

warmXtrophic: HOBO analyses

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DATA INPUT: CSV files are located in the HOBO_data folder in the shared Google drive

DATA OUTPUT: Computes different averages + error for hobo variables measured at each site

```
# clear all existing data
rm(list=ls())

# load in packages and set working directory
library(tidyverse)
library(plotrix)
library(ggpubr)
library(rstatix)

# Set working directory
L1_dir<-Sys.getenv("L1DIR")

# load in the data
KBS <- read.csv(file.path(L1_dir,"HOBO_data/HOBO_paired_sensor_data/KBS/KBS_pairedsensors_L1.csv"))
UMBS <- read.csv(file.path(L1_dir,"HOBO_data/HOBO_paired_sensor_data/UMBS/UMBS_pairedsensors_L1.csv"))

KBS_par <- read.csv(file.path(L1_dir,"PAR/KBS_PAR_L1.csv"))
UMBS_par <- read.csv(file.path(L1_dir,"PAR/UMBS_PAR_L1.csv"))

KBS_pend <- read.csv(file.path(L1_dir,"HOBO_data/HOBO_pendant_data/KBS/KBS_HOBOpendant_L1.csv"))
UMBS_pend <- read.csv(file.path(L1_dir,"HOBO_data/HOBO_pendant_data/UMBS/UMBS_HOBOpendant_L1.csv"))

# date is a character column - convert to date format
KBS$Date_Time <- as.POSIXct(KBS$Date_Time, format = "%Y-%m-%d %H:%M")
UMBS$Date_Time <- as.POSIXct(UMBS$Date_Time, format = "%Y-%m-%d %H:%M")
```

