

# TEST\_SWC

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```
data <-
read.csv2("C:/Users/BMarien/Desktop/laptop/Own_work/Droughts_do_not_advance_the_onset_of_autumn_leaf_senescence_in_temperate_deciduous_forest_trees/Data/Data_used_in_article/W_exp_NSWC_2018NA.csv")
names(data)

## [1] "number"          "Date"              "X"                 "DOY"
## [5] "Time"            "PM"                "Chamber"          "Treatment"
## [9] "water.content"   "water.content_NA"

##
DOY <- as.numeric(as.character(data[,4]))
CHAMBER <- as.factor(as.character(data[,7]))
TREATMENT <- as.factor(as.character(data[,8]))
SWC <- as.numeric(as.character(data[,10]))
CHAMBER <- as.factor(as.character(data[,7]))

##
data1 <- data.frame(DOY, SWC, TREATMENT, CHAMBER)

##
data1 <- na.omit(data1)
names(data1)

## [1] "DOY"          "SWC"          "TREATMENT" "CHAMBER"

## Test GAM
library(mgcv)

## Loading required package: nlme

## This is mgcv 1.8-31. For overview type 'help("mgcv-package")'.

m1 <- gamm(SWC ~ s(DOY, bs = 'tp', by = TREATMENT),
           family = gaussian(),
           method = "REML",
           data = data1)

## Get the summary results
summary(m1$gam)

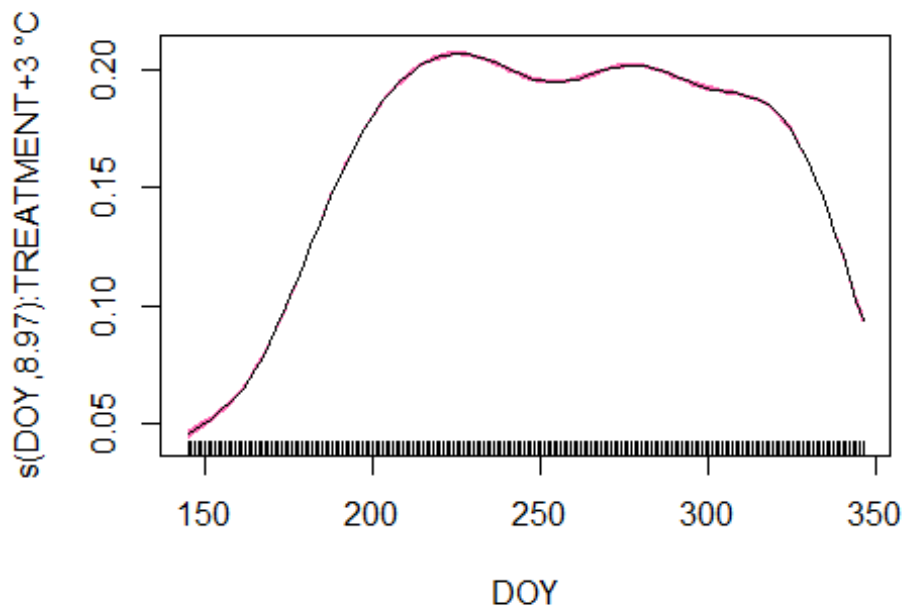
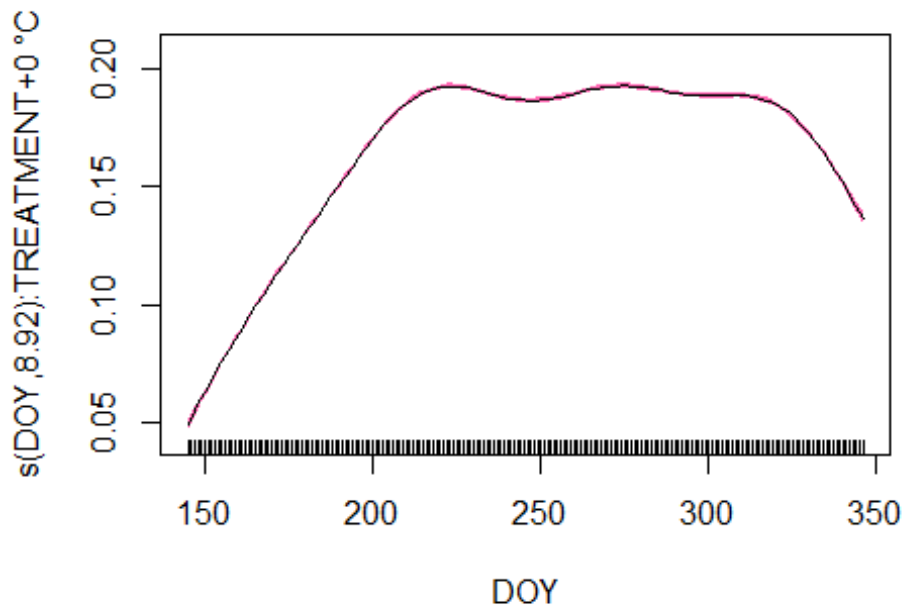
##
## Family: gaussian
```

