Supplementary File 1. Code used for the microclimatic model.

The code was based on Toro Cardona FA, Parra JL, Rojas-Soto, OR. 2023. Predicting daily activity time through ecological niche modeling and microclimatic data. Journal of Animal Ecology, 92, 925–935. https://doi.org/10.1111/1365-2656.13895

install.packages("ncdf4")

library(devtools)

install\_github('mrke/NicheMapR')

library(NicheMapR)

library(ncdf4)

vignette("microclimate-model-tutorial", package = "NicheMapR")

help("micro\_global")

loc: Longitude and latitude (decimal degrees)

timeinterval: The number of time intervals to generate predictions for over a year (must be 12 <= x <=365)

nyears: The number of years to run

soiltype: Rock = 0, sand = 1, loamy sand = 2, sandy loam = 3, loam = 4, silt loam = 5, sandy clay loam = 6, clay loam = 7, silt clay loam = 8, sandy clay = 9, silty clay = 10, clay = 11, user-defined = 12, based on Campbell and Norman 1990 Table 9.1.

REFL: Soil solar reflectance, decimal %

elev: Elevation, if to be user specified (m)

slope: Slope in degrees

aspect: Aspect in degrees (0 = north)

DEP: Soil depths at which calculations are to be made (cm), must be 10 values starting from 0, and more closely spaced near the surface

minshade: Minimum shade level to use (%)

maxshade: Maximum shade level to use (%)

Usrhyt: Local height (m) at which air temperature, wind speed and humidity are to be computed for organism of interest

nc\_data <- nc\_open('global\_climate.nc')

longlat<-c(-23.30350908, 65.98345656)

mod\_1p\_1m<-micro\_global(loc = longlat, timeinterval =365 , nyears=1, soiltype = 9, Usrhyt = 1 , elev= 2692, slope= 9.39, aspect= 64.9 , minshade = 0, maxshade =48 )

mod\_1p\_1cm<-micro\_global(loc = longlat, timeinterval =365 , nyears=1, soiltype = 9, Usrhyt = 0.01 , elev= 2692, slope= 9.39, aspect= 64.9 , minshade = 0, maxshade =48)

head(mod\_1p\_1m$metout)

head(mod\_1p\_1cm$metout)

output\_1m<-mod\_1p\_1m$metout %>% as.data.frame()

output\_1cm<-mod\_1p\_1cm$metout %>% as.data.frame()

write.csv(output\_1m, "example.csv")

library(tidyverse)

31+28+31+30+31+30+12

jul12\_1m<- output\_1m %>% filter(DOY==193)

jul12\_1cm<- output\_1cm %>% filter(DOY==193)

head(jul12\_1cm)

graf<-ggplot()+

 geom\_line(data=jul12\_1cm, aes(x=TIME, y=TALOC), col="black", size=1)+

 geom\_line(data=jul12\_1m, aes(x=TIME, y=TALOC), col="blue", size=1)+

 labs(x="Hour", y= "Temperature (°C)")+

 theme\_bw()

graf

vignette("microclimate-model-theory-equations", package = "NicheMapR")

vignette("microclimate-model-IO", package = "NicheMapR")

vignette("ectotherm-model-tutorial", package = "NicheMapR")

diasmes<-rep(1:12, times =c(31,28,31,30,31,30,31,31,30,31,30,31))

filas <- 12\* 24

clima <- data.frame( longitud= rep(NA,filas), latitud=rep(NA,filas) ,Mes=rep(NA,filas), Hora=rep(NA,filas),Tmin=rep(NA,filas),Tmax=rep(NA,filas), Tprom=rep(NA,filas), Hrmin=rep(NA,filas), Hrmax=rep(NA,filas), Hrprom=rep(NA,filas), Wvmin=rep(NA,filas), Wvmax=rep(NA, filas), Wvprom=rep(NA, filas))

ind <- seq(0,dim(clima)[1], 12)

micro\_surface <- function(x) {

 temp <- micro\_global(loc= x[2:3], timeinterval= 365, nyears= 1, soiltype= x[9], elev= x[6], slope= x[7], aspect= x[8], minshade= x[4], maxshade=x[5], Usrhyt= 0.5)$metout

