Analysis_First_Chapter2

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1. Uploading Libraries

```
library(tidyr)
library(tidyverse)
library(ggplot2)
library(survival)
library(survminer)
library(ranger)
library(ggplot2)
library(ggpubr)
library(ggsci)
library(readxl)
library(showtext)
library(lubridate)
setwd("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter")
# setwd("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter")
data_analysis <-
  read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\data_analysis_cens.xlsx
    col_types = c("numeric", "date","numeric", "date",
        "numeric", "numeric", "numeric", "numeric"))

# #pathsFede
#  setwd("/home/fbartu/Research/Laura_Blanco/Chapter-Survival/PrimerCap/")
#  data_analysis <-
#    read_excel("data_analysis_cens.xlsx",
#      col_types = c("numeric", "date","numeric", "date",
#          "numeric", "numeric", "numeric", "numeric"))


#Now, data of weather (RH and Temperature) in both locations in the field (HOBO's data)
# jardin_clima <-
#   read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\Jardin_clima_total.x
#     col_types = c("date", "numeric", "numeric"))
#
# palafolls_clima <-
#   read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\Palafolls_clima_tota

jardin_clima <-
  read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\Jardin_clima_total.xlsx
    col_types = c("date", "numeric", "numeric"))
```

```r
palafolls_clima <-
  read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\Palafolls_clima_total.x


#URBAN DATAFRAME OF WEATHER
temperaturemeanpal<- palafolls_clima%>%
  #v#calculating means of temperature and rhper day (HOBO makes 3 measures per day)
  group_by(DATE)%>%
  summarise(meantemperature=mean(TEMPERATURE),meanrh = mean(RH) )

temperatureminpal<- palafolls_clima%>%
  #v#calculating mins of temperature and rhper day (HOBO makes 3 measures per day)
  group_by(DATE)%>%
  summarise(mintemperature=min(TEMPERATURE),minrh = min(RH) )

temperaturemaxpal<- palafolls_clima%>%
  #v#calculating max of temperature and rhper day (HOBO makes 3 measures per day)
  group_by(DATE)%>%
  summarise(maxtemperature=max(TEMPERATURE),maxrh = max(RH) )
palafolls_clima<- merge(temperaturemaxpal, temperaturemeanpal, by = "DATE")
palafolls_clima_total<- merge(palafolls_clima, temperatureminpal, by = "DATE")
remove(palafolls_clima)
remove(temperaturemaxpal)
remove(temperatureminpal)
remove(temperaturemeanpal)

#SEMI-URBAN DATAFRAME OF WEATHER
temperaturemeanjar<- jardin_clima%>% #calculating means of temperature and rh per day
  group_by(DATE)%>%
  summarise(meantemperature=mean(TEMPERATURE),meanrh = mean(RH))

temperatureminjar<- jardin_clima%>% #calculating min of temperature and rh per day
  group_by(DATE)%>%
  summarise(mintemperature=min(TEMPERATURE),minrh = min(RH))

temperaturemaxjar<- jardin_clima%>% #calculating max of temperature and rh per day
  group_by(DATE)%>%
  summarise(maxtemperature=max(TEMPERATURE),maxrh = max(RH))
jardin_clima<- merge(temperaturemaxjar, temperaturemeanjar, by = "DATE")
jardin_clima_total<- merge(jardin_clima, temperatureminjar, by = "DATE")
remove(jardin_clima)
remove(temperaturemaxjar)
remove(temperaturemeanjar)
remove(temperatureminjar)

jardin_clima_total$location <- "1"
#creating new columns according to the locations
jardin_clima_total$location<- as.numeric(jardin_clima_total$location)
palafolls_clima_total$location<- "2"
palafolls_clima_total$location<- as.numeric(palafolls_clima_total$location)
#renaming column DATE to match with start_date column from our data_analysis dataframe
jardin_clima_total <- jardin_clima_total %>%
  rename(start_date = DATE)
```

```r
palafolls_clima_total <- palafolls_clima_total %>%
  rename(start_date = DATE)

datos_semi <- inner_join(data_analysis, jardin_clima_total,
                         by = c("start_date", "location"), all= TRUE)
#Combining temperature of each location with the data
datos_urban <- inner_join(data_analysis, palafolls_clima_total,
                          by = c("start_date", "location"), all= TRUE)
datos_lab<- subset(data_analysis, location=="3")
datos_lab$meantemperature <- NA
datos_lab$meanrh <- NA
datos_lab$mintemperature <- NA
datos_lab$minrh <- NA
datos_lab$maxtemperature <- NA
datos_lab$maxrh <- NA
datos_field_lab <- rbind(datos_semi,datos_urban, datos_lab)
#merging all to have a dataframe completed (data survival + weather)
datos_field<- rbind(datos_semi, datos_urban)
clima_field <- rbind(jardin_clima_total, palafolls_clima_total)
```

2. Creating weather variables and duplicating rows per mosquito

```r
df <- read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\datos_field.xlsx",
                 col_types = c("numeric",
                               "date", "date", "numeric", "numeric",
                               "numeric", "numeric", "numeric", "numeric",
                              "numeric", "numeric", "numeric", "numeric"))
clima <- read_excel("C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\clima_field.xlsx",
                    col_types = c("date",
                                  "numeric", "numeric", "numeric", "numeric",
                                   "numeric", "numeric", "numeric"))

#pathsFEDE
# setwd("/home/fbartu/Research/Laura_Blanco/Chapter-Survival/PrimerCap/")
# df <- read_excel("datos_field.xlsx",
#                  col_types = c("numeric",
#                                "date", "date", "numeric", "numeric",
#                                "numeric", "numeric", "numeric", "numeric",
#                               "numeric", "numeric", "numeric", "numeric"))
# clima <- read_excel("clima_field.xlsx",
#                     col_types = c("date",
#                                   "numeric", "numeric", "numeric", "numeric",
#                                    "numeric", "numeric", "numeric"))

new_df <- df[0, ]
# this also works, mantaining object structure (data.frame) and column names

id <- seq_len(nrow(df)) # since there are duplicated ID, we iterate by row

df$start_date <- as.Date(df$start_date, format = '%Y-%m-%d')
```

```
df$start_date <- as.Date(df$start_date, format = '%Y-%m-%d')
clima$start_date <- as.character(as.Date(clima$start_date, format = '%Y-%m-%d'))

new_df <- do.call('rbind', lapply(seq_len(nrow(df)), function(id){
  tmp <- do.call('rbind', replicate(df$total_lived[id],
                                    df[id, ], simplify = FALSE))
  tmp$start_date <- format(seq(tmp$start_date[1], by = 'day',
                               length.out = nrow(tmp)), '%Y-%m-%d')
  tmp
}))

vars <- c('maxtemperature', 'meantemperature',
          'mintemperature', 'maxrh', 'minrh', 'meanrh')
for(d in unique(clima$start_date)){
  new_df[new_df$start_date == d & new_df$location == 1, vars] <-
    clima[clima$start_date == d & clima$location == 1, vars]
  new_df[new_df$start_date == d & new_df$location == 2, vars] <-
    clima[clima$start_date == d & clima$location == 2, vars]
}
```

Adding photoperiod

```
#we add photoperiod
library(meteor)
photoperiod <- photoperiod(152:337,  41.6833)
photoperiod <- as.data.frame(photoperiod)
values = seq(from = as.Date("2021-06-01"), to = as.Date("2021-12-03"),
             by = 'day')
photoperiod$dates <- values
photoperiod$dates <- as.character(as.Date(photoperiod$dates,
                                          format = '%Y-%m-%d'))


new_df$start_date <- as.character(as.Date(new_df$start_date,
                                          format = '%Y-%m-%d'))

str(photoperiod)
```

```
## 'data.frame':    186 obs. of  2 variables:
##  $ photoperiod: num  15 15 15 15 15.1 ...
##  $ dates      : chr  "2021-06-01" "2021-06-02" "2021-06-03" "2021-06-04" ...
```

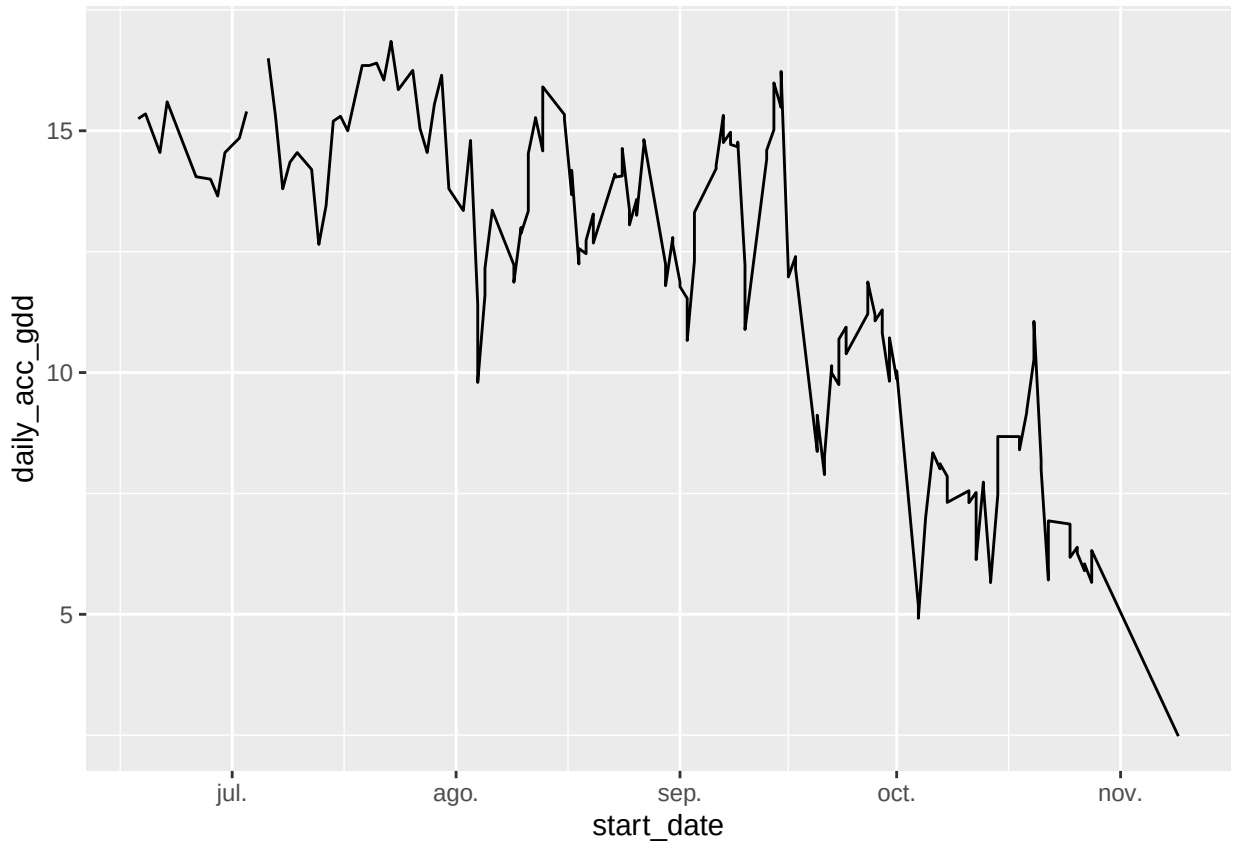
```
new_df[ , 'photoperiod'] <- 0 # new column called photoperiod
vars2 <- c('photoperiod')
for(d in unique(photoperiod$dates)){
  new_df[new_df$start_date == d,vars2] <-
    photoperiod[photoperiod$dates == d, vars2]
}


new_df$`hl/bg` <- factor(new_df$`hl/bg`,
```

```
                          levels = c("1", "2"),
                          labels = c("HB", "BG"))
new_df$location <- factor(new_df$location,
                          levels = c("1", "2"),
                          labels = c("Peri_Urban", "Urban"))
```

Other weather parameters: GDD and MWI

Growing degree days

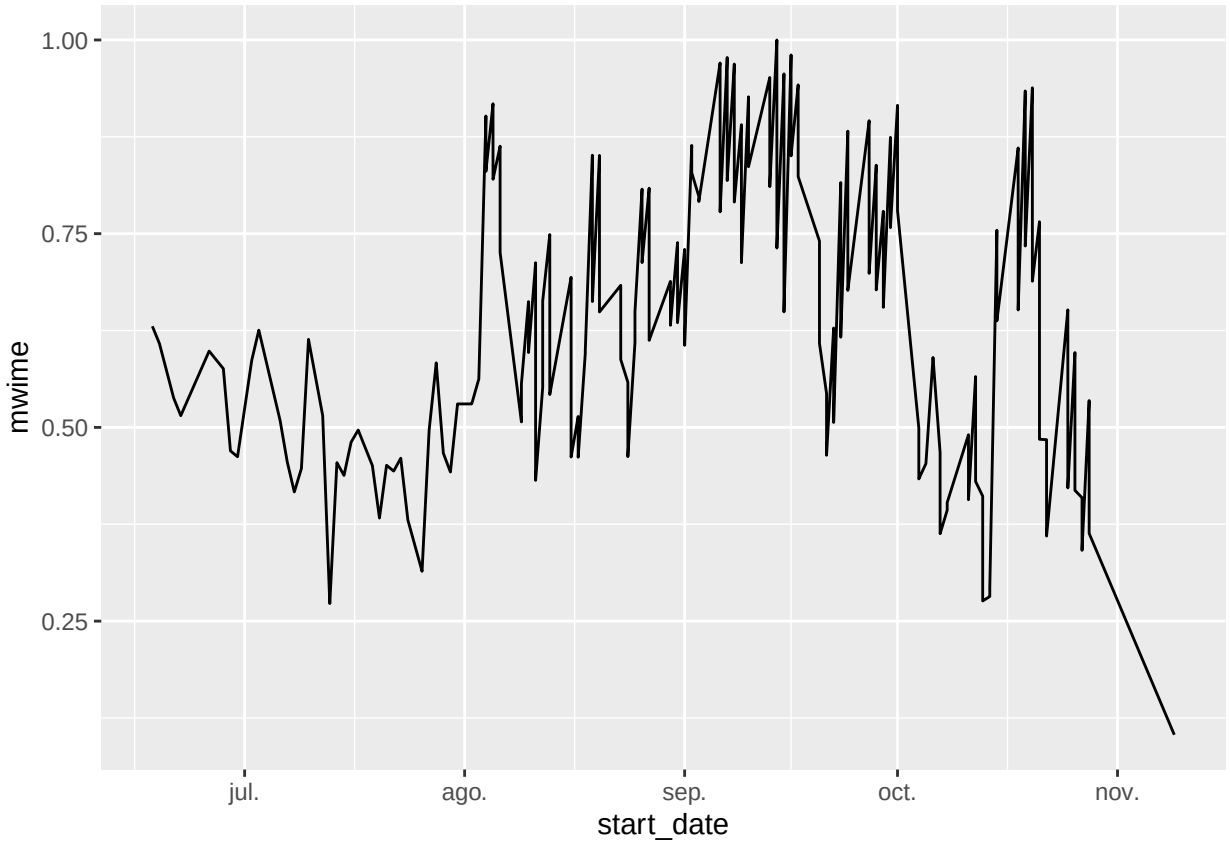
```
#library(scales) not needed because there are other packages we use that import this package
library(pollen)
new_df_gdd <- new_df %>%
  mutate(gdd = gdd(tmax = maxtemperature, tmin = mintemperature, tbase = 10,
                   tbase_max = 30)) %>%
  mutate(daily_acc_gdd = c(NA, diff(gdd)))

ddfield <- datos_field %>%
  mutate(gdd = gdd(tmax = maxtemperature, tmin = mintemperature, tbase = 10,
                   tbase_max = 30)) %>%
  mutate(daily_acc_gdd = c(NA, diff(gdd)))

ddfield <- ddfield  %>%
  rename(method = 'hl/bg')

gdd <-ggplot(aes(x =start_date, y= daily_acc_gdd), data = ddfield) + geom_line()
gdd
```



MWImean

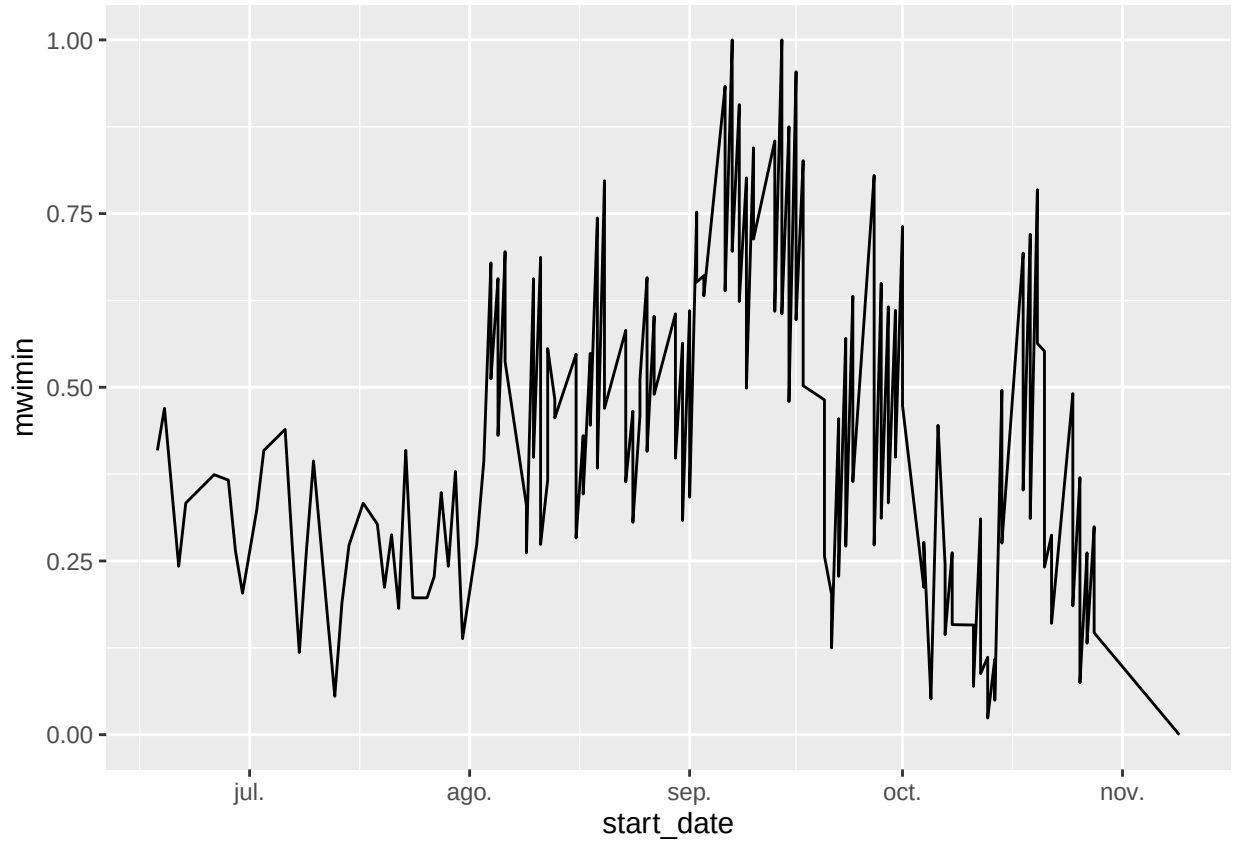
```
# michaelakis mwi
# mwi = function(Hum, Temp) {
#  FH = case_when(Hum < 40~0, Hum >95~0, (Hum >=40 & Hum <= 95)~
#                   ((Hum/55)-(40/55)) )
#   FT = case_when(Temp<=15~0, Temp>30~0, (Temp>15 & Temp <=20)~
#                    (.2*Temp)-3, (Temp>20 & Temp<=25)~1, (Temp>25 & Temp <= 30)~
#                    (-.2*6)+6)
#   return(FH*FT)
# }

#new mwi
mwi = function(Hum, Temp) {
 FH = case_when(Hum < 34~0, (Hum >=34 & Hum <= 100)~
                  ((Hum/66)-(34/66)) )
  FT = case_when(Temp<10~0, Temp>35~0, (Temp>=10 & Temp <=20)~
                   (.1*Temp)-1, (Temp>20 & Temp<=25)~1, (Temp>25 & Temp <= 35)~
                   (-.1*Temp)+3.5)
  return(FH*FT)
}

##MEAN MWI
new_df_gdd= new_df_gdd %>% mutate(
```

```
  FHme = case_when(meanrh < 34~0, (meanrh >=34 & meanrh <= 100)~
                   ((meanrh/66)-(34/66)) ),
  FTme = case_when(meantemperature<10~0, meantemperature>35~0, (meantemperature>=10 & meantemperature <=
  mwime = FHme*FTme)

ddfield= ddfield %>% mutate(
  FHme = case_when(meanrh < 34~0, (meanrh >=34 & meanrh <= 100)~
                   ((meanrh/66)-(34/66)) ),
  FTme = case_when(meantemperature<10~0, meantemperature>35~0, (meantemperature>=10 & meantemperature <=
  mwime = FHme*FTme)

mwiplot <-ggplot(aes(x =start_date, y= mwime), data = ddfield) + geom_line()
mwiplot
```