```

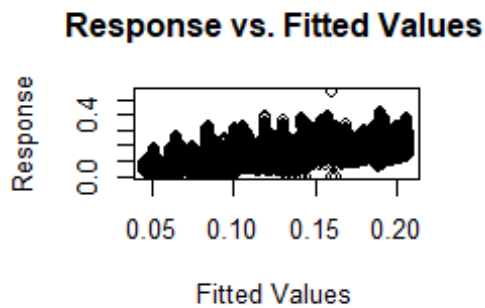
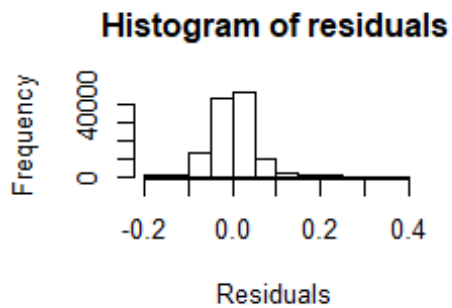
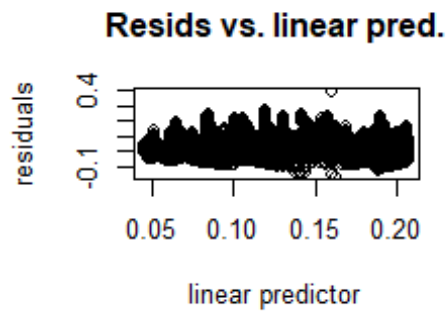
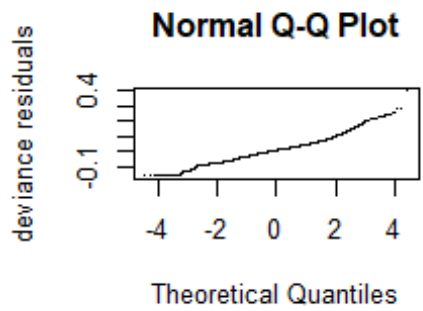
## Link function: identity
##
## Formula:
## SWC ~ s(DOY, bs = "tp", by = TREATMENT)
##
## Parametric coefficients:
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.1652966  0.0001259   1313  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Approximate significance of smooth terms:
##           edf Ref.df    F p-value
## s(DOY):TREATMENT+0 °C 8.919  8.919 5105  <2e-16 ***
## s(DOY):TREATMENT+3 °C 8.974  8.974 8373  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.514
##   Scale est. = 0.0018061  n = 113912