 horas <- unique(temp[,2])

 meses<-rep(c(1,2,3,4,5,6,7,8,9,10,11,12), times=24, length.out=288)

 for(i in 1:24) {

 tiempox <- subset(data.frame(temp), TIME==horas[i])

 tmean <- tapply(tiempox$TALOC, INDEX=diasmes, FUN=mean)

 tmin <- tapply(tiempox$TALOC, INDEX=diasmes, FUN=min)

 tmax <- tapply(tiempox$TALOC, INDEX=diasmes, FUN=max)

 hrmean <- tapply(tiempox$RHLOC, INDEX=diasmes, FUN=mean)

 hrmin <- tapply(tiempox$RHLOC, INDEX=diasmes, FUN=min)

 hrmax <- tapply(tiempox$RHLOC, INDEX=diasmes, FUN=max)

 wvmean <- tapply(tiempox$VLOC, INDEX=diasmes, FUN=mean)

 wvmin <- tapply(tiempox$VLOC, INDEX=diasmes, FUN=min)

 wvmax <- tapply(tiempox$VLOC, INDEX=diasmes, FUN=max)

 clima[(ind[i]+1):ind[i+1],1] <- x[2]

 clima[(ind[i]+1):ind[i+1],2] <- x[3]

 clima[(ind[i]+1):ind[i+1],3] <- 1:12

 clima[(ind[i]+1):ind[i+1],4] <- horas[i]

 clima[(ind[i]+1):ind[i+1],5] <- tmin

 clima[(ind[i]+1):ind[i+1],6] <- tmax

 clima[(ind[i]+1):ind[i+1],7] <- tmean

 clima[(ind[i]+1):ind[i+1],8] <- hrmin

 clima[(ind[i]+1):ind[i+1],9] <- hrmax

 clima[(ind[i]+1):ind[i+1],10] <- hrmean

 clima[(ind[i]+1):ind[i+1],11] <- wvmin

 clima[(ind[i]+1):ind[i+1],12] <- wvmax

 clima[(ind[i]+1):ind[i+1],13] <- wvmean

 }

 return(clima)

}

data<-read.csv("D:/ESCUELA AMBIENTAL SIG/Modelos microclimaticos/Data\_inpunt\_table/Tabla\_input.csv", header=T)

head(data)

modelo <- apply(data, 1, micro\_surface)

dim(modelo[[1]])

tabla <- do.call('rbind', modelo)

write.table (tabla, file="Modelo\_microclim\_AF.txt", sep= "\t")

diasmes<-rep(1:12, times =c(31,28,31,30,31,30,31,31,30,31,30,31))

filas <- 12\* 24

clima <- data.frame( longitud= rep(NA,filas), latitud=rep(NA,filas) ,Mes=rep(NA,filas), Hora=rep(NA,filas),Tmin=rep(NA,filas),Tmax=rep(NA,filas), Tprom=rep(NA,filas), Hrmin=rep(NA,filas), Hrmax=rep(NA,filas), Hrprom=rep(NA,filas), Wvmin=rep(NA,filas), Wvmax=rep(NA, filas), Wvprom=rep(NA, filas))

ind <- seq(0,dim(clima)[1], 12)

micro\_surface <- function(x) {

 temp <- micro\_global(loc= x[2:3], timeinterval= 365, nyears= 1, soiltype= x[9], elev= x[6], slope= x[7], aspect= x[8], minshade= x[4], maxshade=x[5], Usrhyt= 0.5)$metout

 horas <- unique(temp[,2])

 meses<-rep(c(1,2,3,4,5,6,7,8,9,10,11,12), times=24, length.out=288)

 for(i in 1:24) {

 tiempox <- subset(data.frame(temp), TIME==horas[i])

 tmean <- tapply(tiempox$TALOC, INDEX=diasmes, FUN=mean)

 tmin <- tapply(tiempox$TALOC, INDEX=diasmes, FUN=min)

