Lutz Model Comparison

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Introduction

This notebook compares Lutz et al (Lutz et al. 2013) simulations to catchment outlet data.

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")

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

Comparison to Lutz et al. (2013)

To choose field events, cummulative rainfalls over a 30 minute interval exceeding at least 4 mm/hr were selected. The start of the event is considered to be the most recent maximum rainfall intensity associated to

the aliquots making up the composite sample. Therefore, signatures represent the flow proportional average of the discharge taking place at the outlet over the course of the event.

```
wstidier <- read.csv2("Data/OutletData4Lutz_R.csv", header = TRUE)
                      # na.strings=c('#DIV/0!', '', 'NA'), header = TRUE)
wstidier$Date <- as.character(wstidier$Date)
wstidier$Date <- as.POSIXct(strptime(wstidier$Date,
                                     "%Y-%m-%d %H:%M", tz="EST"))
names(wstidier)
```

```
##  [1] "Date"     "Week"     "IDSoil"   "Event"    "Qmax"     "Qmean"
##  [7] "Location" "measure"  "SD"       "Type"     "Source"   "Soil.ID"
```

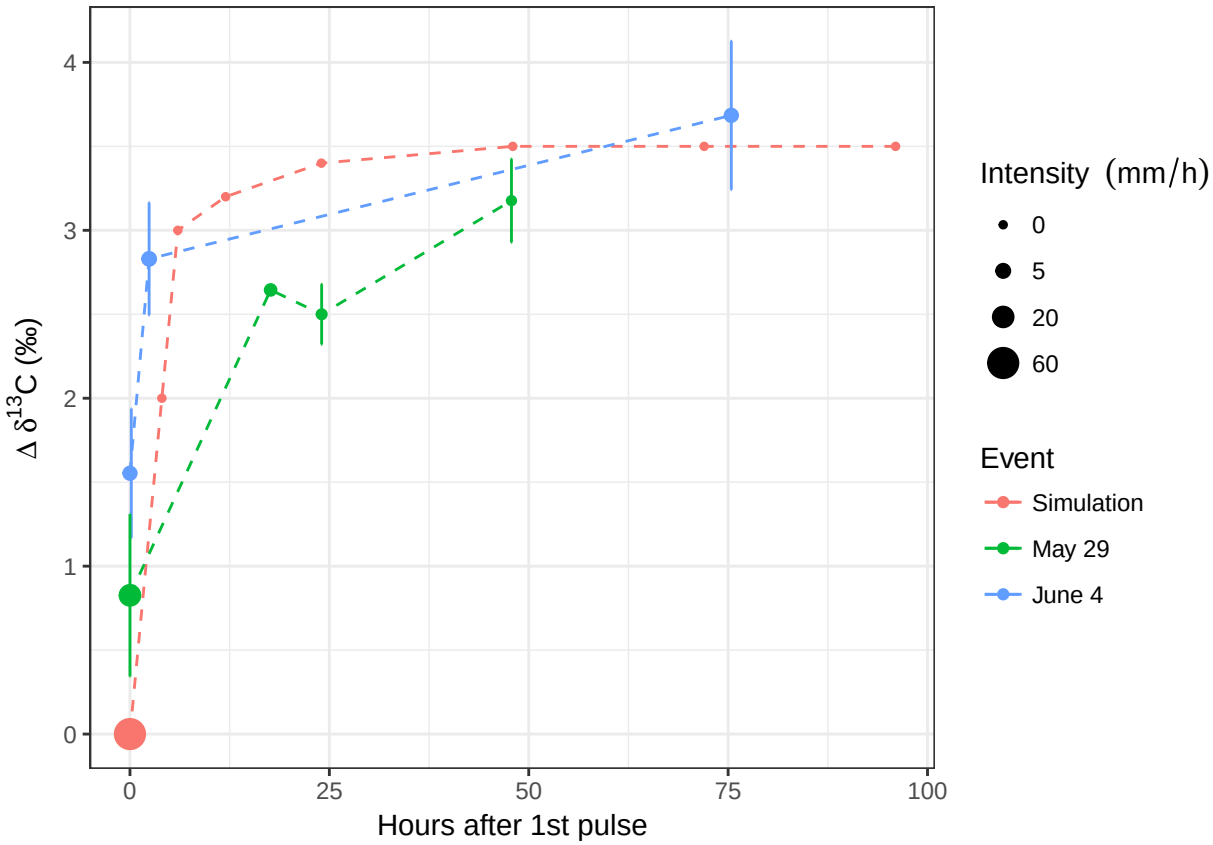
```
rainDay30min <- read.csv2("Data/30minRain.csv", header = T, dec =".")
rainDay30min$Time <- as.character(rainDay30min$Time)
rainDay30min$Date <-  as.POSIXct(strptime(rainDay30min$Time,
                                     "%d/%m/%Y %H:%M", tz="EST"))

rainDay30min$Time <- NULL
rainDay30min$Cumm.mm <- as.numeric(rainDay30min$Cumm.mm)

rainDay30min <- subset(rainDay30min, Cumm.mm > 0)
rainDay30min$mm.hr <- rainDay30min$Cumm.mm*(60/30) # mm/min -> mm/hr
rainDay30min$Cumm.mm <- NULL

#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(wstidier, Location == "diss" &
                      # Date >= as.POSIXct( "2016-03-30 12:18:00" , tz = "EST") &
                    Date >= as.POSIXct("2016-05-12 06:34:00", tz = "EST") &
                      Date <= as.POSIXct("2016-06-24 14:52:00", tz = "EST"))

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

rdiss <- merge(dissolved, rainDay30min, by = "Date", all = T)

# May 11 event
eventMay11 <- subset(rdiss, Date >= as.POSIXct("2016-05-11 19:32:00", tz = "EST") &
                       Date <= as.POSIXct("2016-05-12 06:34:00", tz = "EST"))

  # Take the max rainfall that generated the sample
eventMay11[which(is.na(eventMay11$mm.hr)), "mm.hr"] <- max(eventMay11$mm.hr, na.rm = T)
eventMay11 <- eventMay11[complete.cases(eventMay11[ , "measure"]),]
eventMay11$Date.Ini <- eventMay11$Date[1]
eventMay11$Event <- rep("May 11", nrow(eventMay11))
eventMay11$Approach <- rep("Outlet, 2016", nrow(eventMay11))

# May 12 event
eventMay12 <- subset(rdiss, Date >= as.POSIXct("2016-05-12 08:02:00", tz = "EST") &
                       Date <= as.POSIXct("2016-05-12 09:12:00", tz = "EST"))
```

```
eventMay12[which(is.na(eventMay12$mm.hr)), "mm.hr"] <- max(eventMay12$mm.hr, na.rm = T)
eventMay12 <- eventMay12[complete.cases(eventMay12[ , "measure"]),]
eventMay12$Date.Ini <- eventMay12$Date[1]
eventMay12$Event <- rep("May 12", nrow(eventMay12))
eventMay12$Approach <- rep("Outlet, 2016", nrow(eventMay12))

# May 29 event
eventMay29 <- subset(rdiss, Date >= as.POSIXct("2016-05-29 03:32:00", tz = "EST") &
                       Date <= as.POSIXct("2016-05-31 12:00:00", tz = "EST"))