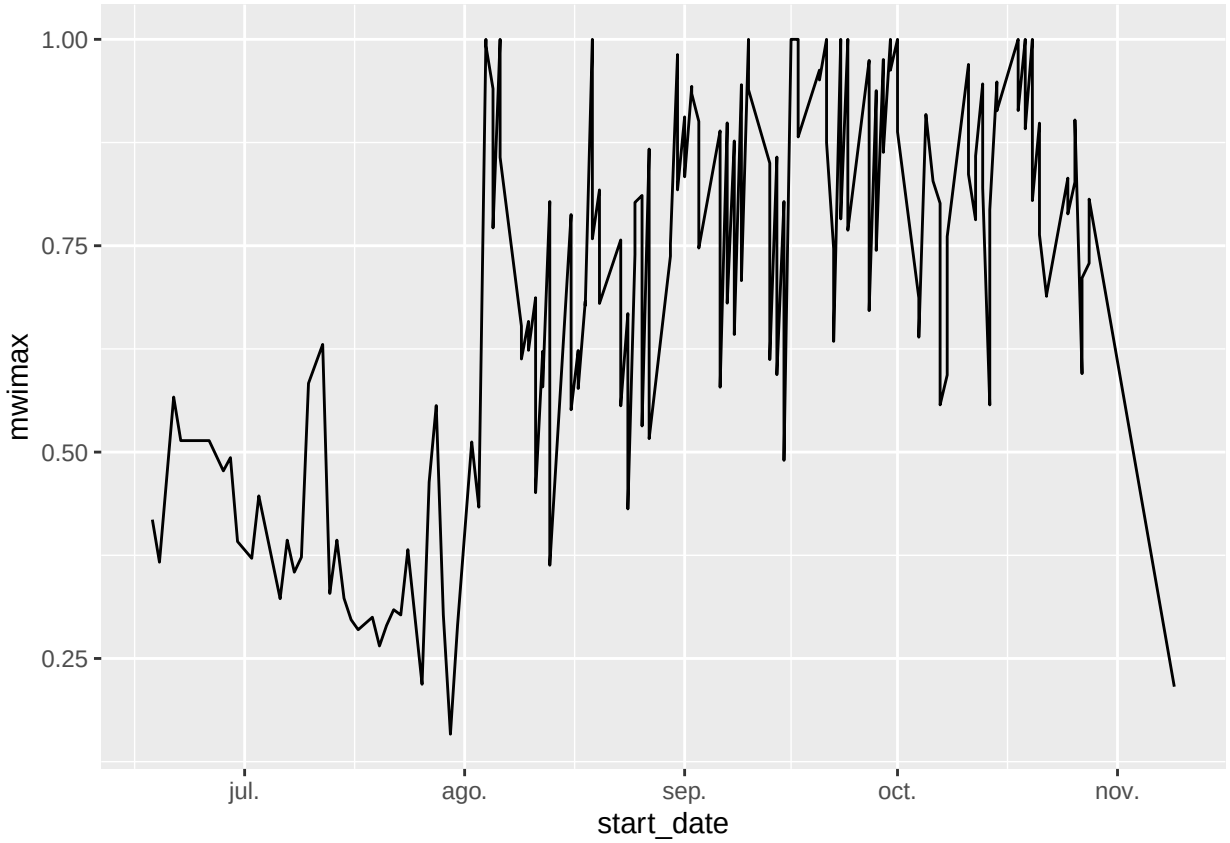



```
##MIN MWI
new_df_gdd= new_df_gdd %>% mutate(
  FHmin = case_when(minrh < 34~0, (minrh >=34 & minrh <= 100)~
                   ((minrh/66)-(34/66)) ),
  FTmin = case_when(mintemperature<10~0, mintemperature>35~0, (mintemperature>=10 & mintemperature <=20
  mwimin = FHmin*FTmin)

ddfield= ddfield %>% mutate(
  FHmin = case_when(minrh < 34~0, (minrh >=34 & minrh <= 100)~
                   ((minrh/66)-(34/66)) ),
  FTmin = case_when(mintemperature<10~0, mintemperature>35~0, (mintemperature>=10 & mintemperature <=20
```

```
  mwimin = FHmin*FTmin)
mwiminplot <-ggplot(aes(x =start_date, y= mwimin), data = ddfield) + geom_line()
mwiminplot
```




```
##MAX MWI
new_df_gdd= new_df_gdd %>% mutate(
  FHmax = case_when(maxrh < 34~0, (maxrh >=34 & maxrh <= 100)~
                    ((maxrh/66)-(34/66)) ),
  FTmax = case_when(maxtemperature<10~0, maxtemperature>35~0, (maxtemperature>=10 & maxtemperature <=20
  mwimax = FHmax*FTmax)

ddfield= ddfield %>% mutate(
  FHmax = case_when(maxrh < 34~0, (maxrh >=34 & maxrh <= 100)~
                    ((maxrh/66)-(34/66)) ),
  FTmax = case_when(maxtemperature<10~0, maxtemperature>35~0, (maxtemperature>=10 & maxtemperature <=20
  mwimax = FHmax*FTmax)
mwimaxplot <-ggplot(aes(x =start_date, y= mwimax), data = ddfield) + geom_line()
mwimaxplot
```



3.Cox-Regression models

1. No random effects
2. Random effects; level 1 (method) + level 2 (location);
    - Separated: (1|method) + (1|location)
    - Together: (1|location/method), to check the effect of the method of capture within location

Temperature

Models with minimum temperatures

```
new_df_gdd <- new_df_gdd  %>%
  rename(method = 'hl/bg')
#writexl::write_xlsx(new_df_gdd, "C:\\Users\\lblan\\OneDrive\\Escritorio\\CEAB\\2022\\First_chapter\\da
library(coxme)
```

```
# No random effect
cox_mint<- coxph(Surv(total_lived, censored) ~ mintemperature, data= new_df_gdd)

summary(cox_mint)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mintemperature,
##     data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##                     coef exp(coef) se(coef)     z Pr(>|z|)
## mintemperature 0.030025  1.030481 0.002078 14.45   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## mintemperature      1.03     0.9704     1.026     1.035
##
## Concordance= 0.538  (se = 0.003 )
## Likelihood ratio test= 214.8  on 1 df,   p=<2e-16
## Wald test            = 208.7  on 1 df,   p=<2e-16
## Score (logrank) test = 209  on 1 df,   p=<2e-16
```

```
cox.zph(cox_mint)
```

```
##                chisq df      p
## mintemperature  9.63  1 0.0019
## GLOBAL          9.63  1 0.0019
```

```
#Random effect - separated
coxme_mint_s<- coxme(Surv(total_lived, censored) ~ mintemperature +
                   (1|location) + (1|method), data= new_df_gdd)
summary(coxme_mint_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125046.8 -125040.8
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 515.23 3.00 0 509.23 486.47
##  Penalized loglik 527.19 2.98 0 521.22 498.58
##
## Model:  Surv(total_lived, censored) ~ mintemperature + (1 | location) +      (1 | method)
## Fixed coefficients
##                      coef exp(coef)   se(coef)     z p
## mintemperature 0.02387999  1.024167 0.00217684 10.97 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.11984332 0.01436242
##  method   Intercept 0.19470477 0.03790995
```

```
exp(confint(coxme_mint_s))
```

```
##                   2.5 %   97.5 %
## mintemperature 1.019807 1.028546
```

```
#Random effect - together
coxme_mint_t<- coxme(Surv(total_lived, censored) ~ mintemperature +
                  (1|location/method), data= new_df_gdd)
exp(confint(coxme_mint_t))
```

```
##                   2.5 %   97.5 %
## mintemperature 1.019723 1.028469
```

```
summary(coxme_mint_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 16 67
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125047.3 -125038.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 514.21 3.00 0 508.21 485.46
##  Penalized loglik 531.13 3.97 0 523.19 493.09
##
## Model:  Surv(total_lived, censored) ~ mintemperature + (1 | location/method)
## Fixed coefficients
##                       coef exp(coef)    se(coef)     z p
## mintemperature 0.02380119  1.024087 0.002178638 10.92 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1849459790 0.0342050152
##  location        (Intercept) 0.0198709809 0.0003948559
```

Models with mean temperatures

```
# No random effect
cox_meant<- coxph(Surv(total_lived, censored) ~ meantemperature,
                  data= new_df_gdd)

summary(cox_meant)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ meantemperature,
##     data = new_df_gdd)
##
##   n= 15155, number of events= 14542
```

```
##
##                     coef exp(coef) se(coef)     z Pr(>|z|)
## meantemperature 0.035534  1.036173 0.002192 16.21   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                 exp(coef) exp(-coef) lower .95 upper .95
## meantemperature     1.036     0.9651     1.032     1.041
##
## Concordance= 0.547  (se = 0.003 )
## Likelihood ratio test= 271.4  on 1 df,   p=<2e-16
## Wald test            = 262.8  on 1 df,   p=<2e-16
## Score (logrank) test = 263.4  on 1 df,   p=<2e-16
```

```
#Random effect - separated
coxme_meant_s<- coxme(Surv(total_lived, censored) ~ meantemperature +
                  (1|location) + (1|method), data= new_df_gdd)
summary(coxme_meant_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 18 75
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125004.6 -124998.5
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 599.73 3.00 0 593.73 570.98
##  Penalized loglik 611.91 2.99 0 605.94 583.28
##
## Model:  Surv(total_lived, censored) ~ meantemperature + (1 | location) +      (1 | method)
## Fixed coefficients
##                       coef exp(coef)    se(coef)    z p
## meantemperature 0.03151728  1.032019 0.002218942 14.2 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.13288329 0.01765797
##  method   Intercept 0.19425609 0.03773543
```

```
exp(confint(coxme_meant_s))
```

```
##                    2.5 %   97.5 %
## meantemperature 1.027541 1.036517
```

```
#Random effect - together
coxme_meant_t<- coxme(Surv(total_lived, censored) ~ meantemperature +
                  (1|location/method), data= new_df_gdd)
exp(confint(coxme_meant_t))
```

```
##                    2.5 %   97.5 %
## meantemperature 1.027488 1.036472
```

```
summary(coxme_meant_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 17 71
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125005.1 -124996.6
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 598.65 3.00 0 592.65 569.89
##  Penalized loglik 615.73 3.97 0 607.79 577.67
##
## Model:  Surv(total_lived, censored) ~ meantemperature + (1 | location/method)
## Fixed coefficients
##                       coef exp(coef)   se(coef)     z p
## meantemperature 0.0314699   1.03197 0.00222067 14.17 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1898531057 0.0360442017
##  location        (Intercept) 0.0199107424 0.0003964377
```

Models with maximum temperatures

```
# No random effect
cox_maxt<- coxph(Surv(total_lived, censored) ~ maxtemperature,
                 data= new_df_gdd)

summary(cox_maxt)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ maxtemperature,
##     data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##                     coef exp(coef) se(coef)    z Pr(>|z|)
## maxtemperature 0.033117  1.033672 0.002136 15.5   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## maxtemperature     1.034     0.9674     1.029     1.038
##
## Concordance= 0.541  (se = 0.003 )
## Likelihood ratio test= 245.8  on 1 df,   p=<2e-16
## Wald test            = 240.3  on 1 df,   p=<2e-16
## Score (logrank) test = 240.6  on 1 df,   p=<2e-16
```

```r
#Random effect - separated
coxme_maxt_s<- coxme(Surv(total_lived, censored) ~ maxtemperature +
                   (1|location) + (1|method), data= new_df_gdd)
summary(coxme_maxt_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -124979.1 -124972.8
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 650.65 3.00 0 644.65 621.89
##  Penalized loglik 663.31 2.99 0 657.33 634.64
##
## Model:  Surv(total_lived, censored) ~ maxtemperature + (1 | location) +      (1 | method)
## Fixed coefficients
##                      coef exp(coef)    se(coef)     z p
## maxtemperature 0.0340556  1.034642 0.002145233 15.88 0
##
## Random effects
##  Group    Variable  Std Dev   Variance
##  location Intercept 0.1729280 0.0299041
##  method   Intercept 0.1950528 0.0380456
```

```r
exp(confint(coxme_maxt_s))
```

```
##                   2.5 %   97.5 %
## maxtemperature 1.030301 1.039002
```

```r
#Random effect - together
coxme_maxt_t<- coxme(Surv(total_lived, censored) ~ maxtemperature +
                   (1|location/method), data= new_df_gdd)

summary(coxme_maxt_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 8 35
##                     NULL Integrated  Fitted
## Log-likelihood -125304.4  -124979.8 -124971
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 649.24 3.00 0 643.24 620.48
##  Penalized loglik 666.81 3.97 0 658.86 628.71
##
## Model:  Surv(total_lived, censored) ~ maxtemperature + (1 | location/method)
## Fixed coefficients
##                       coef exp(coef)    se(coef)     z p
## maxtemperature 0.03400195  1.034587 0.002146769 15.84 0
```

```
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2057477731 0.0423321461
##  location        (Intercept) 0.0200121633 0.0004004867
```

```
exp(confint(coxme_maxt_t))
```

```
##                   2.5 %   97.5 %
## maxtemperature 1.030243 1.038949
```

MWI (Mosquito Weather Index)

```
# No random effect
cox_mwimin<- coxph(Surv(total_lived, censored) ~ mwimin,
                   data= new_df_gdd)

summary(cox_mwimin)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mwimin, data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##           coef exp(coef) se(coef)     z Pr(>|z|)
## mwimin 0.15475   1.16737  0.03196 4.843 1.28e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## mwimin     1.167     0.8566     1.096     1.243
##
## Concordance= 0.508  (se = 0.003 )
## Likelihood ratio test= 23.39  on 1 df,   p=1e-06
## Wald test            = 23.45  on 1 df,   p=1e-06
## Score (logrank) test = 23.46  on 1 df,   p=1e-06
```

```
#Random effect - separated
coxme_mwimin_s<- coxme(Surv(total_lived, censored) ~ mwimin +
                   (1|location) + (1|method), data= new_df_gdd)
summary(coxme_mwimin_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125107.1 -125100.8
##
##                   Chisq   df p    AIC    BIC
```

```
## Integrated loglik 394.58 3.00 0 388.58 365.83
##  Penalized loglik 407.28 2.99 0 401.30 378.62
##
## Model:  Surv(total_lived, censored) ~ mwimin + (1 | location) + (1 |      method)
## Fixed coefficients
##               coef exp(coef)   se(coef)     z    p
## mwimin -0.04933129 0.9518657 0.03561648 -1.39 0.17
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.17513375 0.03067183
##  method   Intercept 0.19618926 0.03849022
```

```
exp(confint(coxme_mwimin_s))
```

```
##           2.5 %   97.5 %
## mwimin 0.887685 1.020687
```

```
#Random effect - together
coxme_mwimin_t<- coxme(Surv(total_lived, censored) ~ mwimin +
                   (1|location/method), data= new_df_gdd)
exp(confint(coxme_mwimin_t))
```

```
##            2.5 %   97.5 %
## mwimin 0.8856942 1.018462
```

```
summary(coxme_mwimin_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125107.1 -125098.3
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 394.61 3.00 0 388.61 365.85
##  Penalized loglik 412.23 3.97 0 404.29 374.14
##
## Model:  Surv(total_lived, censored) ~ mwimin + (1 | location/method)
## Fixed coefficients
##               coef exp(coef)   se(coef)     z    p
## mwimin -0.0515448 0.9497611 0.03563267 -1.45 0.15
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2075090473 0.0430600047
##  location        (Intercept) 0.0200091744 0.0004003671
```

MWIMEAN

```r
#no random effect
cox_mwimean<- coxph(Surv(total_lived, censored) ~ mwime,
                  data= new_df_gdd)

summary(cox_mwimean)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mwime, data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##          coef exp(coef) se(coef)     z Pr(>|z|)
## mwime 0.10816   1.11422  0.03601 3.004  0.00267 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##       exp(coef) exp(-coef) lower .95 upper .95
## mwime     1.114     0.8975     1.038     1.196
##
## Concordance= 0.497  (se = 0.003 )
## Likelihood ratio test= 9.07  on 1 df,   p=0.003
## Wald test            = 9.02  on 1 df,   p=0.003
## Score (logrank) test = 9.02  on 1 df,   p=0.003
```

```r
# Random effect separated
coxme_mwimean_s<- coxme(Surv(total_lived, censored) ~ mwime +
                   (1|location) + (1|method), data= new_df_gdd)
exp(confint(coxme_mwimean_s))
```

```
##           2.5 %   97.5 %
## mwime 0.8843852 1.024973
```

```r
summary(coxme_mwimean_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125107.3 -125100.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 394.36 3.00 0 388.36 365.61
##  Penalized loglik 407.02 2.99 0 401.04 378.37
##
## Model:  Surv(total_lived, censored) ~ mwime + (1 | location) + (1 | method)
## Fixed coefficients
##               coef exp(coef)   se(coef)    z    p
## mwime -0.04909832 0.9520875 0.03763551 -1.3 0.19
##
## Random effects
```

```
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.17211501 0.02962358
##  method   Intercept 0.19607171 0.03844412
```

```
coxme_mwimean_t<- coxme(Surv(total_lived, censored) ~ mwime +
                   (1|location/method), data= new_df_gdd)
exp(confint(coxme_mwimean_t))
```

```
##           2.5 %   97.5 %
## mwime 0.8802006 1.020401
```

```
summary(coxme_mwimean_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125107.2 -125098.4
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 394.54 3.00 0 388.54 365.78
##  Penalized loglik 412.12 3.97 0 404.17 374.03
##
## Model:  Surv(total_lived, censored) ~ mwime + (1 | location/method)
## Fixed coefficients
##              coef exp(coef) se(coef)     z    p
## mwime -0.05370504 0.9477116 0.037705 -1.42 0.15
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2059771551 0.0424265884
##  location        (Intercept) 0.0200031667 0.0004001267
```

