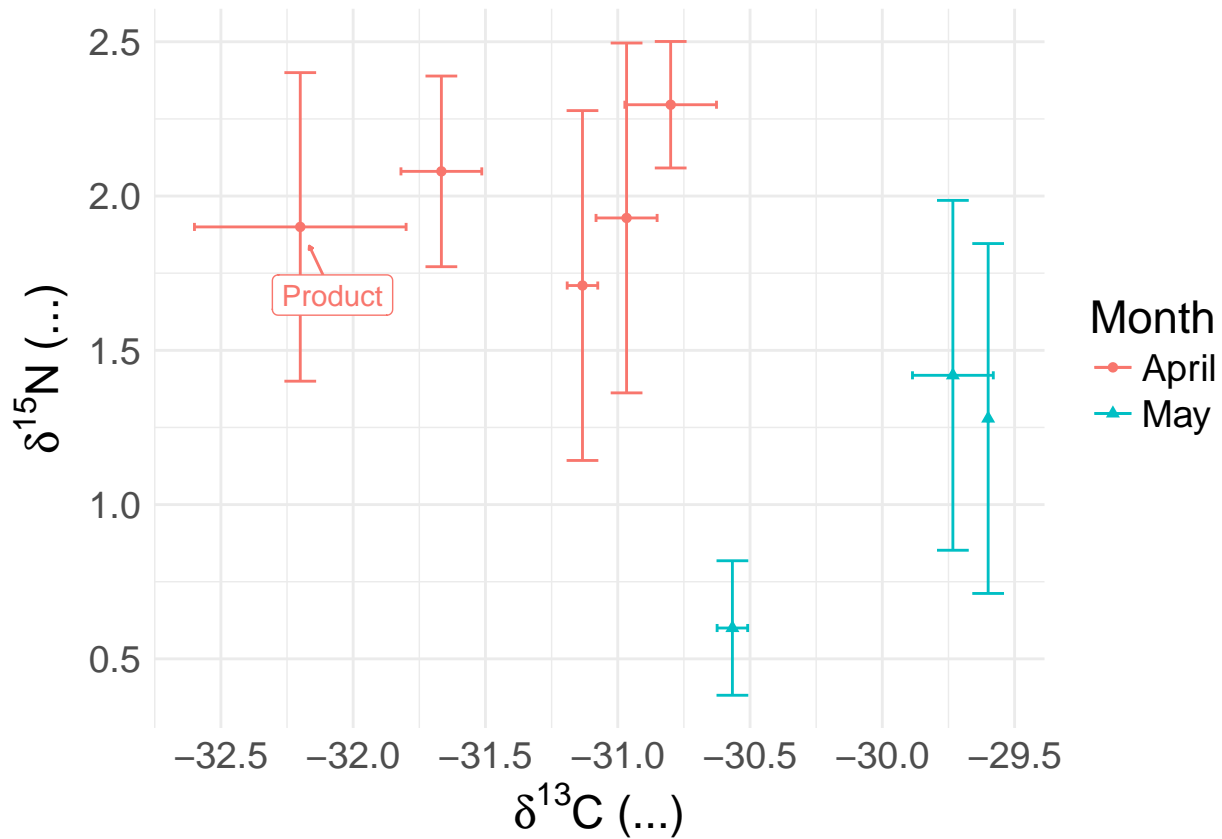
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <b0>

## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbcsToSbcs': dot substituted for
## <e2>

```

```
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbsToSbcs': dot substituted for
## <80>
```

```
## Warning in grid.Call.graphics(L_text, as.graphicsAnnot(x$label), x$x, x
## $y, : conversion failure on ' (%)' in 'mbsToSbcs': dot substituted for
## <b0>
```



```
SAVE = F
PC = T
if (SAVE){
  if (PC){
    ggsave(d,
      filename = "D:/Documents/these_pablo/WriteUp/WaterResearch/images/dual.pdf",
      device = "pdf", dpi = 600, scale = 1, # )# ,
      width = 7, height = 6)
  } else {
    ggsave(d,
      filename = "/Users/DayTightChunks/Documents/PhD/Writeups/Journals/WaterResearch/images/dual.pdf",
      device=cairo_pdf, dpi = 600, scale = 1, # )# ,
      width = 7, height = 6)
  }
}
```