KBS air temperatures

```
# merge the data + filter data for only the daytime during the growing season
KBS_season <- KBS
KBS_season$month <- format(KBS_season$Date_Time,format="%m")
KBS_season$year <- format(KBS_season$Date_Time,format="%Y")
KBS_season$hour <- format(KBS_season$Date_Time, format="%H")
```

```
# remove sensor 1 from 2021 KBS because it failed
str(KBS_season)
```

```
## 'data.frame': 256006 obs. of 17 variables:
## $ X : int 1 2 3 4 5 6 7 8 9 10 ...
## $ Date_Time : POSIXct, format: "2016-01-01 00:00:00" "2016-01-01 01:00:00" ...
## $ XH_warmed_soil_moisture_5cm : num 0.238 0.238 0.233 0.231 0.23 ...
## $ XH_ambient_soil_moisture_5cm : num 0.276 0.276 0.279 0.279 0.279 ...
## $ XH_warmed_air_1m : num -2.36 -2.71 -4.17 -4.53 -4.5 ...
## $ XH_warmed_RH_1m : num 84.9 82.3 88.7 89.3 90.1 90.2 89.3 87.7 87 85.5 ...
## $ XH_ambient_air_1m : num -2.19 -2.57 -4.17 -4.62 -4.62 ...
## $ XH_ambient_RH_1m : num 82.1 79.7 85.7 86.6 87.4 87.3 86.9 85.7 85.2 83.9 ...
## $ XU_warmed_air_10cm : num -2.25 -2.57 -4.02 -4.5 -4.44 ...
## $ XU_warmed_soil_temp_5cm : num 0.934 0.907 0.577 0.522 0.467 0.467 0.412 0.384 0.384 0.384 ..
## $ XU_ambient_soil_temp_5cm : num 2.64 2.58 2.34 2.34 2.32 ...
## $ XU_ambient_air_10cm : num -2.39 -2.74 -3.9 -4.26 -4.17 ...
## $ site : chr "KBS" "KBS" "KBS" "KBS" ...
## $ sensor : int 1 1 1 1 1 1 1 1 1 1 ...
## $ month : chr "01" "01" "01" "01" ...
## $ year : chr "2016" "2016" "2016" "2016" ...
## $ hour : chr "00" "01" "10" "11" ...
```

```
KBS_season <- KBS_season[!(KBS_season$sensor == 1 & KBS_season$year == "2021" ),]
```

```
KBS_season <- KBS_season %>%
  filter(month > "03") %>%
  filter(month < "09") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  dplyr::select(Date_Time, year, month, hour, XH_warmed_air_1m, XH_ambient_air_1m)
```

```
# create new dataframes for temperatures averaged by year & averaged by month and year
```

```
KBS_avg_year <- KBS_season %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time)
```

```
# test for outliers - none extreme
```

```
outliers <- KBS_avg_year %>%
  group_by(treatment, year) %>%
  identify_outliers(temp)
view(outliers)
```

```
# avg temps in the chambers during the daytime
```

```
KBS_avg_temp <- KBS_avg_year %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))
```

```
## `summarise()` ungrouping output (override with `.groups` argument)
```

```
print(KBS_avg_temp)
```

```
## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_air_1m      21.5      8.75
```

```
## 2 XH_warmed_air_1m      23.4    9.34
# avg temps in the chambers during the daytime for each year
KBS_avg_temp_year <- KBS_avg_year %>%
  group_by(year, treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` regrouping output by 'year' (override with `.groups` argument)
print(KBS_avg_temp_year)

## # A tibble: 14 x 4
## # Groups:   year [7]
##   year treatment      mean_temp sd_temp
##   <chr> <chr>          <dbl>   <dbl>
## 1 2015 XH_ambient_air_1m    23.9     5.18
## 2 2015 XH_warmed_air_1m    25.7     6.06
## 3 2016 XH_ambient_air_1m    21.2     9.34
## 4 2016 XH_warmed_air_1m    23.4    10.1
## 5 2017 XH_ambient_air_1m    21.1     7.65
## 6 2017 XH_warmed_air_1m    23.3     8.53
## 7 2018 XH_ambient_air_1m    21.4     9.63
## 8 2018 XH_warmed_air_1m    23.0     9.89
## 9 2019 XH_ambient_air_1m    21.1     8.97
## 10 2019 XH_warmed_air_1m    22.4     8.97
## 11 2020 XH_ambient_air_1m    21.6     9.45
## 12 2020 XH_warmed_air_1m    23.4    10.0
## 13 2021 XH_ambient_air_1m    21.5     8.38
## 14 2021 XH_warmed_air_1m    24.2     9.12
# avg temps in the chambers on hot days
KBS_avg_hot_day <- KBS_season %>%
  filter(XH_ambient_air_1m > 27) %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)
print(KBS_avg_hot_day)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>   <dbl>
## 1 XH_ambient_air_1m    30.8     2.60
## 2 XH_warmed_air_1m    33.1     3.40
# avg temps from march-april and july-august (early season vs late season)
KBS_early <- KBS_season %>%
  filter(month == "03" | month == "04") %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)
```

```

print(KBS_early)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_air_1m    10.4    7.34
## 2 XH_warmed_air_1m    12.7    8.56

KBS_late <- KBS_season %>%
  filter(month == "07" | month == "08") %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

print(KBS_late)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_air_1m    26.4    5.82
## 2 XH_warmed_air_1m    28.1    6.62

# winter warming?
KBS_winter <- KBS
KBS_winter$month <- format(KBS_winter$Date_Time, format="%m")
KBS_winter$year <- format(KBS_winter$Date_Time, format="%Y")
KBS_winter$hour <- format(KBS_winter$Date_Time, format="%H")

KBS_winter <- KBS_winter[!(KBS_winter$sensor == 1 & KBS_winter$year == "2021"),]

KBS_winter <- KBS_winter %>%
  filter(month > "10" | month < "03") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  dplyr::select(Date_Time, year, month, hour, XH_warmed_air_1m, XH_ambient_air_1m)
KBS_avg_winter <- KBS_winter %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(year, treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` regrouping output by 'year' (override with `.groups` argument)

print(KBS_avg_winter)

## # A tibble: 14 x 4
## # Groups:   year [7]
##   year treatment      mean_temp sd_temp
##   <chr> <chr>          <dbl>    <dbl>
## 1 2015 XH_ambient_air_1m    6.23    6.69
## 2 2015 XH_warmed_air_1m    6.78    7.11
## 3 2016 XH_ambient_air_1m    0.766    7.65
## 4 2016 XH_warmed_air_1m    1.49    7.80
## 5 2017 XH_ambient_air_1m    0.772    7.14