MWIMAX

```
#no random effect
cox_mwimax<- coxph(Surv(total_lived, censored) ~ mwimax,
                   data= new_df_gdd)

summary(cox_mwimax)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mwimax, data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##            coef exp(coef) se(coef)      z Pr(>|z|)
## mwimax -0.36363   0.69515  0.03967 -9.167   <2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## mwimax    0.6951      1.439    0.6432    0.7514
##
## Concordance= 0.52  (se = 0.003 )
## Likelihood ratio test= 82.37  on 1 df,   p=<2e-16
## Wald test            = 84.03  on 1 df,   p=<2e-16
## Score (logrank) test = 84.11  on 1 df,   p=<2e-16
```

```
# Random effect separated
coxme_mwimax_s<- coxme(Surv(total_lived, censored) ~ mwimax +
                  (1|location) + (1|method), data= new_df_gdd)
exp(confint(coxme_mwimax_s))
```

```
##            2.5 %    97.5 %
## mwimax 0.5626578 0.6583775
```

```
summary(coxme_mwimax_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125033.7 -125027.3
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 541.39 3.00 0 535.39 512.64
##  Penalized loglik 554.35 2.99 0 548.37 525.68
##
## Model:  Surv(total_lived, censored) ~ mwimax + (1 | location) + (1 |      method)
## Fixed coefficients
##              coef exp(coef)   se(coef)      z p
## mwimax -0.4965303 0.6086388 0.04007903 -12.39 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.20212058 0.04085273
##  method   Intercept 0.19075845 0.03638879
```

```
coxme_mwimax_t<- coxme(Surv(total_lived, censored) ~ mwimax +
                  (1|location/method), data= new_df_gdd)
exp(confint(coxme_mwimax_t))
```

```
##           2.5 %    97.5 %
## mwimax 0.557105 0.6522028
```

```
summary(coxme_mwimax_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
```

```
##   Data: new_df_gdd
##   events, n = 14542, 15155
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125304.4  -125031.4 -125022.4
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 546.14 3.00 0 540.14 517.39
##  Penalized loglik 564.09 3.98 0 556.14 525.97
##
## Model:  Surv(total_lived, censored) ~ mwimax + (1 | location/method)
## Fixed coefficients
##              coef exp(coef)   se(coef)      z p
## mwimax -0.5062006 0.6027814 0.04020526 -12.59 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2189776149 0.0479511958
##  location        (Intercept) 0.0200557823 0.0004022344
```

GDD (Growing Degree Days)

```
# No random effect
cox_gdd<- coxph(Surv(total_lived, censored) ~ daily_acc_gdd,
                 data= new_df_gdd)

summary(cox_gdd)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ daily_acc_gdd,
##     data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##    (1 observation deleted due to missingness)
##
##                   coef exp(coef) se(coef)     z Pr(>|z|)
## daily_acc_gdd 0.035024  1.035645 0.002301 15.22   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##               exp(coef) exp(-coef) lower .95 upper .95
## daily_acc_gdd     1.036     0.9656     1.031      1.04
##
## Concordance= 0.544  (se = 0.003 )
## Likelihood ratio test= 238  on 1 df,   p=<2e-16
## Wald test            = 231.7  on 1 df,   p=<2e-16
## Score (logrank) test = 232.3  on 1 df,   p=<2e-16
```

```
#Random effect - separated
coxme_gdd_s<- coxme(Surv(total_lived, censored) ~ daily_acc_gdd +
                   (1|location) + (1|method), data= new_df_gdd)
exp(confint(coxme_gdd_s))
```

```
##                   2.5 %   97.5 %
## daily_acc_gdd 1.027066 1.036461
```

```
summary(coxme_gdd_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154 (1 observation deleted due to missingness)
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8    -125006 -124999.8
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 577.75 3.00 0 571.75 548.99
##  Penalized loglik 590.01 2.99 0 584.04 561.38
##
## Model:  Surv(total_lived, censored) ~ daily_acc_gdd + (1 | location) +      (1 | method)
## Fixed coefficients
##                      coef exp(coef)    se(coef)     z p
## daily_acc_gdd 0.03125914  1.031753 0.002322962 13.46 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.13839373 0.01915282
##  method   Intercept 0.19408685 0.03766971
```

```
#Random effect - together
coxme_gdd_t<- coxme(Surv(total_lived, censored) ~ daily_acc_gdd +
                  (1|location/method), data= new_df_gdd)

exp(confint(coxme_gdd_t))
```

```
##                   2.5 %   97.5 %
## daily_acc_gdd 1.027004 1.036406
```

```
summary(coxme_gdd_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154 (1 observation deleted due to missingness)
##   Iterations= 16 67
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -125006.5 -124997.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 576.65 3.00 0 570.65 547.90
##  Penalized loglik 593.81 3.97 0 585.87 555.75
##
## Model:  Surv(total_lived, censored) ~ daily_acc_gdd + (1 | location/method)
## Fixed coefficients
##                      coef exp(coef)   se(coef)     z p
## daily_acc_gdd 0.03120251  1.031694 0.00232466 13.42 0
```

```
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1922513923 0.0369605978
##  location        (Intercept) 0.0199271829 0.0003970926
```

Checking all temperatures together

```
# No random effect
cox_temps<- coxph(Surv(total_lived, censored) ~ mintemperature + meantemperature
                  + maxtemperature + mwime + mwimin+ mwimax + daily_acc_gdd,
                  data= new_df_gdd)

summary(cox_temps)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mintemperature +
##     meantemperature + maxtemperature + mwime + mwimin + mwimax +
##     daily_acc_gdd, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##    (1 observation deleted due to missingness)
##
##                     coef exp(coef) se(coef)      z Pr(>|z|)
## mintemperature   0.03678   1.03747  0.02064  1.782   0.0748 .
## meantemperature  0.20250   1.22446  0.02501  8.096 5.68e-16 ***
## maxtemperature   0.04067   1.04150  0.02217  1.834   0.0666 .
## mwime           -0.77211   0.46204  0.17510 -4.409 1.04e-05 ***
## mwimin           0.33957   1.40434  0.12762  2.661   0.0078 **
## mwimax          -0.12434   0.88308  0.08663 -1.435   0.1512
## daily_acc_gdd   -0.24159   0.78538  0.03422 -7.059 1.67e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                 exp(coef) exp(-coef) lower .95 upper .95
## mintemperature     1.0375     0.9639    0.9963    1.0803
## meantemperature    1.2245     0.8167    1.1659    1.2860
## maxtemperature     1.0415     0.9602    0.9972    1.0878
## mwime              0.4620     2.1643    0.3278    0.6512
## mwimin             1.4043     0.7121    1.0936    1.8035
## mwimax             0.8831     1.1324    0.7452    1.0465
## daily_acc_gdd      0.7854     1.2733    0.7344    0.8399
##
## Concordance= 0.551  (se = 0.003 )
## Likelihood ratio test= 500.8  on 7 df,   p=<2e-16
## Wald test            = 517.6  on 7 df,   p=<2e-16
## Score (logrank) test = 514.7  on 7 df,   p=<2e-16
```

```
#Random effect - separated
coxme_temps_s<- coxme(Surv(total_lived, censored) ~ mintemperature + meantemperature
                  + maxtemperature + mwime + mwimin + mwimax + daily_acc_gdd +
```

```
                  (1|location) + (1|method), data= new_df_gdd)
summary(coxme_temps_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154 (1 observation deleted due to missingness)
##   Iterations= 8 43
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124853.2 -124846.7
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 883.27 9.00 0 865.27 797.01
##  Penalized loglik 896.29 8.99 0 878.31 810.13
##
## Model:  Surv(total_lived, censored) ~ mintemperature + meantemperature +      maxtemperature + mwime
## Fixed coefficients
##                         coef exp(coef)   se(coef)     z       p
## mintemperature   0.02308186 1.0233503 0.02005981  1.15 2.5e-01
## meantemperature  0.11835726 1.1256462 0.02590830  4.57 4.9e-06
## maxtemperature   0.06081066 1.0626977 0.02160386  2.81 4.9e-03
## mwime           -0.32164753 0.7249537 0.17652421 -1.82 6.8e-02
## mwimin          -0.07078805 0.9316593 0.12961233 -0.55 5.8e-01
## mwimax          -0.25097048 0.7780453 0.08687792 -2.89 3.9e-03
## daily_acc_gdd   -0.16516778 0.8477515 0.03299941 -5.01 5.6e-07
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.21056245 0.04433654
##  method   Intercept 0.18892487 0.03569261
```

```
#Random effect - together
coxme_temps_t<- coxme(Surv(total_lived, censored) ~ mintemperature +
                        meantemperature
                    + maxtemperature + mwime + mwimin + mwimax + daily_acc_gdd +
                     (1|location/method), data= new_df_gdd)

summary(coxme_temps_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154 (1 observation deleted due to missingness)
##   Iterations= 7 38
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124852.1 -124843.1
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 885.45 9.00 0 867.45 799.18
##  Penalized loglik 903.49 9.97 0 883.54 807.89
##
## Model:  Surv(total_lived, censored) ~ mintemperature + meantemperature +      maxtemperature + mwime
## Fixed coefficients
##                         coef exp(coef)   se(coef)     z       p
```

```
## mintemperature   0.02145837 1.0216903 0.02007082  1.07 2.9e-01
## meantemperature  0.12124789 1.1289047 0.02592254  4.68 2.9e-06
## maxtemperature   0.05862912 1.0603819 0.02162114  2.71 6.7e-03
## mwime           -0.32864539 0.7198983 0.17653750 -1.86 6.3e-02
## mwimin          -0.06530512 0.9367816 0.12960672 -0.50 6.1e-01
## mwimax          -0.25669403 0.7736049 0.08693334 -2.95 3.1e-03
## daily_acc_gdd   -0.16428380 0.8485012 0.03300654 -4.98 6.4e-07
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2222171639 0.0493804679
##  location        (Intercept) 0.0200836385 0.0004033525
```