 tmax <- tapply(tiempox$TALOC, INDEX=diasmes, FUN=max)

 hrmean <- tapply(tiempox$RHLOC, INDEX=diasmes, FUN=mean)

 hrmin <- tapply(tiempox$RHLOC, INDEX=diasmes, FUN=min)

 hrmax <- tapply(tiempox$RHLOC, INDEX=diasmes, FUN=max)

 wvmean <- tapply(tiempox$VLOC, INDEX=diasmes, FUN=mean)

 wvmin <- tapply(tiempox$VLOC, INDEX=diasmes, FUN=min)

 wvmax <- tapply(tiempox$VLOC, INDEX=diasmes, FUN=max)

 clima[(ind[i]+1):ind[i+1],1] <- x[2]

 clima[(ind[i]+1):ind[i+1],2] <- x[3]

 clima[(ind[i]+1):ind[i+1],3] <- 1:12

 clima[(ind[i]+1):ind[i+1],4] <- horas[i]

 clima[(ind[i]+1):ind[i+1],5] <- tmin

 clima[(ind[i]+1):ind[i+1],6] <- tmax

 clima[(ind[i]+1):ind[i+1],7] <- tmean

 clima[(ind[i]+1):ind[i+1],8] <- hrmin

 clima[(ind[i]+1):ind[i+1],9] <- hrmax

 clima[(ind[i]+1):ind[i+1],10] <- hrmean

 clima[(ind[i]+1):ind[i+1],11] <- wvmin

 clima[(ind[i]+1):ind[i+1],12] <- wvmax

 clima[(ind[i]+1):ind[i+1],13] <- wvmean

 }

 return(clima)

}

data<-read.csv("D:/ESCUELA AMBIENTAL SIG/Modelos microclimaticos/Data\_inpunt\_table/Tabla\_input.csv", header=T)

head(data)

modelo <- apply(data, 1, micro\_surface)

tabla <- do.call('rbind', modelo)

write.table (tabla, file="Modelo\_microclim\_AF.txt", sep= "\t")

mod1<-read.table("Modelo\_microclim\_AF.txt", sep= "\t", header = T)

library(dplyr)

unique(mod1$Hora)

jun10<-mod1 %>% filter(Mes==6, Hora==600)

write.csv(example.csv")

library(raster)

ref<-raster("Raster\_referencia.tif")

horas<-c(480, 540, 600, 660, 720, 780, 840, 900, 960, 1020, 1080, 1140, 1200)

horas

meses<-unique(mod1$Mes)

meses

ras\_k\_t<-stack()

tabla\_t <- data.frame(mes=rep(c(1:12), each=13), horas=horas,tmin=NA, tmax=NA, tprom=NA)

u=1

for (i in 1:12) {

 for (j in 1:length(horas)){

 vars\_hm\_t<-subset(mod1, Mes== meses[i] & Hora== horas[j])

 ras\_t <- rasterize(vars\_hm\_t[,1:2], y = ref, field=vars\_hm\_t$Tprom)

 ras\_k\_t <- addLayer(ras\_k\_t, ras\_t)

 u=u+1

 }

}

ene480<-subset(mod1, Hora==480 & Mes==1)

max(ene480$Tmax)

min(ene480$Tmax)

plot(ras\_k\_t[[1]])

summary(ras\_k\_t[[1]])

dir.create("Tmin\_12\_8\_20h")

writeRaster(ras\_k\_t, filename ="Tmin\_12\_8\_20h/Tmin\_" , bylayer=T, format="GTiff")

library(lattice)

library(latticeExtra)

library(rasterVis)

library(RColorBrewer)

library(raster)

#Example

cols <- colorRampPalette(c(c("#98F5FF", "#FF3030")))

map\_mosaic<-levelplot(mic\_enero[[c(1:12)]], main="Title", layout=c(3, 4), scales=list(draw=FALSE ), col.regions=cols)

map\_mosaic

tiff("Grafico\_enero\_tmax.tiff", width = 20, height = 25, units = "cm", res=250)

map\_mosaic

dev.off()