## Get a quick & dirty plot
plot(m1$gam, rug = TRUE, all.terms = TRUE, #pages = 1,
      seWithMean = TRUE, shade = TRUE, shade.col = "hotpink", # SE of partial
      effect + SE of model intercept, reflect overall uncertainty better than CI
      shift = coef(m1$gam)[1]) #Shift scale to include intercept

```

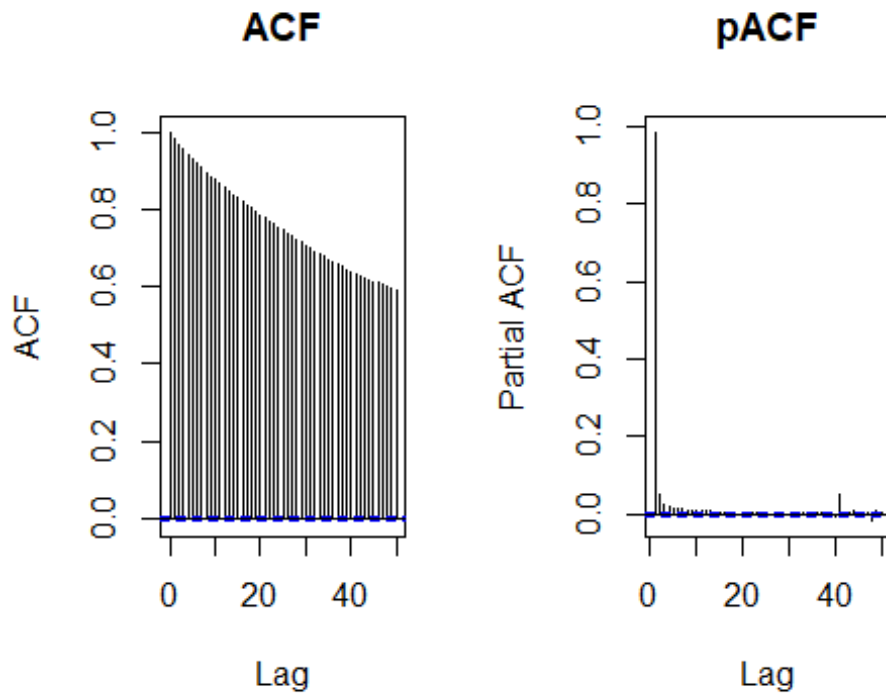


```
## Check the assumptions of normality & homogeneity quick & dirty  
par(mfrow = c(2,2))  
gam.check(m1$gam)
```



```
##
## 'gamm' based fit - care required with interpretation.
## Checks based on working residuals may be misleading.
## Basis dimension (k) checking results. Low p-value (k-index<1) may
## indicate that k is too low, especially if edf is close to k'.
##
##               k'   edf k-index p-value
## s(DOY):TREATMENT+0 °C 9.00 8.92    0.8 <2e-16 ***
## s(DOY):TREATMENT+3 °C 9.00 8.97    0.8 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## ACF and pACF
layout(matrix(1:2, ncol = 2))
acf(resid(m1$lme, type = "normalized"), main = "ACF")
pacf(resid(m1$lme, type = "normalized"), main= "pACF")
```



```

layout(1)

library(forecast)

## Registered S3 method overwritten by 'quantmod':
##   method           from
## as.zoo.data.frame zoo

##
## Attaching package: 'forecast'

## The following object is masked from 'package:nlme':
##
##   getResponse

arma_res2 <- auto.arima(resid(m1$lme, type = "normalized"),
                        approximation=TRUE)
arma_res2$coef

##           ma1           ma2           ma3           ma4           ma5
## -0.06184429 -0.03337808 -0.02644633 -0.02334412 -0.02144040

## plot
library(gratia)
m2_ci_sim <- confint(m1,
                     level = 0.95,
                     parm = "DOY",
                     type = 'simultaneous',

```

```

      nsim = 10000,
      n = 200,
      shift = TRUE)

names(m2_ci_sim)

## [1] "smooth"      "by_variable" "DOY"         "est"         "se"
## [6] "TREATMENT"   "crit"        "lower"       "upper"

head(m2_ci_sim)

## # A tibble: 6 x 9
##   smooth      by_variable DOY   est     se TREATMENT crit lower
##   <chr>      <fct>      <dbl> <dbl> <dbl> <fct>    <dbl> <dbl>
##   <dbl>
## 1 s(DOY):TREATME~ TREATMENT   145  0.0496 1.06e-3 +0 °C    2.99 0.0464
## 0.0527
## 2 s(DOY):TREATME~ TREATMENT   146. 0.0522 9.84e-4 +0 °C    2.99 0.0492
## 0.0551
## 3 s(DOY):TREATME~ TREATMENT   147. 0.0548 9.09e-4 +0 °C    2.99 0.0521
## 0.0575
## 4 s(DOY):TREATME~ TREATMENT   148. 0.0574 8.37e-4 +0 °C    2.99 0.0549
## 0.0599
## 5 s(DOY):TREATME~ TREATMENT   149. 0.0600 7.69e-4 +0 °C    2.99 0.0577
## 0.0623
## 6 s(DOY):TREATME~ TREATMENT   150. 0.0626 7.07e-4 +0 °C    2.99 0.0605
## 0.0647

