Appendix 2 - Validation of the microclimate model in Studenec, Czechia

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In this document we run NicheMapR's microclimate model at the Institute of Vertebrate Biology, Studenec (coordinates: 16.056838, 49.224799; Czechia) using NCEP data as forcing variables. We compare model results with logged data from November 2020 to April 2021.

Humidity and temperature dataloggers were placed outdoors of the institute at different depths.

Note: If you want to reproduce this script make sure you are in the same directory as the weather and datalogger data. It should be something like this:

```
setwd("./ThermHydroBehav/data/micro_studenec")
```

Parameters and running the model

Load packages:

```
library(NicheMapR)
library(microclima)
library(raster)
```

Set location (longitude and latitude for the IVB, Studenec, Czechia) and model parameters. Most model parameters take default values. To improve the fit of the model we decreased the thermal conductivity of the soil (`Thcond` from 2.5 to 1.5) and increased bulk density (`BulkDensity` from 1.3 to 2.45). In addition, we slightly increased the parameter that controls water runon (`rainmult` from 1 to 1.1). We also run the model for two shading levels: full sun (0% shade; `minshade <- 0`) and deep shade (90% shade; `maxshade <- 90`). These shading levels represents the extremes that an organisms may encounter in a given location, as well as all intermediate options (via interpolation).

```
lon <- 16.056838 # Institute of Vertebrate Biology, Studenec, Czechia
lat <- 49.224799 # Institute of Vertebrate Biology, Studenec, Czechia
dstart <- "01/08/2020"
dfinish <- "31/07/2021"
minshade <- 0
maxshade <- 90
rainmult <- 1.1
Thcond <- 1.5 # 2.5
SpecHeat <- 870
Density <- 2.56
BulkDensity <- 2.45 # 1.3
windfac <- 1
REFL <- 0.2
cap <- FALSE
SLE <- 0.95
warm <- 0
```

```r
Usrhyt <- 0.01
clearsky <- FALSE
soilgrids <- 0
spatial <- NA
ERR <- 1
```

We obtained a digital elevation model (DEM) for the study location using the `get_dem` function of the microclima R-package (citation), and downloaded it for later use. From the DEM we calculated elevation, slope and aspect, as well as the horizon angles, which impact on the incidence of solar radiation during the day.

```r
# dem <- microclima::get_dem(r = NA, lat = lat, lon = lon, resolution = 30,
#                            zmin = -20, xdims = 100, ydims = 100)
load("dem.Rda")

elev <- raster::extract(dem, cbind(lon, lat))[1]
xy <- data.frame(x = lon, y = lat)
sp::coordinates(xy) = ~x + y
sp::proj4string(xy) = "+init=epsg:4326"
xy <- as.data.frame(sp::spTransform(xy, raster::crs(dem)))
slope <- raster::terrain(dem, unit = "degrees")
slope <- raster::extract(slope, xy)
aspect <- raster::terrain(dem, opt = "aspect", unit = "degrees")
aspect <- raster::extract(aspect, xy)
ha36 <- 0
for (i in 0:35) {
  har <- microclima::horizonangle(dem, i * 10, raster::res(dem)[1])
  ha36[i + 1] <- atan(raster::extract(har, xy)) * (180/pi)
}
hori <- spline(x = ha36, n = 24, method =  'periodic')$y
hori[hori < 0] <- 0
hori[hori > 90] <- 90
```

With these parameters we run the model with the gads (`run.gads = 1`), soil moisture (`runmoist = 1`), and snow models (`snowmodel = 1`) turned on. In a first run, we set `save` to 1 to download environmental forcing variables from NCEP and store them locally. Then, we set `save = 2` to read in saved weather data in next runs (e.g. while testing parameter values).

```r
micro <- micro_ncep(loc = c(lon, lat), SLE = SLE, warm = warm, soilgrids = soilgrids,
                    dstart = dstart, dfinish = dfinish, Usrhyt = Usrhyt,
                    slope = slope, aspect = aspect, REFL = REFL,
                    hori = hori, minshade = minshade, maxshade = maxshade,
                    rainmult = rainmult, BulkDensity =  BulkDensity, cap = cap,
                    Density = Density, Thcond = Thcond, SpecHeat = SpecHeat,
                    windfac = windfac, spatial = spatial, ERR = ERR, dem = dem,
                    runshade = 1, run.gads = 1, snowmodel = 1, runmoist = 1,
                    save = 2)
```