                       # Date <= as.POSIXct("2016-06-02 12:58:00", tz = "EST"))

eventMay29 <- eventMay29 %>%
  mutate(mm.hr = lead(mm.hr))
eventMay29$mm.hr <- na.locf(eventMay29$mm.hr)
eventMay29 <- eventMay29[complete.cases(eventMay29[, "measure"]), ]
eventMay29$Date.Ini <- eventMay29$Date[1]
eventMay29$Event <- rep("May 29", nrow(eventMay29))
eventMay29$Approach <- rep("Outlet, 2016", nrow(eventMay29))

# June 3rd event
eventJune3 <- subset(rdiss, Date >= as.POSIXct("2016-06-03 03:32:00", tz = "EST") &
                       Date <= as.POSIXct("2016-06-03 12:06:00", tz = "EST"))

eventJune3[which(is.na(eventJune3$mm.hr)), "mm.hr"] <- max(eventJune3$mm.hr, na.rm = T)
eventJune3 <- eventJune3[complete.cases(eventJune3[, "measure"]), ]
eventJune3$Date.Ini <- eventJune3$Date[1]
eventJune3$Event <- rep("June 3", nrow(eventJune3))
eventJune3$Approach <- rep("Outlet, 2016", nrow(eventJune3))


eventJune4 <- subset(rdiss, Date >= as.POSIXct("2016-06-04 06:02:00", tz = "EST") &
                       Date <= as.POSIXct("2016-06-07 12:00:00", tz = "EST"))

eventJune4[which(is.na(eventJune4$mm.hr))[1], "mm.hr"] <- max(eventJune4$mm.hr[1:7], na.rm = T)
eventJune4[which(is.na(eventJune4$mm.hr))[1], "mm.hr"] <- max(eventJune4$mm.hr[8:12], na.rm = T)
eventJune4[which(is.na(eventJune4$mm.hr))[1], "mm.hr"] <- max(eventJune4$mm.hr[13:nrow(eventJune4)], na
eventJune4 <- eventJune4[complete.cases(eventJune4[, "measure"]), ]
eventJune4$Date.Ini <- eventJune4$Date[1]
eventJune4$Event <- rep("June 4", nrow(eventJune4))
eventJune4$Approach <- rep("Outlet, 2016", nrow(eventJune4))


events <- rbind(# eventMay11, eventMay12,
                eventMay29,
                # eventJune3,
                eventJune4)

events$Duration.Hrs =
  as.numeric(difftime(events$Date, events$Date.Ini, units = "hours"), units = "hours")


names(events)
```

```
##  [1] "Date"         "Week"         "IDSoil"       "Event"
```

```
##  [5] "Qmax"          "Qmean"         "Location"      "measure"
##  [9] "SD"            "Type"          "Source"        "Soil.ID"
## [13] "mm.hr"         "Date.Ini"      "Approach"      "Duration.Hrs"
```

```
events <- events[c("Duration.Hrs", "mm.hr", "measure", "SD" ,  "Event", "Approach")]

# Lutz reproduction
Duration.Hrs <- c(0, 4, 6, 12, 24, 48, 72, 96)
mm.hr <- c(60, 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)

eventLutz <- data.frame(Duration.Hrs, mm.hr, measure, SD, Event, Approach)

allEvents <- rbind(eventLutz, events)

LutzEvents <- ggplot(data = allEvents, aes(x= Duration.Hrs, y=measure, colour = Event))+
  theme_bw() +
  geom_point(aes(size = mm.hr)) +
  geom_line(aes(colour = Event), linetype = "dashed") +
  # 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") +
  scale_size_continuous(range = c(1, 5), breaks= c(0, 5, 20, 60), limits = c(0, 60)) +
  guides(size = guide_legend(order = 4,
                             title=expression("Intensity " ~ (mm/h) ),
                             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)
```

Lutz, S. R., H. J. Van Meerveld, M. J. Waterloo, H. P. Broers, and B. M. Van Breukelen. 2013. "A model-based assessment of the potential use of compound-Specific stable isotope analysis in river monitoring of diffuse pesticide pollution." *Hydrology and Earth System Sciences* 17 (11): 4505–24. doi:10.5194/hess-17-4505-2013.