## plot1
library(ggplot2)
plot1 <- ggplot(data = m2_ci_sim, aes(x= DOY, y = est,
                                     color = smooth,
                                     fill=smooth)) +

  geom_ribbon(data = m2_ci_sim,
            aes(ymin = lower, ymax = upper, x = DOY), # simultaneous
            alpha = 0.3) +
  geom_line(size = 1.2) +
  scale_x_continuous(name = "DOY",
                    breaks = seq(145,320,20),
                    limits = c(145,320)) +
  scale_y_continuous(name = "SWC (m³/m³)",
                    breaks = seq(0,0.25,0.05),
                    limits = c(0,0.25)) +
  annotate("rect", xmin=121,xmax=181, ymin=-Inf,ymax=Inf, fill='lightblue',
alpha = 0.4)

##
library(viridis)

## Loading required package: viridisLite

```

```

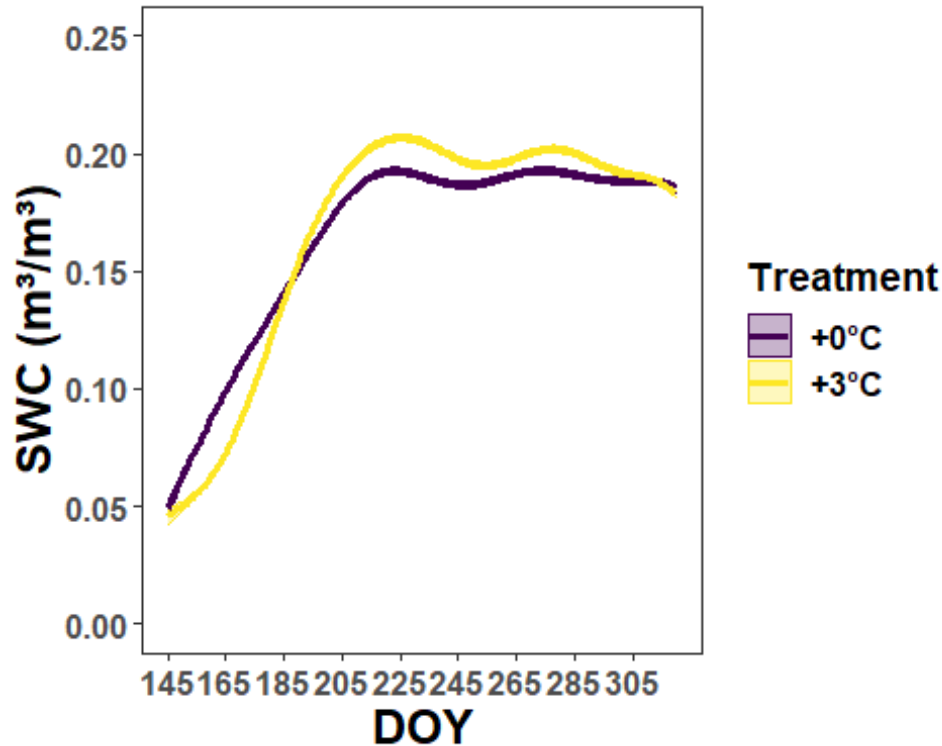
vir_col <- viridis(2, option = 'D')
cols <- c("s(DOY):TREATMENT+0 °C" = vir_col[1],
         "s(DOY):TREATMENT+3 °C" = vir_col[2])
labels <- c("s(DOY):TREATMENT+0 °C" = "+0°C",
          "s(DOY):TREATMENT+3 °C" = "+3°C")

plot1 <- plot1 +
  scale_color_manual(name = "Treatment",
                    values = cols,
                    labels = labels) +
  scale_fill_manual(name = "Treatment",
                   values = cols,
                   labels = labels)

plot1 <- plot1 +
  theme_bw() +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.title.x = element_text(size=18, face="bold"),
        axis.text.x = element_text(size=12, face="bold"),
        axis.title.y = element_text(size=18, face="bold"),
        axis.text.y = element_text(size=12, face="bold"),
        legend.title = element_text(size=14, face="bold"),
        legend.text = element_text(size=12, face="bold"),
        strip.text = element_text(size=12, face = "bold"),
        legend.position = "right")
plot1