Retrieve output for soil temperatures at full sun (`soil`), soil temperatures at maximum shade (`shadsoil`), relative humidity in soil at full sun (`humid`) and relative humidity in soil at maximum shade (`shadhumid`).

```r
soil <- data.frame(micro$soil) # soil temperatures at full sun
shadsoil <- data.frame(micro$shadsoil) # soil temperatures at maximum shade
humid <- data.frame(micro$humid) # RH in soil at full sun
shadhumid <- data.frame(micro$shadhumid) # RH in soil at maximum shade
```

Temperature at full sun

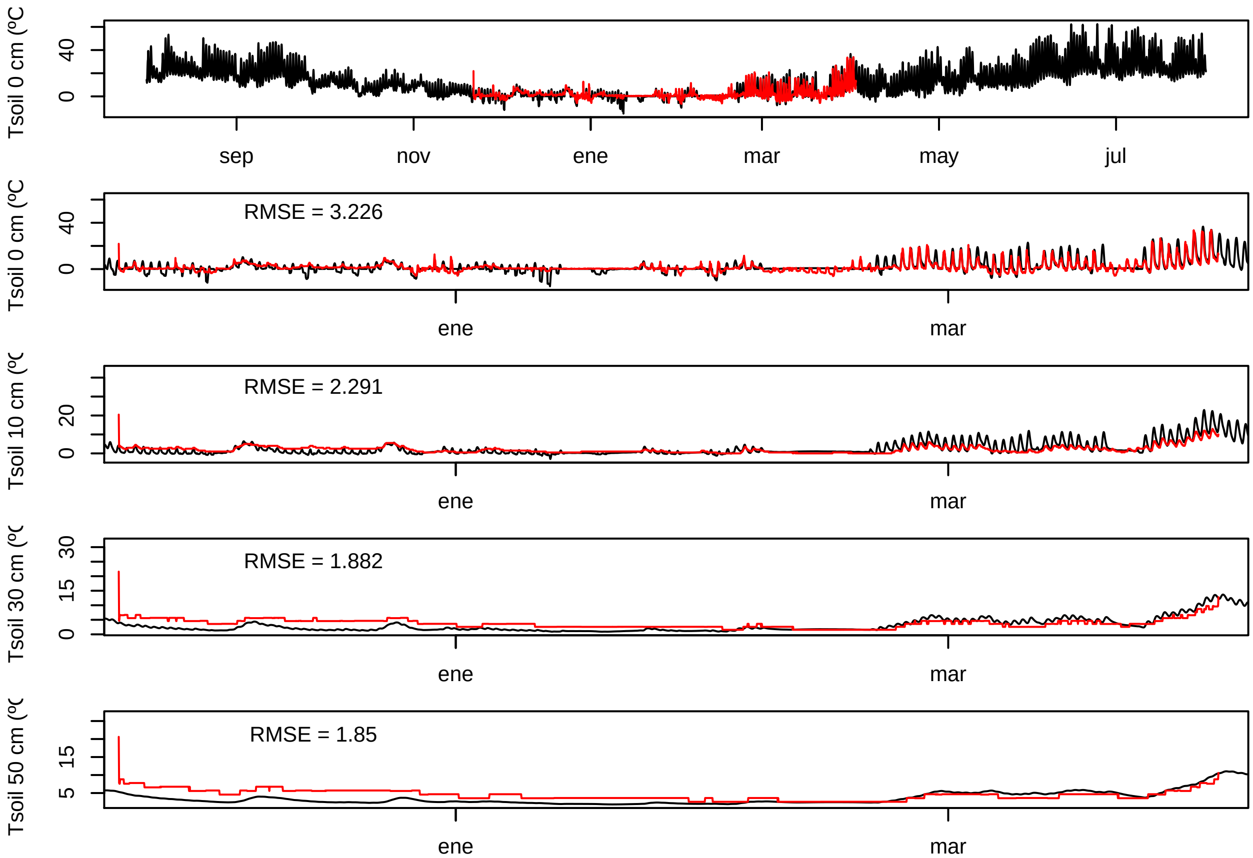

Figure S2.1: Simulated (black lines) and logged temperature data (red lines) at full sun from 01/08/2020 to 31/07/2021, and for the recorded period only at 0, 10, 30 and 50 cm deep.

Temperature at shade (90%)

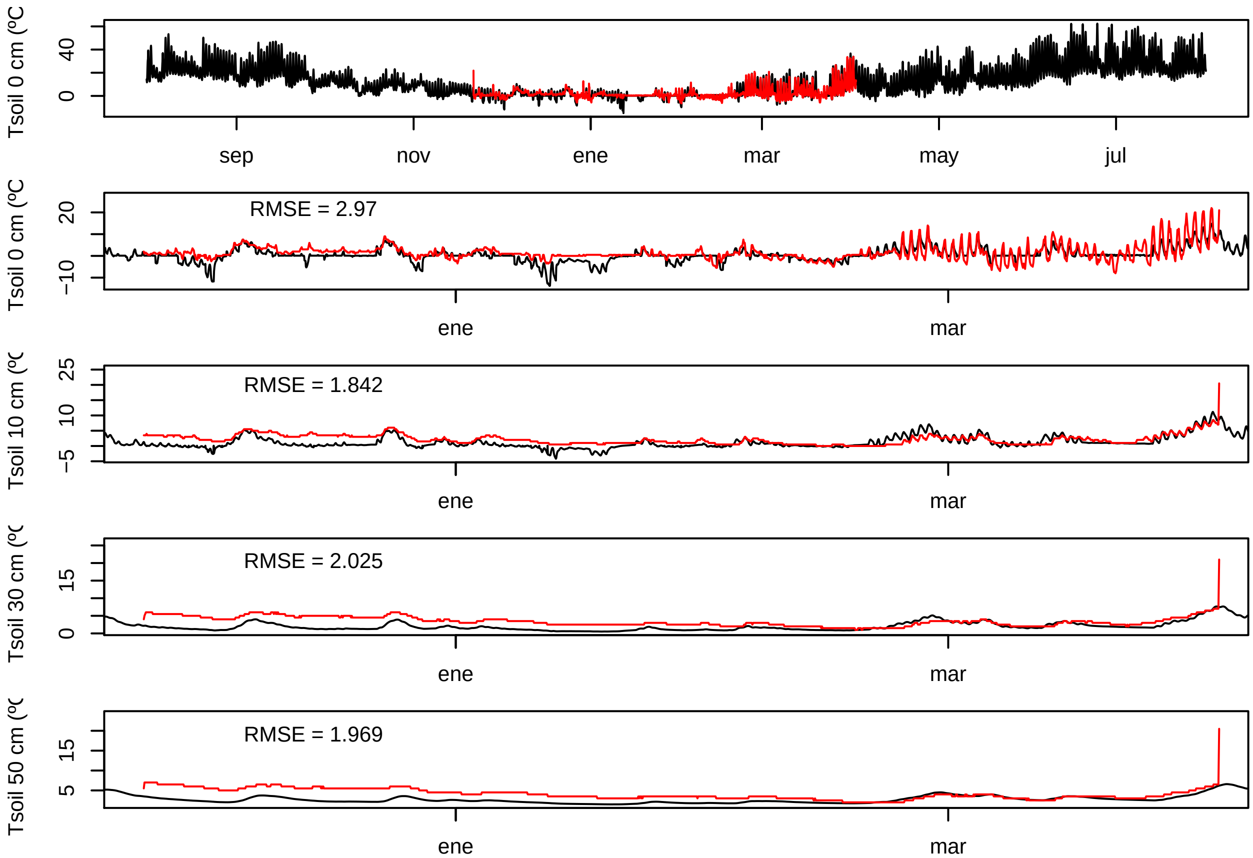

Figure S2.2: Simulated (black lines) and logged temperature data (red lines) at deep shade from 01/08/2020 to 31/07/2021, and for the recorded period only at 0, 10, 30 and 50 cm deep.