Checking collinearity in the 3 cases

```
library(rms)
#No random effects
rms::vif(cox_temps)
```

```
##  mintemperature meantemperature  maxtemperature           mwime          mwimin
##       99.953295      138.406415      117.589049       22.074879       15.154853
##          mwimax   daily_acc_gdd
##        4.668785      235.088052
```

```
#daily_acc_gdd has a lot of collinearity so we should remove it and do it again
cox_temps2 <- coxph(Surv(total_lived, censored) ~ mintemperature + meantemperature
                  + maxtemperature + mwimin + mwime + mwimax,
                  data= new_df_gdd)

summary(cox_temps2)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mintemperature +
##     meantemperature + maxtemperature + mwimin + mwime + mwimax,
##     data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##                     coef exp(coef)  se(coef)      z Pr(>|z|)
## mintemperature  -0.071338  0.931147  0.013372 -5.335 9.56e-08 ***
## meantemperature  0.207875  1.231059  0.024876  8.356  < 2e-16 ***
## maxtemperature  -0.087801  0.915943  0.012961 -6.774 1.25e-11 ***
## mwimin          -0.006616  0.993405  0.117417 -0.056   0.9551
## mwime           -0.428464  0.651509  0.167806 -2.553   0.0107 *
## mwimax          -0.192705  0.824726  0.086207 -2.235   0.0254 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                 exp(coef) exp(-coef) lower .95 upper .95
## mintemperature     0.9311     1.0739    0.9071    0.9559
## meantemperature    1.2311     0.8123    1.1725    1.2926
```

```
## maxtemperature     0.9159     1.0918    0.8930    0.9395
## mwimin             0.9934     1.0066    0.7892    1.2505
## mwime              0.6515     1.5349    0.4689    0.9052
## mwimax             0.8247     1.2125    0.6965    0.9765
##
## Concordance= 0.549  (se = 0.003 )
## Likelihood ratio test= 449.1  on 6 df,   p=<2e-16
## Wald test            = 461.1  on 6 df,   p=<2e-16
## Score (logrank) test = 464.1  on 6 df,   p=<2e-16
```

```
rms::vif(cox_temps2)
```

```
##  mintemperature meantemperature  maxtemperature          mwimin           mwime
##       43.345265      138.825322       39.865540       12.780076       20.557889
##          mwimax
##        4.560266
```

```
#mean temperature is the next variable with higher VIF, we remove it and repeat
cox_temps3 <- coxph(Surv(total_lived, censored) ~ mintemperature
                 + maxtemperature + mwimin + mwime + mwimax,
                 data= new_df_gdd)
summary(cox_temps3)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mintemperature +
##     maxtemperature + mwimin + mwime + mwimax, data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##                     coef exp(coef)  se(coef)      z Pr(>|z|)
## mintemperature  0.031479  1.031980  0.005356  5.878 4.16e-09 ***
## maxtemperature  0.011943  1.012014  0.005055  2.362   0.0182 *
## mwimin         -0.068694  0.933612  0.117439 -0.585   0.5586
## mwime          -0.134181  0.874432  0.164467 -0.816   0.4146
## mwimax         -0.341856  0.710451  0.084608 -4.040 5.33e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## mintemperature    1.0320     0.9690    1.0212    1.0429
## maxtemperature    1.0120     0.9881    1.0020    1.0221
## mwimin            0.9336     1.0711    0.7417    1.1753
## mwime             0.8744     1.1436    0.6335    1.2070
## mwimax            0.7105     1.4076    0.6019    0.8386
##
## Concordance= 0.543  (se = 0.003 )
## Likelihood ratio test= 379.3  on 5 df,   p=<2e-16
## Wald test            = 391.4  on 5 df,   p=<2e-16
## Score (logrank) test = 393.7  on 5 df,   p=<2e-16
```

```
#mean MWI high VIF
cox_temps4 <- coxph(Surv(total_lived, censored) ~ mintemperature
```

```
                + maxtemperature + mwimin + mwimax,
                data= new_df_gdd)
summary(cox_temps4)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mintemperature +
##     maxtemperature + mwimin + mwimax, data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##                     coef exp(coef)  se(coef)      z Pr(>|z|)
## mintemperature  0.032606  1.033143  0.005185  6.289 3.20e-10 ***
## maxtemperature  0.009268  1.009311  0.003847  2.410   0.0160 *
## mwimin         -0.149294  0.861316  0.063680 -2.344   0.0191 *
## mwimax         -0.397136  0.672242  0.050623 -7.845 4.33e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## mintemperature    1.0331     0.9679    1.0227    1.0437
## maxtemperature    1.0093     0.9908    1.0017    1.0169
## mwimin            0.8613     1.1610    0.7603    0.9758
## mwimax            0.6722     1.4876    0.6087    0.7424
##
## Concordance= 0.544  (se = 0.003 )
## Likelihood ratio test= 378.6  on 4 df,   p=<2e-16
## Wald test            = 390.2  on 4 df,   p=<2e-16
## Score (logrank) test = 392.4  on 4 df,   p=<2e-16
```

```
rms::vif(cox_temps4)
```

```
## mintemperature maxtemperature         mwimin         mwimax
##       6.472754       3.504940       3.747708       1.573929
```

```
#mintemperature with high VIF
cox_temps5 <- coxph(Surv(total_lived, censored) ~ maxtemperature + mwimin + mwimax,
                data= new_df_gdd)
summary(cox_temps5)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ maxtemperature +
##     mwimin + mwimax, data = new_df_gdd)
##
##   n= 15155, number of events= 14542
##
##                     coef exp(coef)  se(coef)      z Pr(>|z|)
## maxtemperature  0.027922  1.028315  0.002437 11.457  < 2e-16 ***
## mwimin          0.134724  1.144221  0.044796  3.008  0.00263 **
## mwimax         -0.459515  0.631590  0.049353 -9.311  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
##                exp(coef) exp(-coef) lower .95 upper .95
## maxtemperature    1.0283     0.9725    1.0234    1.0332
## mwimin            1.1442     0.8740    1.0480    1.2492
## mwimax            0.6316     1.5833    0.5734    0.6957
##
## Concordance= 0.539  (se = 0.003 )
## Likelihood ratio test= 339.1  on 3 df,   p=<2e-16
## Wald test            = 351.2  on 3 df,   p=<2e-16
## Score (logrank) test = 352.9  on 3 df,   p=<2e-16
```

```
stats::step(cox_temps5)
```

```
## Start:  AIC=250275.8
## Surv(total_lived, censored) ~ maxtemperature + mwimin + mwimax
##
##                  Df    AIC
## <none>              250276
## - mwimin          1 250283
## - mwimax          1 250359
## - maxtemperature  1 250408

## Call:
## coxph(formula = Surv(total_lived, censored) ~ maxtemperature +
##     mwimin + mwimax, data = new_df_gdd)
##
##                     coef exp(coef)  se(coef)      z       p
## maxtemperature  0.027922  1.028315  0.002437 11.457 < 2e-16
## mwimin          0.134724  1.144221  0.044796  3.008 0.00263
## mwimax         -0.459515  0.631590  0.049353 -9.311 < 2e-16
##
## Likelihood ratio test=339.1  on 3 df, p=< 2.2e-16
## n= 15155, number of events= 14542
```

```
#trying with GDD and removing maxtemperature
cox_temps6 <- coxph(Surv(total_lived, censored) ~ mwimin + daily_acc_gdd + mwimax,
                    data= new_df_gdd)
summary(cox_temps6)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ mwimin + daily_acc_gdd +
##     mwimax, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##    (1 observation deleted due to missingness)
##
##                     coef exp(coef)  se(coef)      z Pr(>|z|)
## mwimin         -0.034439  0.966147  0.053175 -0.648    0.517
## daily_acc_gdd  0.037517  1.038230  0.003136 11.963   <2e-16 ***
## mwimax         -0.412523  0.661978  0.050688 -8.138    4e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
##                exp(coef) exp(-coef) lower .95 upper .95
## mwimin           0.9661     1.0350    0.8705    1.0723
## daily_acc_gdd    1.0382     0.9632    1.0319    1.0446
## mwimax           0.6620     1.5106    0.5994    0.7311
##
## Concordance= 0.541  (se = 0.003 )
## Likelihood ratio test= 351  on 3 df,   p=<2e-16
## Wald test            = 361.5  on 3 df,   p=<2e-16
## Score (logrank) test = 363.5  on 3 df,   p=<2e-16
```

```
rms::vif(cox_temps6)
```

```
##        mwimin daily_acc_gdd        mwimax
##      2.636329      1.985769      1.581871
```

```
new_df_gdd <- new_df_gdd[-1,]
stats::step(cox_temps6)
```

```
## Start:  AIC=250244.7
## Surv(total_lived, censored) ~ mwimin + daily_acc_gdd + mwimax
##
##                 Df    AIC
## - mwimin         1 250243
## <none>             250245
## - mwimax         1 250308
## - daily_acc_gdd  1 250389
##
## Step:  AIC=250243.1
## Surv(total_lived, censored) ~ daily_acc_gdd + mwimax
##
##                 Df    AIC
## <none>             250243
## - mwimax         1 250354
## - daily_acc_gdd  1 250509

## Call:
## coxph(formula = Surv(total_lived, censored) ~ daily_acc_gdd +
##     mwimax, data = new_df_gdd)
##
##                    coef exp(coef)  se(coef)      z      p
## daily_acc_gdd  0.036089  1.036748  0.002227  16.21 <2e-16
## mwimax        -0.432405  0.648947  0.040322 -10.72 <2e-16
##
## Likelihood ratio test=350.5  on 2 df, p=< 2.2e-16
## n= 15154, number of events= 14541
```

```
#Random effects - Separated
rms::vif(coxme_temps_s)
```

```
##  mintemperature meantemperature  maxtemperature           mwime          mwimin
##        86.61080       146.14270       113.05445        20.72447        12.94793
##          mwimax   daily_acc_gdd
##         4.61171       215.08693
```

```
#daily_acc_gdd has a lot of collinearity so we should remove it and do it again
coxme_temps_s2<- coxme(Surv(total_lived, censored) ~ mintemperature + meantemperature
                  + maxtemperature + mwimin + mwime + mwimax +
                   (1|location) + (1|method), data= new_df_gdd)

summary(coxme_temps_s2)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124866.1 -124859.5
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 857.50 8.00 0 841.50 780.82
##  Penalized loglik 870.63 7.99 0 854.65 794.05
##
## Model:  Surv(total_lived, censored) ~ mintemperature + meantemperature +      maxtemperature + mwimi
## Fixed coefficients
##                        coef exp(coef)   se(coef)     z       p
## mintemperature  -0.04927604 0.9519183 0.01362037 -3.62 3.0e-04
## meantemperature  0.11700963 1.1241303 0.02582958  4.53 5.9e-06
## maxtemperature  -0.02340612 0.9768657 0.01377409 -1.70 8.9e-02
## mwimin          -0.33732817 0.7136746 0.11798888 -2.86 4.3e-03
## mwime           -0.05070172 0.9505622 0.16781807 -0.30 7.6e-01
## mwimax          -0.31306687 0.7312010 0.08609279 -3.64 2.8e-04
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.22210080 0.04932876
##  method   Intercept 0.18930856 0.03583773
```

```
rms::vif(coxme_temps_s2)
```

```
##  mintemperature meantemperature  maxtemperature          mwimin           mwime
##       40.852298      146.646438       45.701970       10.693778       18.906159
##          mwimax
##        4.471114
```

```
#mean temperature is the next variable with higher VIF, we remove it and repeat
coxme_temps_s3<- coxme(Surv(total_lived, censored) ~ mintemperature
                  + maxtemperature + mwimin + mwime + mwimax +
                   (1|location) + (1|method), data= new_df_gdd)
summary(coxme_temps_s3)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124876.3 -124869.7
```

```
##
##                    Chisq   df p   AIC    BIC
## Integrated loglik 837.00 7.00 0 823.0 769.91
##  Penalized loglik 850.28 6.99 0 836.3 783.27
##
## Model:  Surv(total_lived, censored) ~ mintemperature + maxtemperature +      mwimin + mwime + mwimax
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## mintemperature  0.007288342 1.0073150 0.005490153  1.33 1.8e-01
## maxtemperature  0.034430514 1.0350301 0.005180823  6.65 3.0e-11
## mwimin         -0.395617327 0.6732643 0.117345494 -3.37 7.5e-04
## mwime           0.122556571 1.1303831 0.163405134  0.75 4.5e-01
## mwimax         -0.399306075 0.6707854 0.083998559 -4.75 2.0e-06
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.23862719 0.05694293
##  method   Intercept 0.18922033 0.03580433
```

```
rms::vif(coxme_temps_s3)
```

```
## mintemperature maxtemperature         mwimin          mwime         mwimax
##       6.639131       6.460671      10.563422      17.934636       4.265675
```

```
#mean MWI is the next variable with higher VIF, we remove it and repeat
coxme_temps_s4<- coxme(Surv(total_lived, censored) ~ mintemperature
                  + maxtemperature + mwimin  + mwimax +
                   (1|location) + (1|method), data= new_df_gdd)
summary(coxme_temps_s4)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -124876.6 -124870
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 836.44 6.00 0 824.44 778.93
##  Penalized loglik 849.71 5.99 0 837.73 792.28
##
## Model:  Surv(total_lived, censored) ~ mintemperature + maxtemperature +      mwimin + mwimax + (1 | l
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## mintemperature  0.006364522 1.0063848 0.005341563  1.19 2.3e-01
## maxtemperature  0.036759028 1.0374430 0.004148089  8.86 0.0e+00
## mwimin         -0.321562555 0.7250153 0.063266979 -5.08 3.7e-07
## mwimax         -0.348828436 0.7055142 0.050300135 -6.93 4.1e-12
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.23777297 0.05653599
##  method   Intercept 0.18909680 0.03575760
```

```
rms::vif(coxme_temps_s4)
```

```
## mintemperature maxtemperature         mwimin         mwimax
##       6.297828       4.136924       3.074118       1.528740
```

```
#mintemperature is the next variable with higher VIF, we remove it and repeat
coxme_temps_s5<- coxme(Surv(total_lived, censored) ~maxtemperature + mwimin  +
                         mwimax +  (1|location) + (1|method), data= new_df_gdd)
summary(coxme_temps_s5)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124877.3 -124870.7
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 835.02 5.00 0 825.02 787.09
##  Penalized loglik 848.33 4.99 0 838.35 800.49
##
## Model:  Surv(total_lived, censored) ~ maxtemperature + mwimin + mwimax +      (1 | location) + (1 | m
## Fixed coefficients
##                        coef exp(coef)    se(coef)     z       p
## maxtemperature  0.04068165 1.0415205 0.002520624 16.14 0.0e+00
## mwimin         -0.27580067 0.7589642 0.050248787 -5.49 4.0e-08
## mwimax         -0.35869712 0.6985859 0.049559571 -7.24 4.6e-13
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.24319638 0.05914448
##  method   Intercept 0.18881115 0.03564965
```

```
exp(confint(coxme_temps_s5))
```

```
##                     2.5 %   97.5 %
## maxtemperature 1.0363877 1.046679
## mwimin         0.6877798 0.837516
## mwimax         0.6339203 0.769848
```

```
rms::vif(coxme_temps_s5)
```

```
## maxtemperature         mwimin         mwimax
##       1.530780       1.943009       1.487704
```

```
#trying with gdd and not maxt
coxme_temps_s6<- coxme(Surv(total_lived, censored) ~daily_acc_gdd + mwimin  +
                         mwimax +  (1|location) + (1|method), data= new_df_gdd)
exp(confint(coxme_temps_s6))
```

```
##                   2.5 %    97.5 %
## daily_acc_gdd 1.0430100 1.0559852
## mwimin        0.5879308 0.7365124
## mwimax        0.6481467 0.7903932
```

```
rms::vif(coxme_temps_s6)
```

```
## daily_acc_gdd        mwimin        mwimax
##      1.984031      2.536794      1.535565
```

```
summary(coxme_temps_s6)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124891.2 -124884.6
##
##                   Chisq   df p    AIC    BIC
## Integrated loglik 807.37 5.00 0 797.37 759.44
##  Penalized loglik 820.50 4.99 0 810.52 772.66
##
## Model:  Surv(total_lived, censored) ~ daily_acc_gdd + mwimin + mwimax +      (1 | location) + (1 | m
## Fixed coefficients
##                       coef exp(coef)    se(coef)     z       p
## daily_acc_gdd  0.04829244 1.0494775 0.003153989 15.31 0.0e+00
## mwimin        -0.41848758 0.6580413 0.057479825 -7.28 3.3e-13
## mwimax        -0.33443147 0.7157449 0.050616632 -6.61 3.9e-11
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.22128829 0.04896851
##  method   Intercept 0.18992575 0.03607179
```

```
#Random effects - Together
rms::vif(coxme_temps_t)
```

```
##  mintemperature meantemperature  maxtemperature           mwime          mwimin
##       86.681772      146.227470      113.180039       20.686813       12.951252
##          mwimax   daily_acc_gdd
##        4.598918      215.073532
```

```
#daily_acc_gdd has a lot of collinearity so we should remove it and do it again
coxme_temps_t2<- coxme(Surv(total_lived, censored) ~ mintemperature +
                       meantemperature
                   + maxtemperature + mwimin + mwime + mwimax  +
                    (1|location/method), data= new_df_gdd)


summary(coxme_temps_t2)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124864.9 -124855.7
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 859.96 8.00 0 843.96 783.28
##  Penalized loglik 878.19 8.98 0 860.24 792.15
##
## Model:  Surv(total_lived, censored) ~ mintemperature + meantemperature +      maxtemperature + mwimi
## Fixed coefficients
##                         coef exp(coef)   se(coef)     z       p
## mintemperature  -0.05055743 0.9506993 0.01362566 -3.71 2.1e-04
## meantemperature  0.12001923 1.1275185 0.02584503  4.64 3.4e-06
## maxtemperature  -0.02520013 0.9751147 0.01378104 -1.83 6.7e-02
## mwimin          -0.33010791 0.7188462 0.11800591 -2.80 5.2e-03
## mwime           -0.05970247 0.9420448 0.16786487 -0.36 7.2e-01
## mwimax          -0.31839139 0.7273181 0.08614815 -3.70 2.2e-04
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2292645199 0.0525622201
##  location        (Intercept) 0.0200985197 0.0004039505
```

```
rms::vif(coxme_temps_t2)
```

```
##  mintemperature meantemperature  maxtemperature          mwimin           mwime
##       40.865861      146.731152       45.724345       10.700338       18.876248
##          mwimax
##        4.458792
```

```
#mean temperature is the next variable with higher VIF, we remove it and repeat
coxme_temps_t3<- coxme(Surv(total_lived, censored) ~ mintemperature
                  + maxtemperature + mwimin + mwime + mwimax  +
                   (1|location/method), data= new_df_gdd)


summary(coxme_temps_t3)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 14 59
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124875.6 -124866.4
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 838.42 7.00 0 824.42 771.33
##  Penalized loglik 856.92 7.98 0 840.97 780.45
##
## Model:  Surv(total_lived, censored) ~ mintemperature + maxtemperature +      mwimin + mwime + mwimax
```

```
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## mintemperature  0.007456241 1.0074841 0.005490367  1.36 1.7e-01
## maxtemperature  0.034125568 1.0347145 0.005180349  6.59 4.5e-11
## mwimin         -0.390175776 0.6769379 0.117357954 -3.32 8.9e-04
## mwime           0.118473997 1.1257776 0.163425098  0.72 4.7e-01
## mwimax         -0.406483325 0.6659882 0.084071915 -4.83 1.3e-06
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2401840683 0.0576883867
##  location        (Intercept) 0.0200645333 0.0004025855
```

```
rms::vif(coxme_temps_t3)
```

```
## mintemperature maxtemperature         mwimin          mwime         mwimax
##       6.636699       6.455825      10.568025      17.900261       4.256049
```

```
#mean MWI is the next variable with higher VIF, we remove it and repeat
coxme_temps_t4<- coxme(Surv(total_lived, censored) ~ mintemperature
                  + maxtemperature + mwimin  + mwimax  +
                   (1|location/method), data= new_df_gdd)


summary(coxme_temps_t4)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 16 67
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124875.9 -124866.6
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 837.89 6.00 0 825.89 780.39
##  Penalized loglik 856.38 6.98 0 842.42 789.49
##
## Model:  Surv(total_lived, censored) ~ mintemperature + maxtemperature +      mwimin + mwimax + (1 | l
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## mintemperature  0.00656430 1.0065859 0.005342324  1.23 2.2e-01
## maxtemperature  0.03637548 1.0370452 0.004148063  8.77 0.0e+00
## mwimin         -0.31858732 0.7271756 0.063277810 -5.03 4.8e-07
## mwimax         -0.35769813 0.6992841 0.050428015 -7.09 1.3e-12
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2396019293 0.0574090845
##  location        (Intercept) 0.0200640099 0.0004025645
```

```
rms::vif(coxme_temps_t4)
```

```
## mintemperature maxtemperature         mwimin         mwimax
##       6.296414       4.134695       3.075789       1.530447
```

```
#min temperature is the next variable with higher VIF, we remove it and repeat
coxme_temps_t5<- coxme(Surv(total_lived, censored) ~ maxtemperature + mwimin  +
                         mwimax  + (1|location/method), data= new_df_gdd)

summary(coxme_temps_t5)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 18 75
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124876.6 -124867.4
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 836.38 5.00 0 826.38 788.46
##  Penalized loglik 854.96 5.98 0 843.00 797.64
##
## Model:  Surv(total_lived, censored) ~ maxtemperature + mwimin + mwimax +      (1 | location/method)
## Fixed coefficients
##                        coef exp(coef)    se(coef)     z       p
## maxtemperature  0.04041705 1.0412449 0.002521624 16.03 0.0e+00
## mwimin         -0.27126834 0.7624119 0.050232743 -5.40 6.7e-08
## mwimax         -0.36788418 0.6921973 0.049688980 -7.40 1.3e-13
##
## Random effects
##  Group           Variable    Std Dev     Variance
##  location/method (Intercept) 0.238723722 0.056989015
##  location        (Intercept) 0.020035020 0.000401402
```

```
exp(confint(coxme_temps_t5))
```

```
##                     2.5 %    97.5 %
## maxtemperature 1.0361115 1.0464038
## mwimin         0.6909259 0.8412941
## mwimax         0.6279638 0.7630013
```

```
rms::vif(coxme_temps_t5)
```

```
## maxtemperature         mwimin         mwimax
##       1.531273       1.942337       1.489669
```

```
#put gdd and change by maxt
coxme_temps_t6<- coxme(Surv(total_lived, censored) ~ daily_acc_gdd + mwimin  +
                         mwimax  + (1|location/method), data= new_df_gdd)

summary(coxme_temps_t6)
```

```
## Cox mixed-effects model fit by maximum likelihood
```

```
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -124890.1 -124881
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 809.46 5.00 0 799.46 761.54
##  Penalized loglik 827.70 5.98 0 815.75 770.40
##
## Model:  Surv(total_lived, censored) ~ daily_acc_gdd + mwimin + mwimax +      (1 | location/method)
## Fixed coefficients
##                       coef exp(coef)    se(coef)     z       p
## daily_acc_gdd  0.04802371 1.0491955 0.003155711 15.22 0.0e+00
## mwimin        -0.41375812 0.6611609 0.057473511 -7.20 6.1e-13
## mwimax        -0.34386472 0.7090248 0.050747789 -6.78 1.2e-11
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2297209153 0.0527716989
##  location        (Intercept) 0.0200983622 0.0004039442
```

```
exp(confint(coxme_temps_t6))
```

```
##                   2.5 %    97.5 %
## daily_acc_gdd 1.0427262 1.0557050
## mwimin        0.5907253 0.7399948
## mwimax        0.6418963 0.7831736
```

Relative Humidity

Minimum relative humidity

```
# No random effect
cox_minrh<- coxph(Surv(total_lived, censored) ~ minrh,
                  data= new_df_gdd)

summary(cox_minrh)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ minrh, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##              coef  exp(coef)   se(coef)      z Pr(>|z|)
## minrh -0.0020949  0.9979073  0.0005979 -3.504 0.000459 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##       exp(coef) exp(-coef) lower .95 upper .95
## minrh    0.9979      1.002    0.9967    0.9991
```

```
##
## Concordance= 0.516  (se = 0.003 )
## Likelihood ratio test= 12.28  on 1 df,   p=5e-04
## Wald test            = 12.28  on 1 df,   p=5e-04
## Score (logrank) test = 12.28  on 1 df,   p=5e-04
```

```
#Random effect - separated
coxme_minrh_s<- coxme(Surv(total_lived, censored) ~ minrh +
                  (1|location) + (1|method), data= new_df_gdd)
exp(confint(coxme_minrh_s))
```

```
##           2.5 %    97.5 %
## minrh 0.9924069 0.9948981
```

```
summary(coxme_minrh_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -125049.5 -125042.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 490.70 3.00 0 484.70 461.94
##  Penalized loglik 503.86 2.99 0 497.87 475.18
##
## Model:  Surv(total_lived, censored) ~ minrh + (1 | location) + (1 | method)
## Fixed coefficients
##               coef exp(coef)     se(coef)     z p
## minrh -0.006368525 0.9936517 0.0006395817 -9.96 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.21759027 0.04734553
##  method   Intercept 0.19529367 0.03813962
```

```
#Random effect - together
coxme_minrh_t<- coxme(Surv(total_lived, censored) ~ minrh +
                  (1|location/method), data= new_df_gdd)
exp(confint(coxme_minrh_t))
```

```
##           2.5 %    97.5 %
## minrh 0.9923985 0.9948896
```

```
summary(coxme_minrh_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
```

```
##                      NULL Integrated    Fitted
## Log-likelihood -125294.8  -125049.4 -125040.3
##
##                     Chisq   df p    AIC    BIC
## Integrated loglik 490.86 3.00 0 484.86 462.11
##  Penalized loglik 509.14 3.98 0 501.19 471.00
##
## Model:  Surv(total_lived, censored) ~ minrh + (1 | location/method)
## Fixed coefficients
##                coef exp(coef)     se(coef)     z p
## minrh -0.006377049 0.9936432 0.0006395605 -9.97 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2312599116 0.0534811467
##  location        (Intercept) 0.0200883709 0.0004035426
```

Mean relative humidity

```
# No random effect
cox_meanrh<- coxph(Surv(total_lived, censored) ~ meanrh,
                   data= new_df_gdd)

summary(cox_meanrh)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ meanrh, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##              coef  exp(coef)   se(coef)      z Pr(>|z|)
## meanrh -0.0034409  0.9965650  0.0007815 -4.403 1.07e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## meanrh    0.9966      1.003     0.995    0.9981
##
## Concordance= 0.516  (se = 0.003 )
## Likelihood ratio test= 19.31  on 1 df,   p=1e-05
## Wald test            = 19.38  on 1 df,   p=1e-05
## Score (logrank) test = 19.39  on 1 df,   p=1e-05
```

```
#Random effect - separated
coxme_meanrh_s<- coxme(Surv(total_lived, censored) ~ meanrh +
                   (1|location) + (1|method), data= new_df_gdd)

exp(confint(coxme_meanrh_s))
```

```
##            2.5 %    97.5 %
## meanrh 0.9905181 0.9936692
```

```
summary(coxme_meanrh_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -125051.4 -125044.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 486.87 3.00 0 480.87 458.12
##  Penalized loglik 499.94 2.99 0 493.95 471.26
##
## Model:  Surv(total_lived, censored) ~ meanrh + (1 | location) + (1 |      method)
## Fixed coefficients
##                coef exp(coef)     se(coef)    z p
## meanrh -0.007939023 0.9920924 0.0008102597 -9.8 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.20797347 0.04325297
##  method   Intercept 0.19544520 0.03819883
```

```
#Random effect - together
coxme_meanrh_t<- coxme(Surv(total_lived, censored) ~ meanrh +
                   (1|location/method), data= new_df_gdd)
exp(confint(coxme_meanrh_t))
```

```
##           2.5 %   97.5 %
## meanrh 0.990481 0.993633
```

```
summary(coxme_meanrh_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -125051.1 -125042
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 487.57 3.00 0 481.57 458.82
##  Penalized loglik 505.71 3.98 0 497.75 467.57
##
## Model:  Surv(total_lived, censored) ~ meanrh + (1 | location/method)
## Fixed coefficients
##                coef exp(coef)    se(coef)     z p
## meanrh -0.007975982 0.9920557 0.000810538 -9.84 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2255811609 0.0508868602
##  location        (Intercept) 0.0200723157 0.0004028979
```

