**How do Douglas-fir and Western Hemlock Respond to Heat Waves in Western Oregon?**

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Anthropogenic climate change, namely heat waves, will likely increase in severity and frequency over time. It is important to understand how trees will respond because they are unmatched in their ability to provide carbon sequestration, habitat, recreation, food, and more. Many studies use models to predict Pacific Northwest forest responses to climate stress, but it is important to analyze live data to ensure model accuracy while identifying patterns in tree growth responses. For example, heat waves and drought are often co-occurring and are therefore rarely decoupled when analyzing specific drivers of climate stress in trees.

The present ongoing study addresses this by asking, “What physiological changes occur among Douglas-fir and western hemlock trees in western Oregon before, during, and after a heat wave?” I have analyzed microclimate and dendrometer data at the HJ Andrews Research Forest to extrapolate stem growth, where up to 75% of a tree’s biomass is stored. So far, microclimate trends reveal increasing occurrences of temperature and precipitation events that exceed stress thresholds for trees at the research site. Stem growth records are still in progress. I have concurrently collected tree cores to contextualize short-term growth with longer records of dendrochronology.

# install if necessary

#packages <- (c("devtools","zoo","chron","dplyr","viridis", "RCurl", "DT"))

#install.packages(setdiff(packages, rownames(installed.packages())))

#devtools::install\_github("treenet/treenetproc")

library(treenetproc)

library(zoo)

library(chron)

library(viridis)

library(dplyr)

# helper functions

left <- function(string, char){substr(string, 1,char)}

right <- function (string, char){substr(string,nchar(string)-(char-1),nchar(string))}

setwd("~/Documents/Ameriflux/Me6/dendrometers")

# readin dendrometer data (ts,)

ID = '137' #dendrometer ID number

all\_data<-read.table('./data/data\_92223137\_2022\_08\_29\_0.csv', header=F, sep=";", dec=',')

dendro\_data = all\_data[,c(2,7)]

colnames(dendro\_data) <- c('datetime','value')

#fix timestamp

ts = as.POSIXct(dendro\_data['datetime'][,],format="%Y.%m.%d %H:%M",tz="GMT")

dendro\_data\_L0<-cbind(dendro\_data["value"]+0,ts,series=ID)

# level 1 processing (time align)

#?treenetproc::proc\_L1

dendro\_data\_L1 <- proc\_L1(data\_L0 = dendro\_data\_L0,

reso = 60 ,

#input = "wide",

date\_format ="%Y-%m-%d %H:%M:%S",

tz = "GMT")

head(dendro\_data\_L1)

# level 1 processing of temperature data

temp\_data\_L0 <- cbind(all\_data[,c(4,6)],ts,series=ID)

colnames(temp\_data\_L0) <-c('value','empty','ts','series')

# align data

temp\_data\_L1 <- proc\_L1(data\_L0 = temp\_data\_L0,

reso = 60,

date\_format ="%Y-%m-%d %H:%M:%S",

tz = "GMT")

head(temp\_data\_L1)

# process and plot

par(mfrow=c(1,1))

par(mar = c(5, 5, 5, 5))

# detect errors

dendro\_data\_L2 <- proc\_dendro\_L2(dendro\_L1 = dendro\_data\_L1,

temp\_L1 = temp\_data\_L1,

tol\_jump = 15,

plot = TRUE,

tz="GMT")

# check the data

head(dendro\_data\_L2)

# plot minimum daily twd against day of year

par(mfrow=c(1,1))

par(mar = c(5, 5, 5, 5))

plot(1, 1,

ylim=c(-1,max(dendro\_data\_L2$twd,na.rm=T)),

xlim=c(120,240),

ylab=expression("twd ("\*mu\*"m)"),

xlab="Day of year",

col="white")

col\_sel<-c("cyan","darkorange","purple")

for(y in c(1:length(unique(left(dendro\_data\_L2$ts,4))))){

# selected year

sel<-dendro\_data\_L2[which(left(dendro\_data\_L2$ts,4)==unique(left(dendro\_data\_L2$ts,4))[y]),]

# calc twd

twd<-suppressWarnings(aggregate(sel$twd,list(as.Date(sel$ts)),min,na.rm=T))

twd$doy<-as.numeric(strftime(as.Date(twd$Group.1), format = "%j"))

# clean

twd[which(twd$x=="Inf"),"x"]<-NA

lines(twd$doy,twd$x,col=col\_sel[y],lwd=1.5)

twd[which(is.na(twd$x)==T),"x"]

polygon(c(c(0,twd$doy),c(rev(twd$doy),0)),

c(c(0,twd$x),rep(0,nrow(twd)+1)),

col=rgb(0,0,0,0.1),

border=rgb(0,0,0,0))

}

# plot growth against day of year

par(mfrow=c(1,1))

par(mar = c(5, 5, 5, 5))

plot(1, 1,

ylim=c(-1,max(dendro\_data\_L2$gro\_yr,na.rm=T)),

xlim=c(120,240),

ylab=expression("growth ("\*mu\*"m)"),

xlab="Day of year",

col="white")

col\_sel<-c("darkorange","purple")

for(y in c(1:length(unique(left(dendro\_data\_L2$ts,4))))){

# selected year

sel<-dendro\_data\_L2[which(left(dendro\_data\_L2$ts,4)==unique(left(dendro\_data\_L2$ts,4))[y]),]

# calc twd

gro<-suppressWarnings(aggregate(sel$gro\_yr,list(as.Date(sel$ts)),max,na.rm=T))

gro$doy<-as.numeric(strftime(as.Date(gro$Group.1), format = "%j"))

# clean

gro[which(gro$x=="Inf"),"x"]<-NA

lines(gro$doy,gro$x,col=col\_sel[y],lwd=1.5)

gro[which(is.na(gro$x)==T),"x"]

}