Humidity at full sun

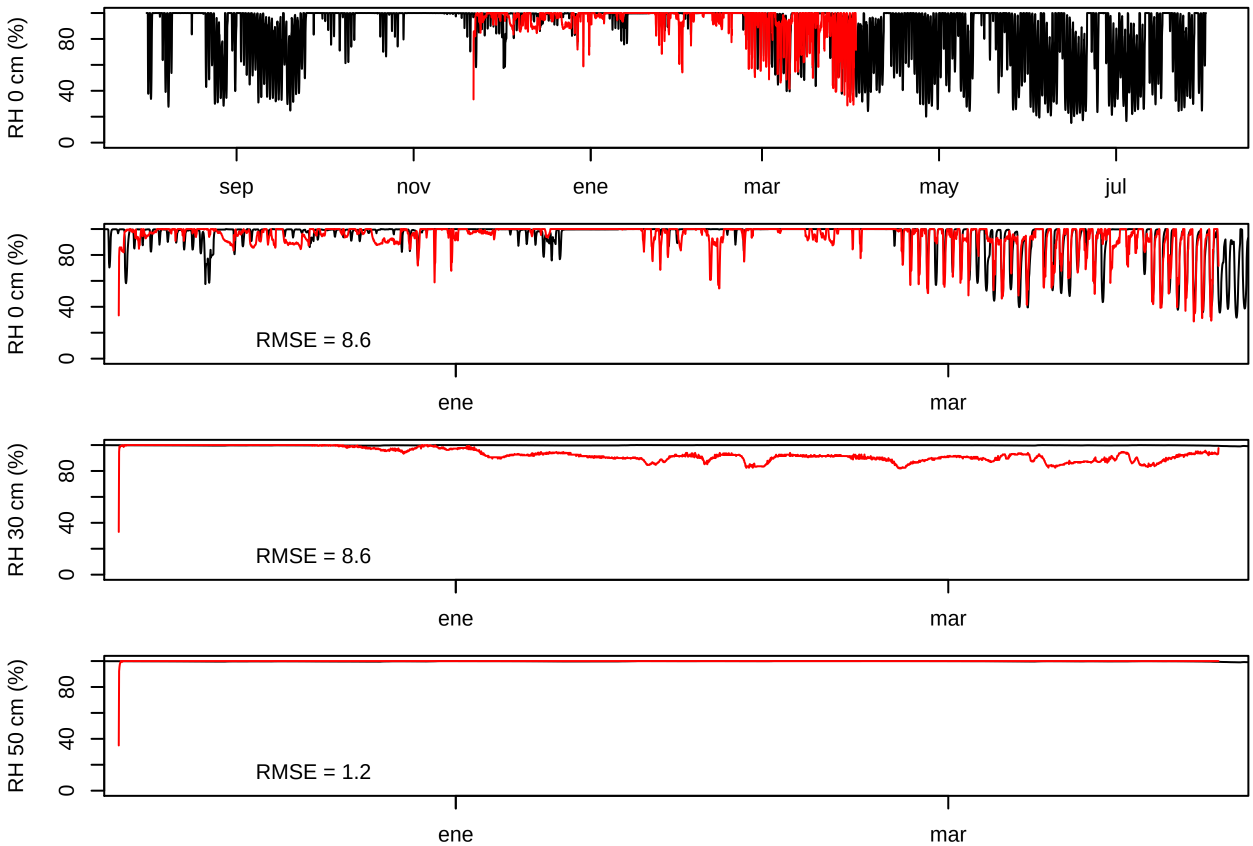

Figure S2.3: Simulated (black lines) and logged soil humidity (red lines) at full sun from 01/08/2020 to 31/07/2021, and for the recorded period only at 0, 10, 30 and 50 cm deep.