Maximum relative humidity

```
# No random effect
cox_maxrh<- coxph(Surv(total_lived, censored) ~ maxrh,
                  data= new_df_gdd)

summary(cox_maxrh)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ maxrh, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##              coef  exp(coef)   se(coef)      z Pr(>|z|)
## maxrh -0.0030313  0.9969733  0.0009514 -3.186  0.00144 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##       exp(coef) exp(-coef) lower .95 upper .95
## maxrh     0.997      1.003    0.9951    0.9988
##
## Concordance= 0.508  (se = 0.003 )
## Likelihood ratio test= 10.05  on 1 df,   p=0.002
## Wald test            = 10.15  on 1 df,   p=0.001
## Score (logrank) test = 10.15  on 1 df,   p=0.001
```

```
#Random effect - separated
coxme_maxrh_s<- coxme(Surv(total_lived, censored) ~ maxrh +
                   (1|location) + (1|method), data= new_df_gdd)
exp(confint(coxme_maxrh_s))
```

```
##           2.5 %    97.5 %
## maxrh 0.9911302 0.9948644
```

```
summary(coxme_maxrh_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -125072.4 -125066
##
##                    Chisq   df p   AIC    BIC
## Integrated loglik 444.80 3.00 0 438.8 416.05
##  Penalized loglik 457.69 2.99 0 451.7 429.02
##
## Model:  Surv(total_lived, censored) ~ maxrh + (1 | location) + (1 | method)
## Fixed coefficients
##              coef exp(coef)     se(coef)     z       p
## maxrh -0.00702911 0.9929955 0.0009593553 -7.33 2.4e-13
```

```
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.18997490 0.03609046
##  method   Intercept 0.19610649 0.03845775
```

```
#Random effect - together
coxme_maxrh_t<- coxme(Surv(total_lived, censored) ~ maxrh +
                   (1|location/method), data= new_df_gdd)
exp(confint(coxme_maxrh_t))
```

```
##           2.5 %    97.5 %
## maxrh 0.9910726 0.9948087
```

```
summary(coxme_maxrh_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -125072.1 -125063.2
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 445.45 3.00 0 439.45 416.70
##  Penalized loglik 463.33 3.98 0 455.37 425.21
##
## Model:  Surv(total_lived, censored) ~ maxrh + (1 | location/method)
## Fixed coefficients
##               coef exp(coef)     se(coef)     z       p
## maxrh -0.007086124 0.9929389 0.0009598838 -7.38 1.6e-13
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2160588437 0.0466814239
##  location        (Intercept) 0.0200360615 0.0004014438
```

All RH together + Check collinearity

```
#No random effects
cox_rhs <- coxph(Surv(total_lived, censored) ~ minrh + meanrh
                 + maxrh + mwimin + mwime + mwimax,
                 data= new_df_gdd)
rms::vif(cox_rhs)
```

```
##     minrh    meanrh     maxrh    mwimin     mwime    mwimax
## 32.692372 55.656483  9.823637 14.229008 15.999182  2.872901
```

```r
#meanrh has a lot of collinearity so we should remove it and do it again
cox_rhs2 <- coxph(Surv(total_lived, censored) ~ minrh + maxrh
                  + mwimin + mwime + mwimax,
                  data= new_df_gdd)

summary(cox_rhs2)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ minrh + maxrh +
##     mwimin + mwime + mwimax, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##              coef exp(coef)  se(coef)       z Pr(>|z|)
## minrh  -0.008570  0.991467  0.001199  -7.150 8.69e-13 ***
## maxrh   0.006242  1.006262  0.001567   3.983 6.80e-05 ***
## mwimin  0.398871  1.490142  0.107864   3.698 0.000217 ***
## mwime   0.386027  1.471124  0.121291   3.183 0.001459 **
## mwimax -0.779796  0.458500  0.063939 -12.196  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## minrh     0.9915     1.0086    0.9891    0.9938
## maxrh     1.0063     0.9938    1.0032    1.0094
## mwimin    1.4901     0.6711    1.2062    1.8409
## mwime     1.4711     0.6798    1.1599    1.8659
## mwimax    0.4585     2.1810    0.4045    0.5197
##
## Concordance= 0.539  (se = 0.003 )
## Likelihood ratio test= 299.6  on 5 df,   p=<2e-16
## Wald test            = 304.8  on 5 df,   p=<2e-16
## Score (logrank) test = 305.6  on 5 df,   p=<2e-16
```

```r
rms::vif(cox_rhs2)
```

```
##     minrh     maxrh    mwimin     mwime    mwimax
##  4.041587  2.708100 11.123474 11.400562  2.588162
```

```r
#mwimean has a lot of collinearity so we should remove it and do it again
cox_rhs3 <- coxph(Surv(total_lived, censored) ~ minrh + maxrh
                  + mwimin  + mwimax,
                  data= new_df_gdd)

summary(cox_rhs3)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ minrh + maxrh +
##     mwimin + mwimax, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
```

```
##             coef exp(coef)  se(coef)       z Pr(>|z|)
## minrh  -0.010058  0.989992  0.001100  -9.141  < 2e-16 ***
## maxrh   0.007866  1.007897  0.001478   5.321 1.03e-07 ***
## mwimin  0.702058  2.017902  0.050779  13.826  < 2e-16 ***
## mwimax -0.666852  0.513322  0.053259 -12.521  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## minrh     0.9900     1.0101    0.9879    0.9921
## maxrh     1.0079     0.9922    1.0050    1.0108
## mwimin    2.0179     0.4956    1.8267    2.2291
## mwimax    0.5133     1.9481    0.4624    0.5698
##
## Concordance= 0.54  (se = 0.003 )
## Likelihood ratio test= 289.5  on 4 df,   p=<2e-16
## Wald test            = 291.6  on 4 df,   p=<2e-16
## Score (logrank) test = 292.1  on 4 df,   p=<2e-16
```

```
rms::vif(cox_rhs3)
```

```
##    minrh    maxrh   mwimin   mwimax
## 3.441672 2.422584 2.502104 1.805632
```

```
#Shall we eliminate a variable here?
stats::step(cox_rhs3)
```

```
## Start:  AIC=250308.2
## Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwimax
##
##          Df    AIC
## <none>      250308
## - maxrh   1 250335
## - minrh   1 250391
## - mwimax  1 250457
## - mwimin  1 250504

## Call:
## coxph(formula = Surv(total_lived, censored) ~ minrh + maxrh +
##     mwimin + mwimax, data = new_df_gdd)
##
##             coef exp(coef)  se(coef)       z        p
## minrh  -0.010058  0.989992  0.001100  -9.141  < 2e-16
## maxrh   0.007866  1.007897  0.001478   5.321 1.03e-07
## mwimin  0.702058  2.017902  0.050779  13.826  < 2e-16
## mwimax -0.666852  0.513322  0.053259 -12.521  < 2e-16
##
## Likelihood ratio test=289.5  on 4 df, p=< 2.2e-16
## n= 15154, number of events= 14541
```

```
#nop
summary(cox_rhs3)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ minrh + maxrh +
##     mwimin + mwimax, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##             coef exp(coef)  se(coef)       z Pr(>|z|)
## minrh  -0.010058  0.989992  0.001100  -9.141  < 2e-16 ***
## maxrh   0.007866  1.007897  0.001478   5.321 1.03e-07 ***
## mwimin  0.702058  2.017902  0.050779  13.826  < 2e-16 ***
## mwimax -0.666852  0.513322  0.053259 -12.521  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##        exp(coef) exp(-coef) lower .95 upper .95
## minrh     0.9900     1.0101    0.9879    0.9921
## maxrh     1.0079     0.9922    1.0050    1.0108
## mwimin    2.0179     0.4956    1.8267    2.2291
## mwimax    0.5133     1.9481    0.4624    0.5698
##
## Concordance= 0.54  (se = 0.003 )
## Likelihood ratio test= 289.5  on 4 df,   p=<2e-16
## Wald test            = 291.6  on 4 df,   p=<2e-16
## Score (logrank) test = 292.1  on 4 df,   p=<2e-16
```

```
#Random effects - Separated
coxme_rh_s<- coxme(Surv(total_lived, censored) ~ minrh + meanrh
                 + maxrh + mwimin + mwime + mwimax  +
                  (1|location) + (1|method), data= new_df_gdd)

summary(coxme_rh_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124900.7 -124894.1
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 788.35 8.00 0 772.35 711.67
##  Penalized loglik 801.43 7.99 0 785.45 724.84
##
## Model:  Surv(total_lived, censored) ~ minrh + meanrh + maxrh + mwimin +      mwime + mwimax + (1 | lo
## Fixed coefficients
##               coef exp(coef)    se(coef)      z       p
## minrh   0.01173971 1.0118089 0.003406294   3.45 5.7e-04
## meanrh -0.03616013 0.9644858 0.005830306  -6.20 5.6e-10
## maxrh   0.01914568 1.0193301 0.003031163   6.32 2.7e-10
## mwimin -0.61915996 0.5383965 0.127446806  -4.86 1.2e-06
```

```
## mwime   1.48018457 4.3937566 0.147550243  10.03 0.0e+00
## mwimax -1.04734875 0.3508668 0.067542793 -15.51 0.0e+00
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.21724157 0.04719390
##  method   Intercept 0.18916413 0.03578307
```

```
rms::vif(coxme_rh_s)
```

```
##     minrh    meanrh     maxrh    mwimin     mwime    mwimax
## 28.316187 51.250996  9.737931 12.634918 15.097095  2.790398
```

```
#meanrh has a lot of collinearity so we should remove it and do it again
coxme_rh_s2<- coxme(Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwime + mwimax  +
                  (1|location) + (1|method), data= new_df_gdd)

summary(coxme_rh_s2)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124920.1 -124913.5
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 749.45 7.00 0 735.45 682.35
##  Penalized loglik 762.64 6.99 0 748.65 695.63
##
## Model:  Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwime +      mwimax + (1 | location) +
## Fixed coefficients
##                coef exp(coef)    se(coef)      z       p
## minrh  -0.007983438 0.9920483 0.001189122  -6.71 1.9e-11
## maxrh   0.002890211 1.0028944 0.001552513   1.86 6.3e-02
## mwimin -0.298814745 0.7416968 0.116208027  -2.57 1.0e-02
## mwime   1.042329950 2.8358166 0.128645267   8.10 5.6e-16
## mwimax -0.923210445 0.3972417 0.064526755 -14.31 0.0e+00
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.22684908 0.05146051
##  method   Intercept 0.19020125 0.03617652
```

```
rms::vif(coxme_rh_s2)
```

```
##     minrh     maxrh    mwimin     mwime    mwimax
##  3.452495  2.582051 10.568160 11.603889  2.562920
```

```
#mwimean has a lot of collinearity, so we remove it and do it again
coxme_rh_s3<- coxme(Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwimax  +
                  (1|location) + (1|method), data= new_df_gdd)
coxme_rh_s3
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8    -124953 -124946.6
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 683.64 6.00 0 671.64 626.13
##  Penalized loglik 696.48 5.99 0 684.50 639.06
##
## Model:  Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwimax +      (1 | location) + (1 | m
## Fixed coefficients
##               coef exp(coef)    se(coef)      z     p
## minrh  -0.01162949 0.9884379 0.001094775 -10.62 0e+00
## maxrh   0.00729271 1.0073194 0.001450487   5.03 5e-07
## mwimin  0.54476566 1.7242043 0.052245328  10.43 0e+00
## mwimax -0.62507279 0.5352225 0.053278651 -11.73 0e+00
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.19316956 0.03731448
##  method   Intercept 0.18872443 0.03561691
```

```
exp(confint(coxme_rh_s3))
```

```
##            2.5 %    97.5 %
## minrh  0.9863192 0.9905611
## maxrh  1.0044597 1.0101872
## mwimin 1.5563864 1.9101172
## mwimax 0.4821514 0.5941351
```

```
rms::vif(coxme_rh_s3)
```

```
##    minrh    maxrh   mwimin   mwimax
## 2.968087 2.258754 2.194725 1.750572
```

```
#Random effects - Together
coxme_rh_t<- coxme(Surv(total_lived, censored) ~ minrh + meanrh
                  + maxrh + mwimin + mwime + mwimax  +
                   (1|location/method), data= new_df_gdd)

summary(coxme_rh_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124899.5 -124890.4
##
##                    Chisq   df p    AIC    BIC
```

```
## Integrated loglik 790.64 8.00 0 774.64 713.96
##  Penalized loglik 808.80 8.98 0 790.85 722.76
##
## Model:  Surv(total_lived, censored) ~ minrh + meanrh + maxrh + mwimin +      mwime + mwimax + (1 | lo
## Fixed coefficients
##               coef exp(coef)    se(coef)      z       p
## minrh   0.01188200 1.0119529 0.003407381   3.49 4.9e-04
## meanrh -0.03635544 0.9642975 0.005831688  -6.23 4.5e-10
## maxrh   0.01930663 1.0194942 0.003031961   6.37 1.9e-10
## mwimin -0.61361080 0.5413925 0.127450730  -4.81 1.5e-06
## mwime   1.47177630 4.3569675 0.147581246   9.97 0.0e+00
## mwimax -1.05475391 0.3482781 0.067596670 -15.60 0.0e+00
##
## Random effects
##  Group           Variable    Std Dev     Variance
##  location/method (Intercept) 0.226587237 0.051341776
##  location        (Intercept) 0.020093458 0.000403747
```

```
rms::vif(coxme_rh_t)
```

```
##     minrh    meanrh     maxrh    mwimin     mwime    mwimax
## 28.354265 51.271193  9.734499 12.636116 15.063889  2.781629
```

```
#meanrh has a lot of collinearity so we should remove it and do it again
coxme_rh_t2<- coxme(Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwime + mwimax  +
                  (1|location/method), data= new_df_gdd)

summary(coxme_rh_t2)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 6 27
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -124919.2 -124910
##
##                   Chisq   df p    AIC    BIC
## Integrated loglik 751.34 7.00 0 737.34 684.24
##  Penalized loglik 769.67 7.98 0 753.71 693.20
##
## Model:  Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwime +      mwimax + (1 | location/me
## Fixed coefficients
##               coef exp(coef)    se(coef)      z       p
## minrh  -0.00794886 0.9920826 0.001189503  -6.68 2.3e-11
## maxrh   0.00296216 1.0029666 0.001552885   1.91 5.6e-02
## mwimin -0.29136574 0.7472423 0.116192163  -2.51 1.2e-02
## mwime   1.03132504 2.8047798 0.128646934   8.02 1.1e-15
## mwimax -0.92958762 0.3947165 0.064560871 -14.40 0.0e+00
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2328043912 0.0541978845
##  location        (Intercept) 0.0201400621 0.0004056221
```

```
rms::vif(coxme_rh_t2)
```

```
##     minrh     maxrh    mwimin     mwime    mwimax
##  3.457083  2.581101 10.565311 11.573024  2.553363
```

```
#meanmwi has a lot of collinearity so we should remove it and do it again

coxme_rh_t3<- coxme(Surv(total_lived, censored) ~ minrh + maxrh + mwimin  + mwimax  +
                   (1|location/method), data= new_df_gdd)
exp(confint(coxme_rh_s3))
```

```
##            2.5 %    97.5 %
## minrh  0.9863192 0.9905611
## maxrh  1.0044597 1.0101872
## mwimin 1.5563864 1.9101172
## mwimax 0.4821514 0.5941351
```

```
coxme_rh_t3
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124951.4 -124942.5
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 686.91 6.00 0 674.91 629.40
##  Penalized loglik 704.68 6.98 0 690.73 637.83
##
## Model:  Surv(total_lived, censored) ~ minrh + maxrh + mwimin + mwimax +      (1 | location/method)
## Fixed coefficients
##                coef exp(coef)    se(coef)      z       p
## minrh  -0.011554722 0.9885118 0.001095308 -10.55 0.0e+00
## maxrh   0.007323433 1.0073503 0.001450693   5.05 4.5e-07
## mwimin  0.543077781 1.7212965 0.052253221  10.39 0.0e+00
## mwimax -0.635549434 0.5296444 0.053396253 -11.90 0.0e+00
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2126804732 0.0452329837
##  location        (Intercept) 0.0200477821 0.0004019136
```

Photoperiod

```
# No random effect
cox_pho<- coxph(Surv(total_lived, censored) ~ photoperiod,
                  data= new_df_gdd)

summary(cox_pho)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                 coef exp(coef) se(coef)     z Pr(>|z|)
## photoperiod 0.159151  1.172515 0.006781 23.47   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##             exp(coef) exp(-coef) lower .95 upper .95
## photoperiod     1.173     0.8529     1.157     1.188
##
## Concordance= 0.559  (se = 0.003 )
## Likelihood ratio test= 556.9  on 1 df,   p=<2e-16
## Wald test            = 550.9  on 1 df,   p=<2e-16
## Score (logrank) test = 553.7  on 1 df,   p=<2e-16
```

```
#Random effect - separated
coxme_pho_s<- coxme(Surv(total_lived, censored) ~ photoperiod +
                  (1|location) + (1|method), data= new_df_gdd)
summary(coxme_pho_s)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124870.2 -124864.3
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 849.24 3.00 0 843.24 820.49
##  Penalized loglik 861.16 2.99 0 855.19 832.55
##
## Model:  Surv(total_lived, censored) ~ photoperiod + (1 | location) +      (1 | method)
## Fixed coefficients
##                  coef exp(coef)    se(coef)     z p
## photoperiod 0.1459378  1.157124 0.006854719 21.29 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.12025165 0.01446046
##  method   Intercept 0.18942736 0.03588273
```

```
#Random effect - together
coxme_pho_t<- coxme(Surv(total_lived, censored) ~ photoperiod +
                  (1|location/method), data= new_df_gdd)

summary(coxme_pho_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
```

```
##   Iterations= 9 39
##                       NULL Integrated    Fitted
## Log-likelihood -125294.8  -124869.2 -124860.8
##
##                     Chisq   df p    AIC    BIC
## Integrated loglik 851.24 3.00 0 845.24 822.48
##  Penalized loglik 868.04 3.97 0 860.10 830.01
##
## Model:  Surv(total_lived, censored) ~ photoperiod + (1 | location/method)
## Fixed coefficients
##                  coef exp(coef)    se(coef)     z p
## photoperiod 0.1464935  1.157767 0.006867567 21.33 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1808051733 0.0326905107
##  location        (Intercept) 0.0198124749 0.0003925342
```