## Warning: Removed 52 row(s) containing missing values (geom_path).
## Warning: Removed 1 rows containing missing values (geom_rect).

```



```
#####
#####

## Compare the smooths following Rose et al. (2012)
pdat <- expand.grid(DOY = seq(145, 320, length = 175),
                  TREATMENT = c("+0 °C", "+3 °C"))
xp <- predict(m1$gam, newdata = pdat, type = 'lpmatrix')

##
c1 <- grepl('+0 °C', colnames(xp))
c2 <- grepl('+3 °C', colnames(xp))

##
r1 <- with(pdat, TREATMENT == '+0 °C')
r2 <- with(pdat, TREATMENT == '+3 °C')

##
X <- xp[r1, ] - xp[r2, ]

##
X[, !(c1 | c2)] <- 0

##
X[, !grepl('^s\\(', colnames(xp))] <- 0

##
```



```

dif <- X %>% coef(m1$gam)

##
se <- sqrt(rowSums((X %>% vcov(m1$gam, unconditional = TRUE)) * X))

##
crit <- qt(.975, df.residual(m1$gam))
upr <- dif + (crit * se)
lwr <- dif - (crit * se)

##
smooth_diff <- function(model, newdata, f1, f2, var, alpha = 0.05,
                        unconditional = FALSE) {
  xp <- predict(model, newdata = newdata, type = 'lpmatrix')
  c1 <- grepl(f1, colnames(xp))
  c2 <- grepl(f2, colnames(xp))
  r1 <- newdata[[var]] == f1
  r2 <- newdata[[var]] == f2

  ##
  X <- xp[r1, ] - xp[r2, ]

  ##
  X[, ! (c1 | c2)] <- 0

  ##
  X[, !grepl('^s\\(', colnames(xp))] <- 0
  dif <- X %>% coef(model)
  se <- sqrt(rowSums((X %>% vcov(model, unconditional = unconditional)) * X))
  crit <- qt(alpha/2, df.residual(model), lower.tail = FALSE)
  upr <- dif + (crit * se)
  lwr <- dif - (crit * se)
  data.frame(pair = paste(f1, f2, sep = '-'),
             diff = dif,
             se = se,
             upper = upr,
             lower = lwr)
}

##
comp1 <- smooth_diff(m1$gam, pdat, '+0 °C', '+3 °C', 'TREATMENT')
comp <- cbind(Doy = seq(145, 320, length = 175),
             rbind(comp1)) #comp2, comp3

##
library(ggplot2)
plot2 <- ggplot(comp, aes(x = Doy, y = diff)) +
  geom_ribbon(aes(ymin = lower, ymax = upper), alpha = 0.2) +
  geom_line(size = 1) +

```

```

coord_cartesian(ylim = c(-0.05,0.05)) +
geom_hline(yintercept=0,linetype="dashed", color = "red", size = 1) +
labs(x = 'DOY', y = 'Difference in \n SWC trend (m³/m³)') +
scale_x_continuous(name = "DOY",
                    breaks = seq(145,320,20),
                    limits = c(145,320)) +
  annotate("rect", xmin=145,xmax=181, ymin=-Inf,ymax=Inf, fill='lightblue',
alpha = 0.4)

plot2_F <- plot2 +
  theme_bw() +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.title.x = element_text(size=18, face="bold"),
        axis.text.x = element_text(size=12, face="bold"),
        axis.title.y = element_text( size=18, face="bold"),
        axis.text.y = element_text(size=12, face="bold"),
        legend.title = element_text( size=14, face="bold"),
        legend.text = element_text(size=12, face="bold"),
        legend.position = "bottom")
plot2_F

```