Humidity at shade (90%)

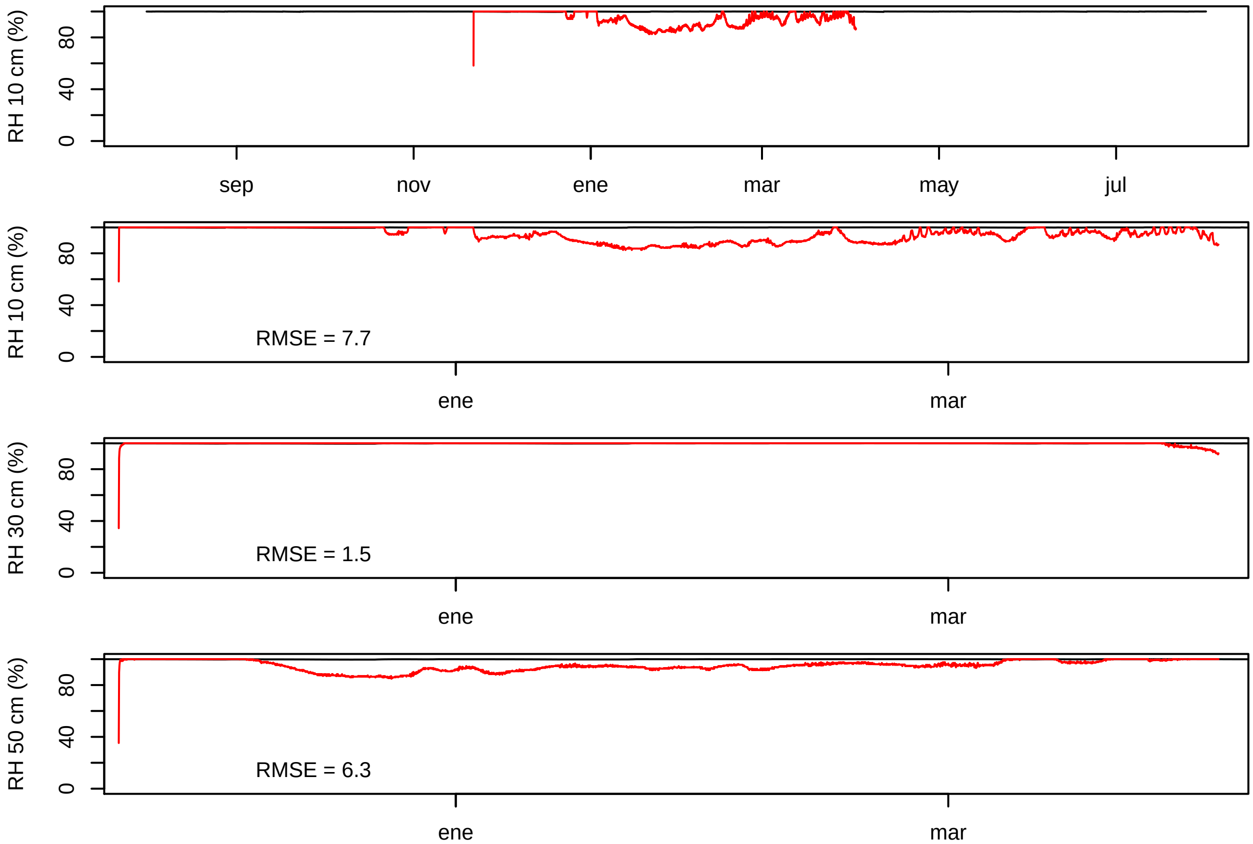

Figure S2.4: Simulated (black lines) and logged soil humidity (red lines) at deep shade from 01/08/2020 to 31/07/2021, and for the recorded period only at 0, 10, 30 and 50 cm deep.