Complete models, adding all variables

```
#No random effect

coxph_allv<- coxph(Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +
                  maxrh + mintemperature + meantemperature + maxtemperature +
                  mwimin + mwimax + daily_acc_gdd +location + method, data= new_df_gdd)

summary(coxph_allv)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + minrh +
##     meanrh + maxrh + mintemperature + meantemperature + maxtemperature +
##     mwimin + mwimax + daily_acc_gdd + location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                      coef exp(coef)  se(coef)       z Pr(>|z|)
## photoperiod      0.197022  1.217771  0.015387  12.804  < 2e-16 ***
## minrh            0.006739  1.006762  0.003240   2.080  0.03750 *
## meanrh          -0.007931  0.992100  0.005255  -1.509  0.13126
## maxrh            0.005839  1.005856  0.003002   1.945  0.05178 .
## mintemperature   0.063421  1.065475  0.020790   3.051  0.00228 **
## meantemperature  0.002129  1.002131  0.026743   0.080  0.93654
## maxtemperature   0.082944  1.086481  0.021678   3.826  0.00013 ***
## mwimin          -0.185496  0.830692  0.124093  -1.495  0.13496
## mwimax          -0.379804  0.683996  0.058427  -6.500 8.01e-11 ***
## daily_acc_gdd   -0.171911  0.842054  0.034502  -4.983 6.27e-07 ***
## locationUrban   -0.222901  0.800194  0.022140 -10.068  < 2e-16 ***
## methodBG         0.258137  1.294516  0.018853  13.692  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                 exp(coef) exp(-coef) lower .95 upper .95
```

```
## photoperiod        1.2178     0.8212    1.1816    1.2551
## minrh              1.0068     0.9933    1.0004    1.0132
## meanrh             0.9921     1.0080    0.9819    1.0024
## maxrh              1.0059     0.9942    1.0000    1.0118
## mintemperature     1.0655     0.9385    1.0229    1.1098
## meantemperature    1.0021     0.9979    0.9510    1.0561
## maxtemperature     1.0865     0.9204    1.0413    1.1336
## mwimin             0.8307     1.2038    0.6513    1.0594
## mwimax             0.6840     1.4620    0.6100    0.7670
## daily_acc_gdd      0.8421     1.1876    0.7870    0.9010
## locationUrban      0.8002     1.2497    0.7662    0.8357
## methodBG           1.2945     0.7725    1.2476    1.3432
##
## Concordance= 0.592  (se = 0.003 )
## Likelihood ratio test= 1060  on 12 df,   p=<2e-16
## Wald test            = 1105  on 12 df,   p=<2e-16
## Score (logrank) test = 1114  on 12 df,   p=<2e-16
```

```
rms::vif(coxph_allv) #gdd and meant with high vif
```

```
##     photoperiod           minrh          meanrh           maxrh  mintemperature
##        5.611399       29.706846       45.567702        9.980555      100.780490
## meantemperature  maxtemperature          mwimin          mwimax   daily_acc_gdd
##      159.192337      114.570097       14.352517        2.215245      238.232702
##   locationUrban        methodBG
##        1.711774        1.005566
```

```
cox_allv2<- coxph(Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +
                  maxrh + mintemperature  + maxtemperature +
                  mwimin + mwimax + meantemperature+ location + method, data= new_df_gdd)

summary(cox_allv2)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + minrh +
##     meanrh + maxrh + mintemperature + maxtemperature + mwimin +
##     mwimax + meantemperature + location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                       coef  exp(coef)   se(coef)       z Pr(>|z|)
## photoperiod      0.1911545  1.2106465  0.0153488  12.454  < 2e-16 ***
## minrh            0.0100733  1.0101242  0.0031546   3.193  0.00141 **
## meanrh          -0.0092621  0.9907807  0.0052302  -1.771  0.07658 .
## maxrh            0.0067022  1.0067247  0.0029930   2.239  0.02514 *
## mintemperature  -0.0137238  0.9863699  0.0136577  -1.005  0.31497
## maxtemperature   0.0009704  1.0009708  0.0142301   0.068  0.94563
## mwimin          -0.4721448  0.6236632  0.1091645  -4.325 1.52e-05 ***
## mwimax          -0.3279104  0.7204276  0.0576399  -5.689 1.28e-08 ***
## meantemperature  0.0083222  1.0083569  0.0266855   0.312  0.75515
## locationUrban   -0.2379342  0.7882546  0.0220357 -10.798  < 2e-16 ***
## methodBG         0.2578754  1.2941775  0.0188529  13.678  < 2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                 exp(coef) exp(-coef) lower .95 upper .95
## photoperiod        1.2106     0.8260    1.1748    1.2476
## minrh              1.0101     0.9900    1.0039    1.0164
## meanrh             0.9908     1.0093    0.9807    1.0010
## maxrh              1.0067     0.9933    1.0008    1.0126
## mintemperature     0.9864     1.0138    0.9603    1.0131
## maxtemperature     1.0010     0.9990    0.9734    1.0293
## mwimin             0.6237     1.6034    0.5035    0.7725
## mwimax             0.7204     1.3881    0.6435    0.8066
## meantemperature    1.0084     0.9917    0.9570    1.0625
## locationUrban      0.7883     1.2686    0.7549    0.8230
## methodBG           1.2942     0.7727    1.2472    1.3429
##
## Concordance= 0.591  (se = 0.003 )
## Likelihood ratio test= 1034  on 11 df,   p=<2e-16
## Wald test            = 1071  on 11 df,   p=<2e-16
## Score (logrank) test = 1080  on 11 df,   p=<2e-16
```

```
rms::vif(cox_allv2) #meant with high vif
```

```
##     photoperiod           minrh          meanrh           maxrh  mintemperature
##        5.603575       28.189541       45.237344        9.938183       44.808667
##  maxtemperature          mwimin          mwimax meantemperature   locationUrban
##       49.233717       11.117570        2.135839      160.969038        1.695747
##        methodBG
##        1.005619
```

```
cox_allv3<- coxph(Surv(total_lived, censored) ~ photoperiod + minrh  + meanrh +
                  maxrh + mintemperature  + maxtemperature +
                  mwimin + mwimax +location + method, data= new_df_gdd)
summary(cox_allv3)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + minrh +
##     meanrh + maxrh + mintemperature + maxtemperature + mwimin +
##     mwimax + location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                     coef exp(coef)  se(coef)       z Pr(>|z|)
## photoperiod     0.192574  1.212366  0.014660  13.136  < 2e-16 ***
## minrh           0.010151  1.010203  0.003144   3.228  0.00124 **
## meanrh         -0.009342  0.990702  0.005223  -1.788  0.07370 .
## maxrh           0.006790  1.006813  0.002979   2.279  0.02268 *
## mintemperature -0.009878  0.990171  0.005873  -1.682  0.09260 .
## maxtemperature  0.005071  1.005084  0.005438   0.932  0.35108
## mwimin         -0.470318  0.624804  0.108999  -4.315 1.60e-05 ***
## mwimax         -0.329355  0.719387  0.057452  -5.733 9.89e-09 ***
## locationUrban  -0.238717  0.787638  0.021892 -10.904  < 2e-16 ***
## methodBG        0.257776  1.294049  0.018850  13.675  < 2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## photoperiod       1.2124     0.8248    1.1780    1.2477
## minrh             1.0102     0.9899    1.0040    1.0164
## meanrh            0.9907     1.0094    0.9806    1.0009
## maxrh             1.0068     0.9932    1.0010    1.0127
## mintemperature    0.9902     1.0099    0.9788    1.0016
## maxtemperature    1.0051     0.9949    0.9944    1.0159
## mwimin            0.6248     1.6005    0.5046    0.7736
## mwimax            0.7194     1.3901    0.6428    0.8051
## locationUrban     0.7876     1.2696    0.7546    0.8222
## methodBG          1.2940     0.7728    1.2471    1.3428
##
## Concordance= 0.591  (se = 0.003 )
## Likelihood ratio test= 1034  on 10 df,   p=<2e-16
## Wald test            = 1071  on 10 df,   p=<2e-16
## Score (logrank) test = 1080  on 10 df,   p=<2e-16
```

```
rms::vif(cox_allv3) #meanrh with high vif
```

```
##    photoperiod          minrh         meanrh          maxrh mintemperature
##       5.111272      28.016876      45.131385       9.850122       8.287367
## maxtemperature         mwimin         mwimax  locationUrban       methodBG
##       7.190808      11.086354       2.122566       1.673737       1.005331
```

```
cox_allv4<- coxph(Surv(total_lived, censored) ~ photoperiod + minrh  +
                  maxrh   + mintemperature +
                  mwimin + mwimax +  maxtemperature + location + method, data= new_df_gdd)
summary(cox_allv4)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + minrh +
##     maxrh + mintemperature + mwimin + mwimax + maxtemperature +
##     location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                     coef exp(coef)  se(coef)       z Pr(>|z|)
## photoperiod     0.194775  1.215037  0.014598  13.343  < 2e-16 ***
## minrh           0.005316  1.005330  0.001593   3.337 0.000848 ***
## maxrh           0.002223  1.002226  0.001544   1.440 0.149971
## mintemperature -0.008901  0.991139  0.005846  -1.523 0.127876
## mwimin         -0.473341  0.622918  0.108851  -4.349 1.37e-05 ***
## mwimax         -0.333285  0.716566  0.057371  -5.809 6.27e-09 ***
## maxtemperature  0.003286  1.003292  0.005341   0.615 0.538314
## locationUrban  -0.243742  0.783690  0.021725 -11.219  < 2e-16 ***
## methodBG        0.258285  1.294708  0.018848  13.704  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## photoperiod       1.2150     0.8230    1.1808    1.2503
```

```
## minrh             1.0053     0.9947    1.0022    1.0085
## maxrh             1.0022     0.9978    0.9992    1.0053
## mintemperature    0.9911     1.0089    0.9798    1.0026
## mwimin            0.6229     1.6053    0.5032    0.7711
## mwimax            0.7166     1.3955    0.6404    0.8018
## maxtemperature    1.0033     0.9967    0.9928    1.0138
## locationUrban     0.7837     1.2760    0.7510    0.8178
## methodBG          1.2947     0.7724    1.2478    1.3434
##
## Concordance= 0.591  (se = 0.003 )
## Likelihood ratio test= 1031  on 9 df,   p=<2e-16
## Wald test            = 1066  on 9 df,   p=<2e-16
## Score (logrank) test = 1075  on 9 df,   p=<2e-16
```

```
rms::vif(cox_allv4)
```

```
##    photoperiod          minrh          maxrh mintemperature         mwimin
##       5.061077       7.182200       2.653815       8.199840      11.031121
##         mwimax maxtemperature  locationUrban       methodBG
##       2.118064       6.937224       1.648278       1.005066
```

```
cox_allv5<- coxph(Surv(total_lived, censored) ~ photoperiod + minrh  +
                  maxrh   + mintemperature +
                  mwimax +  maxtemperature + location + method, data= new_df_gdd)
summary(cox_allv5)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + minrh +
##     maxrh + mintemperature + mwimax + maxtemperature + location +
##     method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                       coef  exp(coef)   se(coef)       z Pr(>|z|)
## photoperiod     1.963e-01  1.217e+00  1.459e-02  13.456  < 2e-16 ***
## minrh          -1.512e-05  1.000e+00  1.024e-03  -0.015   0.9882
## maxrh           3.777e-03  1.004e+00  1.502e-03   2.514   0.0119 *
## mintemperature -2.195e-02  9.783e-01  4.989e-03  -4.399 1.09e-05 ***
## mwimax         -4.361e-01  6.465e-01  5.239e-02  -8.325  < 2e-16 ***
## maxtemperature -1.478e-03  9.985e-01  5.226e-03  -0.283   0.7774
## locationUrban  -2.308e-01  7.939e-01  2.152e-02 -10.727  < 2e-16 ***
## methodBG        2.575e-01  1.294e+00  1.885e-02  13.665  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## photoperiod       1.2169     0.8218    1.1826    1.2521
## minrh             1.0000     1.0000    0.9980    1.0020
## maxrh             1.0038     0.9962    1.0008    1.0067
## mintemperature    0.9783     1.0222    0.9688    0.9879
## mwimax            0.6465     1.5467    0.5834    0.7165
## maxtemperature    0.9985     1.0015    0.9883    1.0088
## locationUrban     0.7939     1.2596    0.7611    0.8281
```

```
## methodBG          1.2937     0.7730    1.2468    1.3424
##
## Concordance= 0.589  (se = 0.003 )
## Likelihood ratio test= 1012  on 8 df,   p=<2e-16
## Wald test            = 1039  on 8 df,   p=<2e-16
## Score (logrank) test = 1046  on 8 df,   p=<2e-16
```

```
rms::vif(cox_allv5)
```

```
##    photoperiod          minrh          maxrh mintemperature         mwimax
##       5.038611       2.998556       2.532253       6.053866       1.780818
## maxtemperature  locationUrban       methodBG
##       6.655568       1.616683       1.004930
```

```
cox_allv6<- coxph(Surv(total_lived, censored) ~ photoperiod + minrh  +
                  maxrh   + mintemperature +
                  mwimax  + location + method, data= new_df_gdd)
rms::vif(cox_allv6) #we have removed maxtemperature and mwimin!
```

```
##    photoperiod          minrh          maxrh mintemperature         mwimax
##       3.761419       2.798073       2.379646       3.939168       1.765327
##  locationUrban       methodBG
##       1.265670       1.004926
```

```
##MODELS##
coxph_1<- coxph(Surv(total_lived, censored) ~ photoperiod +  mwimax  +
                  location + method, data= new_df_gdd)
summary(coxph_1)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + mwimax +
##     location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                    coef exp(coef)  se(coef)      z Pr(>|z|)
## photoperiod    0.135030  1.144571  0.006726  20.07   <2e-16 ***
## mwimax        -0.429385  0.650909  0.041245 -10.41   <2e-16 ***
## locationUrban -0.219278  0.803098  0.017798 -12.32   <2e-16 ***
## methodBG       0.261715  1.299156  0.018826  13.90   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##               exp(coef) exp(-coef) lower .95 upper .95
## photoperiod      1.1446     0.8737    1.1296    1.1598
## mwimax           0.6509     1.5363    0.6004    0.7057
## locationUrban    0.8031     1.2452    0.7756    0.8316
## methodBG         1.2992     0.7697    1.2521    1.3480
##
## Concordance= 0.589  (se = 0.003 )
## Likelihood ratio test= 966.6  on 4 df,   p=<2e-16
## Wald test            = 982.3  on 4 df,   p=<2e-16
## Score (logrank) test = 988.2  on 4 df,   p=<2e-16
```

```
coxph_2<- coxph(Surv(total_lived, censored) ~ photoperiod +  mwimin +
                    + location + method,
                     data= new_df_gdd)
summary(coxph_2)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + mwimin +
##     +location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                     coef exp(coef)  se(coef)      z Pr(>|z|)
## photoperiod    0.170874  1.186341  0.007143  23.92   <2e-16 ***
## mwimin        -0.398355  0.671423  0.039041 -10.20   <2e-16 ***
## locationUrban -0.250204  0.778642  0.018826 -13.29   <2e-16 ***
## methodBG       0.265336  1.303869  0.018814  14.10   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##               exp(coef) exp(-coef) lower .95 upper .95
## photoperiod      1.1863     0.8429    1.1698    1.2031
## mwimin           0.6714     1.4894    0.6220    0.7248
## locationUrban    0.7786     1.2843    0.7504    0.8079
## methodBG         1.3039     0.7669    1.2567    1.3528
##
## Concordance= 0.591  (se = 0.003 )
## Likelihood ratio test= 965.5  on 4 df,   p=<2e-16
## Wald test            = 985.3  on 4 df,   p=<2e-16
## Score (logrank) test = 992  on 4 df,   p=<2e-16
```

```
library("texreg")

coxph_3<- coxph(Surv(total_lived, censored) ~ photoperiod + mintemperature
                  + minrh +  location + method,
                     data= new_df_gdd)
summary(coxph_3)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + mintemperature +
##     minrh + location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                      coef  exp(coef)   se(coef)       z Pr(>|z|)
## photoperiod     0.2072247  1.2302590  0.0124660  16.623  < 2e-16 ***
## mintemperature -0.0270089  0.9733526  0.0039954  -6.760 1.38e-11 ***
## minrh          -0.0013792  0.9986217  0.0007697  -1.792   0.0731 .
## locationUrban  -0.2275839  0.7964556  0.0191221 -11.902  < 2e-16 ***
## methodBG        0.2649037  1.3033055  0.0188164  14.078  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
##                exp(coef) exp(-coef) lower .95 upper .95
## photoperiod       1.2303     0.8128    1.2006    1.2607
## mintemperature    0.9734     1.0274    0.9658    0.9810
## minrh             0.9986     1.0014    0.9971    1.0001
## locationUrban     0.7965     1.2556    0.7672    0.8269
## methodBG          1.3033     0.7673    1.2561    1.3523
##
## Concordance= 0.59  (se = 0.003 )
## Likelihood ratio test= 942.8  on 5 df,   p=<2e-16
## Wald test            = 953.2  on 5 df,   p=<2e-16
## Score (logrank) test = 958.6  on 5 df,   p=<2e-16
```

```
coxph_4<- coxph(Surv(total_lived, censored) ~ photoperiod + mintemperature
                  + maxrh +  location + method,
                     data= new_df_gdd)
summary(coxph_4)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + mintemperature +
##     maxrh + location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                     coef exp(coef)  se(coef)       z Pr(>|z|)
## photoperiod     0.212042  1.236200  0.011155  19.009  < 2e-16 ***
## mintemperature -0.028725  0.971684  0.003572  -8.041 8.88e-16 ***
## maxrh          -0.002104  0.997898  0.001027  -2.049   0.0404 *
## locationUrban  -0.223943  0.799360  0.018397 -12.173  < 2e-16 ***
## methodBG        0.265167  1.303649  0.018817  14.092  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## photoperiod       1.2362     0.8089    1.2095    1.2635
## mintemperature    0.9717     1.0291    0.9649    0.9785
## maxrh             0.9979     1.0021    0.9959    0.9999
## locationUrban     0.7994     1.2510    0.7711    0.8287
## methodBG          1.3036     0.7671    1.2564    1.3526
##
## Concordance= 0.59  (se = 0.003 )
## Likelihood ratio test= 943.8  on 5 df,   p=<2e-16
## Wald test            = 954.6  on 5 df,   p=<2e-16
## Score (logrank) test = 960.4  on 5 df,   p=<2e-16
```

```
coxph_5<- coxph(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
                  minrh + location + method,
                     data= new_df_gdd)
summary(coxph_5)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
##     minrh + location + method, data = new_df_gdd)
##
```

```
##   n= 15154, number of events= 14541
##
##                     coef  exp(coef)   se(coef)       z Pr(>|z|)
## photoperiod    0.2232800  1.2501706  0.0142783  15.638  < 2e-16 ***
## daily_acc_gdd -0.0331602  0.9673836  0.0048140  -6.888 5.64e-12 ***
## minrh         -0.0020246  0.9979774  0.0007218  -2.805  0.00503 **
## locationUrban -0.1947650  0.8230280  0.0193375 -10.072  < 2e-16 ***
## methodBG       0.2657961  1.3044690  0.0188134  14.128  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##               exp(coef) exp(-coef) lower .95 upper .95
## photoperiod      1.2502     0.7999    1.2157    1.2857
## daily_acc_gdd    0.9674     1.0337    0.9583    0.9766
## minrh            0.9980     1.0020    0.9966    0.9994
## locationUrban    0.8230     1.2150    0.7924    0.8548
## methodBG         1.3045     0.7666    1.2572    1.3535
##
## Concordance= 0.59  (se = 0.003 )
## Likelihood ratio test= 944.4  on 5 df,   p=<2e-16
## Wald test            = 951.8  on 5 df,   p=<2e-16
## Score (logrank) test = 958.3  on 5 df,   p=<2e-16
```

```
coxph_6<- coxph(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
                maxrh + location + method,
                    data= new_df_gdd)
summary(coxph_6)
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
##     maxrh + location + method, data = new_df_gdd)
##
##   n= 15154, number of events= 14541
##
##                     coef exp(coef)  se(coef)       z Pr(>|z|)
## photoperiod    0.232140  1.261296  0.013408  17.314  < 2e-16 ***
## daily_acc_gdd -0.035974  0.964666  0.004563  -7.883 3.19e-15 ***
## maxrh         -0.002249  0.997753  0.001020  -2.205   0.0275 *
## locationUrban -0.181382  0.834117  0.017959 -10.100  < 2e-16 ***
## methodBG       0.266236  1.305044  0.018814  14.151  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##               exp(coef) exp(-coef) lower .95 upper .95
## photoperiod      1.2613     0.7928    1.2286    1.2949
## daily_acc_gdd    0.9647     1.0366    0.9561    0.9733
## maxrh            0.9978     1.0023    0.9958    0.9998
## locationUrban    0.8341     1.1989    0.8053    0.8640
## methodBG         1.3050     0.7663    1.2578    1.3541
##
## Concordance= 0.59  (se = 0.003 )
## Likelihood ratio test= 941.4  on 5 df,   p=<2e-16
## Wald test            = 948.3  on 5 df,   p=<2e-16
## Score (logrank) test = 955.4  on 5 df,   p=<2e-16
```

Complete models, adding all variables, and with levels

```
#Random effect - separated
coxme_allv<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +
                     maxrh + mintemperature + meantemperature + maxtemperature +
                     mwimin + mwimax + daily_acc_gdd + (1|location) + (1|method),
                     data= new_df_gdd)
summary(coxme_allv)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 38
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124771.2 -124765.1
##
##                     Chisq    df p     AIC    BIC
## Integrated loglik 1047.20 12.00 0 1023.20 932.18
##  Penalized loglik 1059.58 11.99 0 1035.61 944.70
##
## Model:  Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +      maxrh + mintemperature + m
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## photoperiod      0.197413893 1.2182482 0.015380012 12.84 0.0e+00
## minrh            0.006759293 1.0067822 0.003239691  2.09 3.7e-02
## meanrh          -0.007996526 0.9920354 0.005255003 -1.52 1.3e-01
## maxrh            0.005890570 1.0059080 0.003001498  1.96 5.0e-02
## mintemperature   0.063615458 1.0656825 0.020793110  3.06 2.2e-03
## meantemperature  0.002360826 1.0023636 0.026740125  0.09 9.3e-01
## maxtemperature   0.082824146 1.0863508 0.021681924  3.82 1.3e-04
## mwimin          -0.183404537 0.8324313 0.124083925 -1.48 1.4e-01
## mwimax          -0.380430402 0.6835671 0.058425855 -6.51 7.4e-11
## daily_acc_gdd   -0.172385678 0.8416545 0.034508059 -5.00 5.9e-07
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.15934541 0.02539096
##  method   Intercept 0.18452042 0.03404778
```

```
rms::vif(coxme_allv) #gdd with high vif
```

```
##     photoperiod           minrh          meanrh           maxrh  mintemperature
##        5.457019       25.254471       40.670812        9.325341       91.896864
## meantemperature  maxtemperature          mwimin          mwimax   daily_acc_gdd
##      155.119700      114.429499       11.681894        2.096065      234.068594
```

```
coxme_allv2<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +
                     maxrh + mintemperature  + maxtemperature +
                     mwimin + mwimax + meantemperature+ (1|location) + (1|method),
                     data= new_df_gdd)
summary(coxme_allv2)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 19 98
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124784.1 -124777.8
##
##                     Chisq    df p     AIC    BIC
## Integrated loglik 1021.53 11.00 0  999.53 916.10
##  Penalized loglik 1034.04 10.99 0 1012.07 928.74
##
## Model:  Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +      maxrh + mintemperature + ma
## Fixed coefficients
##                          coef exp(coef)    se(coef)     z       p
## photoperiod      0.1915288395 1.2110998 0.015342451 12.48 0.0e+00
## minrh            0.0100999989 1.0101512 0.003154632  3.20 1.4e-03
## meanrh          -0.0093274805 0.9907159 0.005229858 -1.78 7.5e-02
## maxrh            0.0067537420 1.0067766 0.002992614  2.26 2.4e-02
## mintemperature  -0.0137476024 0.9863465 0.013656558 -1.01 3.1e-01
## maxtemperature   0.0006244466 1.0006246 0.014225178  0.04 9.6e-01
## mwimin          -0.4707932259 0.6245067 0.109163788 -4.31 1.6e-05
## mwimax          -0.3283701914 0.7200964 0.057638497 -5.70 1.2e-08
## meantemperature  0.0085717220 1.0086086 0.026682548  0.32 7.5e-01
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.16706822 0.02791179
##  method   Intercept 0.18177465 0.03304202
```

```
rms::vif(coxme_allv2) #meantemperature with high vif
```

```
##     photoperiod           minrh          meanrh           maxrh  mintemperature
##        5.439519       23.924515       40.345141        9.277258       40.703016
##  maxtemperature          mwimin          mwimax meantemperature
##       49.143583        9.013277        2.011965      156.523608
```

```
coxme_allv3<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh  + meanrh +
                      maxrh + mintemperature  + maxtemperature +
                      mwimin + mwimax + (1|location) + (1|method), data= new_df_gdd)
summary(coxme_allv3)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 16 83
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124784.1 -124777.9
##
##                     Chisq    df p     AIC    BIC
## Integrated loglik 1021.43 10.00 0 1001.43 925.58
##  Penalized loglik 1033.94  9.99 0 1013.97 938.23
##
## Model:  Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +      maxrh + mintemperature + ma
```

```
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## photoperiod     0.192989214 1.2128697 0.014651904 13.17 0.0e+00
## minrh           0.010179923 1.0102319 0.003144308  3.24 1.2e-03
## meanrh         -0.009409407 0.9906347 0.005222974 -1.80 7.2e-02
## maxrh           0.006843757 1.0068672 0.002978984  2.30 2.2e-02
## mintemperature -0.009786929 0.9902608 0.005873001 -1.67 9.6e-02
## maxtemperature  0.004849066 1.0048608 0.005433566  0.89 3.7e-01
## mwimin         -0.468912250 0.6256825 0.108996541 -4.30 1.7e-05
## mwimax         -0.329857596 0.7190261 0.057450900 -5.74 9.4e-09
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.16763930 0.02810293
##  method   Intercept 0.18170251 0.03301580
```

```
rms::vif(coxme_allv3) #meanrh with high vif
```

```
##    photoperiod          minrh         meanrh          maxrh mintemperature
##       4.960605      23.769878      40.238070       9.192841       7.529160
## maxtemperature          mwimin          mwimax
##       7.170278       8.984975       1.999198
```

```
coxme_allv4<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh  +
                      maxrh +  mwimin + mwimax + mintemperature + maxtemperature +
                      (1|location) + (1|method),
                    data= new_df_gdd,
                    refine.n = 500)
rms::vif(coxme_allv4) #removing maxtemperature
```

```
##    photoperiod          minrh          maxrh         mwimin         mwimax
##       4.913649       6.093384       2.477241       8.951244       1.995839
## mintemperature maxtemperature
##       7.457659       6.914694
```

```
coxme_allv5<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh  +
                      maxrh + mintemperature +mwimin +mwimax+  (1|location) + (1|method),
                    data= new_df_gdd,
                    refine.n = 500)
rms::vif(coxme_allv5) #we know now the variables that doesn't have collinearity
```

```
##    photoperiod          minrh          maxrh mintemperature         mwimin
##       3.701180       5.453081       2.283485       6.340041       8.581555
##         mwimax
##       1.941038
```

```
coxme_allv5_gdd <- coxme(Surv(total_lived, censored) ~ photoperiod + minrh  +
                      maxrh + daily_acc_gdd +mwimin +mwimax+  (1|location) + (1|method),
                    data= new_df_gdd,
                    refine.n = 500)
rms::vif(coxme_allv5_gdd) #if we change temperature and put gdd, we still not
```

```
##   photoperiod         minrh         maxrh daily_acc_gdd        mwimin
##      4.823310      6.378432      2.347918      9.120088      9.702627
##        mwimax
##      2.027815
```

```
#have collinearity
```

```
##Random effect - together
coxme_allv_t<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +
                     maxrh + mintemperature + meantemperature + maxtemperature +
                     mwimin + mwimax + (1|location/method), data= new_df_gdd)

summary(coxme_allv_t)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 43
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124780.2 -124771.5
##
##                     Chisq    df p     AIC    BIC
## Integrated loglik 1029.37 11.00 0 1007.37 923.94
##  Penalized loglik 1046.64 11.97 0 1022.71 931.94
##
## Model:  Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +      maxrh + mintemperature + m
## Fixed coefficients
##                          coef exp(coef)    se(coef)     z       p
## photoperiod      0.195015242 1.2153295 0.015375305 12.68 0.0e+00
## minrh            0.010295115 1.0103483 0.003155263  3.26 1.1e-03
## meanrh          -0.009582131 0.9904636 0.005229200 -1.83 6.7e-02
## maxrh            0.006959936 1.0069842 0.002992850  2.33 2.0e-02
## mintemperature  -0.014518208 0.9855867 0.013657553 -1.06 2.9e-01
## meantemperature  0.009940342 1.0099899 0.026682157  0.37 7.1e-01
## maxtemperature  -0.001085309 0.9989153 0.014226765 -0.08 9.4e-01
## mwimin          -0.468954109 0.6256563 0.109199226 -4.29 1.8e-05
## mwimax          -0.340907555 0.7111246 0.057763230 -5.90 3.6e-09
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1957273176 0.0383091829
##  location        (Intercept) 0.0199897797 0.0003995913
```

```
rms::vif(coxme_allv_t) #meantemperature with high vif
```

```
##     photoperiod           minrh          meanrh           maxrh  mintemperature
##        5.451218       23.957200       40.345791        9.274046       40.676917
## meantemperature  maxtemperature          mwimin          mwimax
##      156.422878       49.151454        9.021626        2.012517
```

```
coxme_allv_t2<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +
                    maxrh + mintemperature + maxtemperature +
                   mwimin + mwimax + (1|location/method), data= new_df_gdd)

summary(coxme_allv_t2)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 43
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124780.2 -124771.6
##
##                     Chisq    df p     AIC    BIC
## Integrated loglik 1029.23 10.00 0 1009.23 933.39
##  Penalized loglik 1046.51 10.97 0 1024.58 941.39
##
## Model:  Surv(total_lived, censored) ~ photoperiod + minrh + meanrh +      maxrh + mintemperature + ma
## Fixed coefficients
##                        coef exp(coef)    se(coef)     z       p
## photoperiod     0.196706512 1.2173867 0.014689735 13.39 0.0e+00
## minrh           0.010386772 1.0104409 0.003145105  3.30 9.6e-04
## meanrh         -0.009675862 0.9903708 0.005222419 -1.85 6.4e-02
## maxrh           0.007063916 1.0070889 0.002979308  2.37 1.8e-02
## mintemperature -0.009924674 0.9901244 0.005876591 -1.69 9.1e-02
## maxtemperature  0.003813155 1.0038204 0.005435569  0.70 4.8e-01
## mwimin         -0.466743856 0.6270407 0.109027071 -4.28 1.9e-05
## mwimax         -0.342624331 0.7099049 0.057577793 -5.95 2.7e-09
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1959844608 0.0384099089
##  location        (Intercept) 0.0199916371 0.0003996656
```

```
rms::vif(coxme_allv_t2) #meanrh with highest vif
```

```
##    photoperiod          minrh         meanrh          maxrh mintemperature
##       4.975619      23.805320      40.240405       9.190233       7.532688
## maxtemperature         mwimin         mwimax
##       7.175146       8.992428       1.999975
```

```
coxme_allv_t3<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh  +
                    maxrh + mintemperature + maxtemperature +
                    mwimin + mwimax + (1|location/method), data= new_df_gdd)

summary(coxme_allv_t3)
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
```

```
##                      NULL Integrated    Fitted
## Log-likelihood -125294.8  -124781.9 -124773.3
##
##                      Chisq   df p     AIC    BIC
## Integrated loglik 1025.80 9.00 0 1007.80 939.54
##  Penalized loglik 1043.14 9.97 0 1023.21 947.60
##
## Model:  Surv(total_lived, censored) ~ photoperiod + minrh + maxrh + mintemperature +      maxtempera
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## photoperiod     0.198961821 1.2201354 0.014628290 13.60 0.0e+00
## minrh           0.005377198 1.0053917 0.001593662  3.37 7.4e-04
## maxrh           0.002333467 1.0023362 0.001544908  1.51 1.3e-01
## mintemperature -0.008916292 0.9911233 0.005849374 -1.52 1.3e-01
## maxtemperature  0.001969834 1.0019718 0.005337733  0.37 7.1e-01
## mwimin         -0.469757340 0.6251539 0.108875325 -4.31 1.6e-05
## mwimax         -0.346623785 0.7070713 0.057496289 -6.03 1.7e-09
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1979638976 0.0391897048
##  location        (Intercept) 0.0199998428 0.0003999937
```

```
rms::vif(coxme_allv_t3) #maxtemperature with highest vif
```

```
##    photoperiod          minrh          maxrh mintemperature maxtemperature
##       4.929063       6.103088       2.477662       7.461492       6.920463
##         mwimin         mwimax
##       8.957995       1.996743
```

```
coxme_allv_t4<- coxme(Surv(total_lived, censored) ~ photoperiod + minrh  +
                      maxrh + mintemperature  +
                      mwimin + mwimax + (1|location/method), data= new_df_gdd)
rms::vif(coxme_allv_t4) #maxtemperature with highest vif
```

```
##    photoperiod          minrh          maxrh mintemperature         mwimin
##       3.707955       5.466050       2.283001       6.349184       8.588838
##         mwimax
##       1.940053
```

#Finally... which one? :))

We should check the AIC and BIC of each model, maybe taking only the option of (1|location) + (1|method) (1|location/method) (1|location) + (1|method) + (1|location/method) for:

1. model with MWImax, photoperiod
2. model with MWImin, photoperiod
3. model with MinT, minRH, photoperiod
4. model with MinT, maxRH, photoperiod
5. model with GDD, minRH, photoperiod
6. model with GDD, maxRH, photoperiod

Create tables with the HR, CI95%, var and sd + tables with the AIC + BIC + loglikelihood (integrated)

```
#model 1.
model1<- coxme(Surv(total_lived, censored) ~ photoperiod + mwimax +
                 (1|location)+ (1|method) +(1|location/method),
                       data= new_df_gdd,
                     refine.n = 500)
exp(confint(model1))
```

```
##                 2.5 %    97.5 %
## photoperiod 1.1300395 1.1602701
## mwimax      0.5960754 0.7008917
```

```
model1
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 15 63
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8    -124814 -124806.3
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 961.67 6.00 0 949.67 904.16
##  Penalized loglik 977.15 4.89 0 967.36 930.25
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mwimax + (1 | location) +      (1 | method) + (1
## Fixed coefficients
##                    coef exp(coef)    se(coef)      z p
## photoperiod  0.1354527 1.1450550 0.006734892  20.11 0
## mwimax      -0.4363950 0.6463624 0.041323789 -10.56 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location        Intercept   0.1285202288 0.0165174492
##  method          Intercept   0.1842729262 0.0339565113
##  location/method (Intercept) 0.0593605277 0.0035236723
##  location        (Intercept) 0.0201747447 0.0004070203
```

```
model2<- coxme(Surv(total_lived, censored) ~ photoperiod + mwimin  +
                    (1|location)+ (1|method) +(1|location/method),
                    data= new_df_gdd,
                  refine.n = 500)
exp(confint(model2))
```

```
##                 2.5 %    97.5 %
## photoperiod 1.1706882 1.2039775
## mwimin      0.6208004 0.7234193
```

```
model2
```

```
## Cox mixed-effects model fit by maximum likelihood
```

```
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 9 39
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124815.6 -124807.8
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 958.58 6.00 0 946.58 901.07
##  Penalized loglik 974.18 4.88 0 964.43 927.45
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mwimin + (1 | location) +      (1 | method) + (1
## Fixed coefficients
##                    coef exp(coef)   se(coef)      z p
## photoperiod  0.1716112 1.1872162 0.00715290  23.99 0
## mwimin      -0.4002559 0.6701485 0.03902609 -10.26 0
##
## Random effects
##  Group           Variable    Std Dev     Variance
##  location        Intercept   0.109141698 0.011911910
##  method          Intercept   0.187466724 0.035143773
##  location/method (Intercept) 0.053285855 0.002839382
##  location        (Intercept) 0.109141628 0.011911895
```

```
model3<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ minrh  +
                     (1|location)+ (1|method) +(1|location/method),
                     data= new_df_gdd,
                   refine.n = 500)
exp(confint(model3))
```

```
##                    2.5 %   97.5 %
## photoperiod    1.2030320 1.263415
## mintemperature 0.9652319 0.980492
## minrh          0.9971845 1.000198
```

```
model3
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 9 39
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -124826.7 -124819
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 936.30 7.00 0 922.30 869.21
##  Penalized loglik 951.72 5.88 0 939.97 895.39
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mintemperature +      minrh + (1 | location) + (
## Fixed coefficients
##                         coef exp(coef)     se(coef)     z       p
## photoperiod     0.209331622 1.2328538 0.0124933661 16.76 0.0e+00
## mintemperature -0.027543831 0.9728320 0.0040016495 -6.88 5.9e-12
## minrh          -0.001310968 0.9986899 0.0007696826 -1.70 8.9e-02
```

```
##
## Random effects
##  Group           Variable    Std Dev     Variance
##  location        Intercept   0.096843288 0.009378622
##  method          Intercept   0.187086231 0.035001258
##  location/method (Intercept) 0.054388377 0.002958096
##  location        (Intercept) 0.096843288 0.009378622
```

```
model4<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ maxrh  +
                     (1|location)+ (1|method) +(1|location/method),
                     data= new_df_gdd,
                   refine.n = 500)
model4
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 9 39
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8    -124826 -124818.3
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 937.60 7.00 0 923.60 870.50
##  Penalized loglik 953.02 5.88 0 941.26 896.65
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mintemperature +      maxrh + (1 | location) + (
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## photoperiod     0.213597301 1.2381240 0.011174416 19.11 0.0e+00
## mintemperature -0.029088245 0.9713307 0.003575205 -8.14 4.4e-16
## maxrh          -0.002110154 0.9978921 0.001027156 -2.05 4.0e-02
##
## Random effects
##  Group           Variable    Std Dev     Variance
##  location        Intercept   0.094921320 0.009010057
##  method          Intercept   0.187189077 0.035039750
##  location/method (Intercept) 0.055478821 0.003077900
##  location        (Intercept) 0.094921258 0.009010045
```

```
exp(confint(model4))
```

```
##                     2.5 %   97.5 %
## photoperiod    1.2113020 1.265540
## mintemperature 0.9645482 0.978161
## maxrh          0.9958851 0.999903
```

```
model5<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                 minrh +  (1|location)+ (1|method) +(1|location/method),
                       data= new_df_gdd,
                     refine.n = 500)
model5
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 9 39
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124825.4 -124817.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 938.82 7.00 0 924.82 871.73
##  Penalized loglik 953.95 5.88 0 942.19 897.60
##
## Model:  Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd + minrh +      (1 | location) + (1
## Fixed coefficients
##                        coef exp(coef)     se(coef)     z       p
## photoperiod    0.226570986 1.2542916 0.0143057025 15.84 0.0e+00
## daily_acc_gdd -0.034128961 0.9664469 0.0048215336 -7.08 1.5e-12
## minrh         -0.001948192 0.9980537 0.0007209165 -2.70 6.9e-03
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location        Intercept   0.1101525704 0.0121335888
##  method          Intercept   0.1877169823 0.0352376654
##  location/method (Intercept) 0.0565113032 0.0031935274
##  location        (Intercept) 0.0200821798 0.0004032939
```

```
exp(confint(model5))
```

```
##                    2.5 %    97.5 %
## photoperiod   1.2196114 1.2899580
## daily_acc_gdd 0.9573569 0.9756231
## minrh         0.9966445 0.9994649
```

```
model6<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                maxrh +  (1|location)+ (1|method) +(1|location/method),
                      data= new_df_gdd,
                   refine.n = 500)
model6
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124826.7 -124819.2
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 936.33 7.00 0 922.33 869.23
##  Penalized loglik 951.34 5.88 0 939.58 894.97
##
## Model:  Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd + maxrh +      (1 | location) + (1
## Fixed coefficients
##                        coef exp(coef)    se(coef)     z       p
## photoperiod    0.234914074 1.2648001 0.013435830 17.48 0.0e+00
```

```
## daily_acc_gdd -0.036782977 0.9638853 0.004570898 -8.05 8.9e-16
## maxrh         -0.002234293 0.9977682 0.001019907 -2.19 2.8e-02
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location        Intercept   0.0988189755 0.0097651899
##  method          Intercept   0.1885398049 0.0355472580
##  location/method (Intercept) 0.0572684653 0.0032796771
##  location        (Intercept) 0.0200136511 0.0004005462
```

```
exp(confint(model6))
```

```
##                   2.5 %    97.5 %
## photoperiod   1.2319279 1.2985494
## daily_acc_gdd 0.9552886 0.9725593
## maxrh         0.9957757 0.9997647
```

```
#model 1.
model1<- coxme(Surv(total_lived, censored) ~ photoperiod + mwimax +
                (1|location/method),
                      data= new_df_gdd,
                    refine.n = 500)
exp(confint(model1))
```

```
##                 2.5 %    97.5 %
## photoperiod 1.1300733 1.1603089
## mwimax      0.5955683 0.7003171
```

```
model1
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 15 63
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124814.8 -124806.2
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 960.03 4.00 0 952.03 921.70
##  Penalized loglik 977.21 4.97 0 967.27 929.56
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mwimax + (1 | location/method)
## Fixed coefficients
##                    coef exp(coef)    se(coef)      z p
## photoperiod  0.1354843 1.1450913 0.006735782  20.11 0
## mwimax      -0.4372306 0.6458225 0.041331645 -10.58 0
##
## Random effects
##  Group           Variable    Std Dev    Variance
##  location/method (Intercept) 0.19264862 0.03711349
##  location        (Intercept) 0.01995370 0.00039815
```

```
model2<- coxme(Surv(total_lived, censored) ~ photoperiod + mwimin  +
                     (1|location/method),
                      data= new_df_gdd,
                    refine.n = 500)
exp(confint(model2))
```

```
##                 2.5 %    97.5 %
## photoperiod 1.1707982 1.2040969
## mwimin      0.6206863 0.7232794
```

```
model2
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                       NULL Integrated    Fitted
## Log-likelihood -125294.8  -124816.5 -124807.7
##
##                     Chisq   df p    AIC    BIC
## Integrated loglik 956.72 4.00 0 948.72 918.38
##  Penalized loglik 974.26 4.97 0 964.31 926.59
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mwimin + (1 | location/method)
## Fixed coefficients
##                    coef exp(coef)    se(coef)      z p
## photoperiod  0.1717078 1.1873309 0.007154239  24.00 0
## mwimin      -0.4004446 0.6700221 0.039023601 -10.26 0
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.2045801805 0.0418530503
##  location        (Intercept) 0.0200165318 0.0004006615
```

```
model3<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+
                minrh  +
                (1|location/method),
                      data= new_df_gdd,
                    refine.n = 500)
exp(confint(model3))
```

```
##                    2.5 %    97.5 %
## photoperiod    1.2033181 1.2637304
## mintemperature 0.9651665 0.9804284
## minrh          0.9971897 1.0002029
```

```
model3
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
```

```
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124827.6 -124818.9
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 934.50 5.00 0 924.50 886.57
##  Penalized loglik 951.79 5.97 0 939.85 894.57
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mintemperature +      minrh + (1 | location/metho
## Fixed coefficients
##                         coef exp(coef)     se(coef)     z       p
## photoperiod     0.209575370 1.2331543 0.0124964430 16.77 0.0e+00
## mintemperature -0.027610188 0.9727675 0.0040023592 -6.90 5.3e-12
## minrh          -0.001305713 0.9986951 0.0007697027 -1.70 9.0e-02
##
## Random effects
##  Group           Variable    Std Dev     Variance
##  location/method (Intercept) 0.196501057 0.038612666
##  location        (Intercept) 0.019980315 0.000399213
```

```
model4<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ maxrh
               +(1|location/method),
                       data= new_df_gdd,
                     refine.n = 500)
model4
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 20 83
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8    -124827 -124818.3
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 935.71 5.00 0 925.71 887.78
##  Penalized loglik 953.07 5.96 0 941.15 895.93
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mintemperature +      maxrh + (1 | location/metho
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## photoperiod     0.213791169 1.2383640 0.011176730 19.13 0.0e+00
## mintemperature -0.029122813 0.9712972 0.003575448 -8.15 3.3e-16
## maxrh          -0.002105785 0.9978964 0.001027169 -2.05 4.0e-02
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1707284026 0.0291481874
##  location        (Intercept) 0.0199523569 0.0003980965
```

```
exp(confint(model4))
```

```
##                    2.5 %    97.5 %
## photoperiod    1.2115314 1.2657909
```

```
## mintemperature 0.9645144 0.9781277
## maxrh          0.9958895 0.9999074
```

```
model5<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                minrh +(1|location/method),
                      data= new_df_gdd,
                   refine.n = 500)
model5
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 15 63
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124826.3 -124817.8
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 937.04 5.00 0 927.04 889.11
##  Penalized loglik 954.01 5.97 0 942.08 896.82
##
## Model:  Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd + minrh +      (1 | location/metho
## Fixed coefficients
##                        coef exp(coef)     se(coef)     z       p
## photoperiod    0.226774028 1.2545463 0.0143116948 15.85 0.0e+00
## daily_acc_gdd -0.034196769 0.9663813 0.0048229496 -7.09 1.3e-12
## minrh         -0.001952791 0.9980491 0.0007211123 -2.71 6.8e-03
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1866119549 0.0348240217
##  location        (Intercept) 0.0199034091 0.0003961457
```

```
exp(confint(model5))
```

```
##                    2.5 %    97.5 %
## photoperiod   1.2198448 1.2902351
## daily_acc_gdd 0.9572894 0.9755597
## minrh         0.9966395 0.9994607
```

```
model6<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                maxrh +(1|location/method),
                      data= new_df_gdd,
                   refine.n = 500)
model6
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 9 39
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124827.6 -124819.1
##
```

```
##                     Chisq   df p    AIC    BIC
## Integrated loglik 934.53 5.00 0 924.53 886.61
##  Penalized loglik 951.40 5.97 0 939.46 894.20
##
## Model:  Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd + maxrh +      (1 | location/metho
## Fixed coefficients
##                        coef exp(coef)    se(coef)     z       p
## photoperiod    0.235091170 1.2650241 0.013440504 17.49 0.0e+00
## daily_acc_gdd -0.036848417 0.9638222 0.004571936 -8.06 7.8e-16
## maxrh         -0.002246447 0.9977561 0.001020021 -2.20 2.8e-02
##
## Random effects
##  Group           Variable    Std Dev      Variance
##  location/method (Intercept) 0.1828429839 0.0334315568
##  location        (Intercept) 0.0198360970 0.0003934707
```

```
exp(confint(model6))
```

```
##                    2.5 %    97.5 %
## photoperiod   1.2321348 1.2987913
## daily_acc_gdd 0.9552242 0.9724977
## maxrh         0.9957633 0.9997528
```

```
model1<- coxme(Surv(total_lived, censored) ~ photoperiod + mwimax +
                 (1|location)+ (1|method),
                       data= new_df_gdd,
                     refine.n = 500)
exp(confint(model1))
```

```
##                  2.5 %    97.5 %
## photoperiod 1.1297074 1.1598882
## mwimax      0.6008167 0.7062354
```

```
model1
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                      NULL Integrated    Fitted
## Log-likelihood -125294.8  -124817.7 -124811.6
##
##                     Chisq   df p    AIC    BIC
## Integrated loglik 954.19 4.00 0 946.19 915.85
##  Penalized loglik 966.57 3.99 0 958.60 928.34
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mwimax + (1 | location) +      (1 | method)
## Fixed coefficients
##                    coef exp(coef)    se(coef)      z p
## photoperiod  0.1351411  1.144698 0.006725865  20.09 0
## mwimax      -0.4286360  0.651397 0.041240251 -10.39 0
##
```

```
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.15703634 0.02466041
##  method   Intercept 0.18696861 0.03495726
```

```
model2<- coxme(Surv(total_lived, censored) ~ photoperiod + mwimin  +
                      (1|location)+ (1|method),
                      data= new_df_gdd,
                    refine.n = 500)
exp(confint(model2))
```

```
##                 2.5 %   97.5 %
## photoperiod 1.1698696 1.203090
## mwimin      0.6226763 0.725606
```

```
model2
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 8 35
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124818.4 -124812.1
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 952.86 4.00 0 944.86 914.52
##  Penalized loglik 965.53 3.99 0 957.56 927.30
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mwimin + (1 | location) +      (1 | method)
## Fixed coefficients
##                   coef exp(coef)    se(coef)      z p
## photoperiod  0.1708929 1.1863636 0.007143294  23.92 0
## mwimin      -0.3972383 0.6721738 0.039026294 -10.18 0
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.17838417 0.03182091
##  method   Intercept 0.18860585 0.03557217
```

```
model3<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ minrh  +
                      (1|location)+ (1|method),
                      data= new_df_gdd,
                    refine.n = 500)
exp(confint(model3))
```

```
##                    2.5 %    97.5 %
## photoperiod    1.2006985 1.2608279
## mintemperature 0.9657730 0.9810171
## minrh          0.9971385 1.0001506
```

```
model3
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124829.7 -124823.4
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 930.30 5.00 0 920.30 882.38
##  Penalized loglik 942.78 4.99 0 932.81 894.97
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mintemperature +      minrh + (1 | location) + (
## Fixed coefficients
##                         coef exp(coef)     se(coef)     z       p
## photoperiod     0.207336042 1.2303960 0.0124658166 16.63 0.0e+00
## mintemperature -0.026995897 0.9733652 0.0039952458 -6.76 1.4e-11
## minrh          -0.001357516 0.9986434 0.0007694615 -1.76 7.8e-02
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.16321155 0.02663801
##  method   Intercept 0.18919189 0.03579357
```

```
model4<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ maxrh  +
                     (1|location)+ (1|method),
                     data= new_df_gdd,
                   refine.n = 500)
model4
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated  Fitted
## Log-likelihood -125294.8  -124829.2 -124823
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 931.30 5.00 0 921.30 883.37
##  Penalized loglik 943.74 4.99 0 933.77 895.93
##
## Model:  Surv(total_lived, censored) ~ photoperiod + mintemperature +      maxrh + (1 | location) + (
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z       p
## photoperiod     0.212027651 1.2361821 0.011155033 19.01 0.0e+00
## mintemperature -0.028670079 0.9717370 0.003571549 -8.03 1.0e-15
## maxrh          -0.002085955 0.9979162 0.001026868 -2.03 4.2e-02
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.16046354 0.02574855
##  method   Intercept 0.18937600 0.03586327
```

```
exp(confint(model4))
```

```
##                     2.5 %    97.5 %
## photoperiod    1.2094482 1.2635069
## mintemperature 0.9649585 0.9785631
## maxrh          0.9959098 0.9999267
```

```
model5<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                minrh +  (1|location)+ (1|method),
                      data= new_df_gdd,
                   refine.n = 500)
model5
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124828.7 -124822.6
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 932.24 5.00 0 922.24 884.32
##  Penalized loglik 944.41 4.99 0 934.44 896.63
##
## Model:  Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd + minrh +      (1 | location) + (1
## Fixed coefficients
##                        coef exp(coef)     se(coef)     z       p
## photoperiod    0.223690982 1.2506845 0.0142709410 15.67 0.0e+00
## daily_acc_gdd -0.033252344 0.9672944 0.0048123984 -6.91 4.9e-12
## minrh         -0.001991426 0.9980106 0.0007211321 -2.76 5.8e-03
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.13652897 0.01864016
##  method   Intercept 0.18758851 0.03518945
```

```
exp(confint(model5))
```

```
##                     2.5 %    97.5 %
## photoperiod   1.2161869 1.2861606
## daily_acc_gdd 0.9582137 0.9764612
## minrh         0.9966010 0.9994221
```

```
model6<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                maxrh +  (1|location)+ (1|method),
                      data= new_df_gdd,
                   refine.n = 500)
model6
```

```
## Cox mixed-effects model fit by maximum likelihood
##   Data: new_df_gdd
```

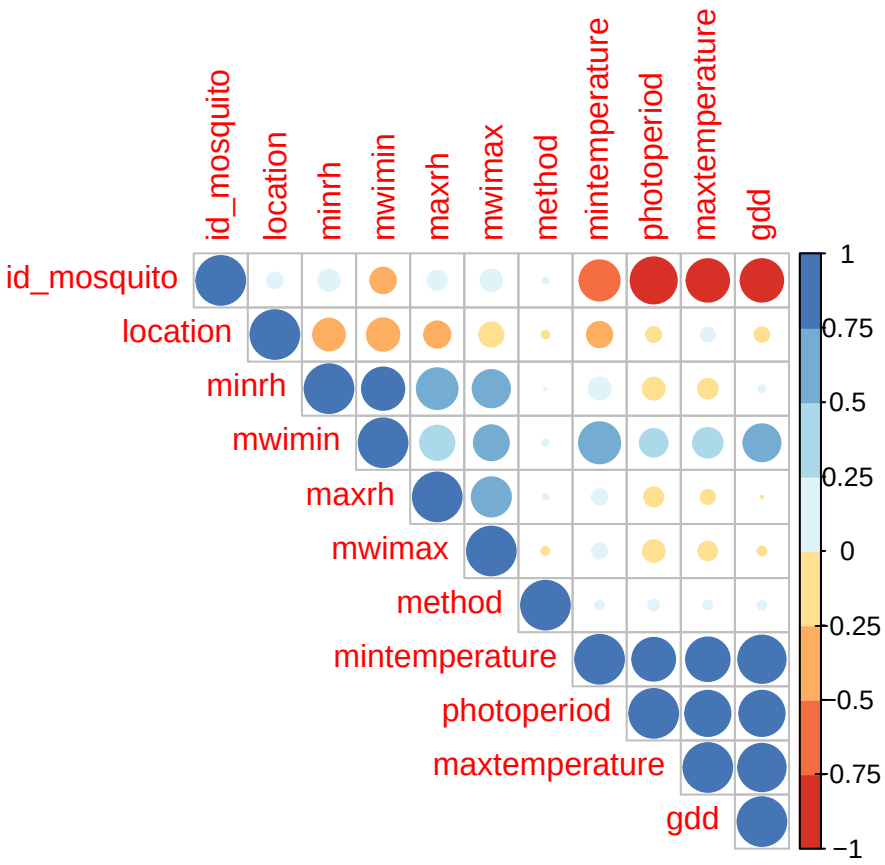
```
##   events, n = 14541, 15154
##   Iterations= 7 31
##                     NULL Integrated    Fitted
## Log-likelihood -125294.8  -124830.2 -124824.2
##
##                    Chisq   df p    AIC    BIC
## Integrated loglik 929.35 5.00 0 919.35 881.43
##  Penalized loglik 941.38 4.99 0 931.41 893.60
##
## Model:  Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd + maxrh +      (1 | location) + (1
## Fixed coefficients
##                         coef exp(coef)    se(coef)     z     p
## photoperiod    0.232384329 1.2616045 0.013404758 17.34 0e+00
## daily_acc_gdd -0.036011444 0.9646293 0.004562784 -7.89 3e-15
## maxrh         -0.002218578 0.9977839 0.001019847 -2.18 3e-02
##
## Random effects
##  Group    Variable  Std Dev    Variance
##  location Intercept 0.12737395 0.01622412
##  method   Intercept 0.18760716 0.03519644
```

```
exp(confint(model6))
```

```
##                    2.5 %    97.5 %
## photoperiod   1.2288902 1.2951897
## daily_acc_gdd 0.9560411 0.9732945
## maxrh         0.9957914 0.9997803
```

looking for correlation

```
library(corrplot)
library(RColorBrewer)

t = cbind(new_df_gdd$id_mosquito, new_df_gdd$method, new_df_gdd$location, new_df_gdd$maxtemperature,
      new_df_gdd$mintemperature, new_df_gdd$minrh, new_df_gdd$maxrh, new_df_gdd$photoperiod,new_df_gdd$
      new_df_gdd$mwimax, new_df_gdd$mwimin)
colnames(t) <- c("id_mosquito", "method", "location", "maxtemperature", "mintemperature", "minrh","maxrh

t<- as.data.frame(t)
M <-cor(t)
corrp<- corrplot(M, type="upper", order="hclust",
         col=brewer.pal(n=8, name="RdYlBu"))
```




```
#loglik calculation in normal cox

cox3 <- coxph(formula = Surv(total_lived, censored) ~ photoperiod + mintemperature +
    minrh, data = new_df_gdd)
cox3$loglik #-124994.3
```

```
## [1] -125294.8 -124994.3
```

```
cox6 <- coxph(formula = Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
    maxrh, data = new_df_gdd)
cox6$loglik #-124975.3
```

```
## [1] -125294.8 -124975.3
```

```
#loglik calculation with levels: COX vs INTERACTION+LEVELS
model3all<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ minrh  +
                    (1|location)+ (1|method) +(1|location/method),
                    data= new_df_gdd,
                  refine.n = 500)  #loglik -124826.7
  2*(-124826.7+124994.3) #335.2
```

```
## [1] 335.2
```

```
  pchisq(335.2,5,lower.tail = F) #2.684731e-70
```

```
## [1] 2.684731e-70
```

```
model6all<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                maxrh +  (1|location)+ (1|method) +(1|location/method),
                      data= new_df_gdd,
                    refine.n = 500) #loglik -124826.7
  2*(-124826.7+124975.3) #297.2
```

```
## [1] 297.2
```

```
  pchisq(297.2,5,lower.tail = F) #4.005055e-62
```

```
## [1] 4.005055e-62
```

```
#loglik calculation with levels: Cox with separated interactions
model3sep<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ minrh  +
                      (1|location)+ (1|method),
                      data= new_df_gdd,
                    refine.n = 500) #loglik -124829.7
2*(-124829.7+124994.3) #329.2
```

```
## [1] 329.2
```

```
  pchisq(329.2,5,lower.tail = F) #5.249144e-69
```

```
## [1] 5.249144e-69
```

```
model6sep<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                maxrh +  (1|location)+ (1|method),
                      data= new_df_gdd,
                    refine.n = 500) #loglik -124830.2
2*(-124830.2+124975.3) #290.2
```

```
## [1] 290.2
```

```
  pchisq(290.2,5,lower.tail = F) #1.280022e-60
```

```
## [1] 1.280022e-60
```

```
#loglik calculations with levels: COX vs interaction
model3all<- coxme(Surv(total_lived, censored) ~ photoperiod + mintemperature+ minrh  +
                      (1|location/method),
                      data= new_df_gdd,
                    refine.n = 500)  #loglik -124827.6
  2*(-124827.6+124994.3) #333.4
```

```
## [1] 333.4
```

```
  pchisq(333.4,5,lower.tail = F) #6.550569e-70
```

```
## [1] 6.550569e-70
```

```
model6all<- coxme(Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd  +
                maxrh +(1|location/method),
                      data= new_df_gdd,
                    refine.n = 500) #loglik -124827.6
  2*(-124827.6+124975.3) #295.4
```

```
## [1] 295.4
```

```
  pchisq(295.4,5,lower.tail = F) #9.762086e-62
```

```
## [1] 9.762086e-62
```

##CHECK ASSUMPTIONS

```
#cox.zph(model6)
#ggcoxzph(cox.zph(model6))

#cox.zph(model3)
#ggcoxzph(cox.zph(model3))

sample <- sample_n(new_df_gdd, 1850)
coxph_sample <- coxph(formula = Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
    maxrh, data = sample)
coxph_sample
```

```
## Call:
## coxph(formula = Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
##     maxrh, data = sample)
##
##                     coef exp(coef)  se(coef)      z        p
## photoperiod    0.270691  1.310870  0.036614  7.393 1.44e-13
## daily_acc_gdd -0.040107  0.960687  0.012202 -3.287  0.00101
## maxrh          0.006589  1.006611  0.002805  2.349  0.01882
##
## Likelihood ratio test=83.45  on 3 df, p=< 2.2e-16
## n= 1850, number of events= 1774
```

```
cox.zph(coxph_sample)
```

```
##               chisq df    p
## photoperiod   1.639  1 0.20
## daily_acc_gdd 0.772  1 0.38
## maxrh         0.336  1 0.56
## GLOBAL        2.418  3 0.49
```

```
# samplerandom<- function(location, method){
#   new_df_gdd2<- new_df_gdd %>%
#     group_by(location) %>%
#     case_when(method="BG" ~ 0)
#   sample <- sample_n(new_df_gdd, 50)
#   coxph_sample <- coxph(formula = Surv(total_lived, censored) ~ photoperiod + daily_acc_gdd +
#     maxrh, data = sample)
# }
```