```

```
## 6 2017 XH_warmed_air_1m      1.60      7.62
## 7 2018 XH_ambient_air_1m    -0.294     6.28
## 8 2018 XH_warmed_air_1m      0.422     6.51
## 9 2019 XH_ambient_air_1m    -0.947     6.67
## 10 2019 XH_warmed_air_1m    -0.245     6.77
## 11 2020 XH_ambient_air_1m     1.84     6.56
## 12 2020 XH_warmed_air_1m     2.00     6.60
## 13 2021 XH_ambient_air_1m    -1.55     6.50
## 14 2021 XH_warmed_air_1m    -0.569     7.21
```

#nighttime warming?

```
KBS_night <- KBS
KBS_night$month <- format(KBS_night$Date_Time,format="%m")
KBS_night$year <- format(KBS_night$Date_Time,format="%Y")
KBS_night$hour <- format(KBS_night$Date_Time, format="%H")
KBS_night <- KBS_night %>%
  filter(month > "03" | month < "09") %>%
  filter(hour > "20" | hour < "06") %>%
  select(Date_Time, year, month, hour, XH_warmed_air_1m, XH_ambient_air_1m)
KBS_avg_night <- KBS_night %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(year, treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))
```

`summarise()` regrouping output by 'year' (override with `.groups` argument)

```
print(KBS_avg_night)
```

```
## # A tibble: 14 x 4
## # Groups:   year [7]
##   year treatment      mean_temp sd_temp
##   <chr> <chr>          <dbl>   <dbl>
## 1 2015 XH_ambient_air_1m    10.8    7.15
## 2 2015 XH_warmed_air_1m     9.61    7.44
## 3 2016 XH_ambient_air_1m     6.82    9.50
## 4 2016 XH_warmed_air_1m     6.51    9.47
## 5 2017 XH_ambient_air_1m     7.15    9.31
## 6 2017 XH_warmed_air_1m     6.77    9.26
## 7 2018 XH_ambient_air_1m     6.47   10.2
## 8 2018 XH_warmed_air_1m     6.34   10.3
## 9 2019 XH_ambient_air_1m     6.11    9.82
## 10 2019 XH_warmed_air_1m     6.03    9.90
## 11 2020 XH_ambient_air_1m     6.87    8.75
## 12 2020 XH_warmed_air_1m     6.58    9.01
## 13 2021 XH_ambient_air_1m     8.09   10.4
## 14 2021 XH_warmed_air_1m     7.84   10.4
```

UMBS air temperatures

```
UMBS_season <- UMBS
UMBS_season$month <- format(UMBS_season$Date_Time,format="%m")
UMBS_season$year <- format(UMBS_season$Date_Time,format="%Y")
UMBS_season$hour <- format(UMBS_season$Date_Time, format="%H")
```

```

UMBS_season <- UMBS_season %>%
  filter(month > "03") %>%
  filter(month < "09") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  select(Date_Time, year, month, hour, XH_warmed_air_1m, XH_ambient_air_1m)

# create new dataframes for temperatures averaged by year & averaged by month and year
UMBS_avg_year <- UMBS_season %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time)

# test for outliers - none extreme
outliers <- UMBS_avg_year %>%
  group_by(treatment, year) %>%
  identify_outliers(temp)

# avg temps in the chambers during the daytime
UMBS_avg_temp <- UMBS_avg_year %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)
print(UMBS_avg_temp)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_air_1m      19.1      9.05
## 2 XH_warmed_air_1m       22.1     10.3

# avg temps in the chambers during the daytime for each year
UMBS_avg_temp_year <- UMBS_avg_year %>%
  group_by(year, treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` regrouping output by 'year' (override with `.groups` argument)
print(UMBS_avg_temp_year)

## # A tibble: 14 x 4
## # Groups:   year [7]
##   year treatment      mean_temp sd_temp
##   <chr> <chr>          <dbl>    <dbl>
## 1 2015 XH_ambient_air_1m      23.5      5.60
## 2 2015 XH_warmed_air_1m       26.2      7.22
## 3 2016 XH_ambient_air_1m      19.2      9.58
## 4 2016 XH_warmed_air_1m       22.2     10.6
## 5 2017 XH_ambient_air_1m      18.3      7.71
## 6 2017 XH_warmed_air_1m       20.9      8.92
## 7 2018 XH_ambient_air_1m      19.6     10.3
## 8 2018 XH_warmed_air_1m       22.5     11.6
## 9 2019 XH_ambient_air_1m      17.7      8.90
## 10 2019 XH_warmed_air_1m       20.9     10.3

```

```
## 11 2020 XH_ambient_air_1m      18.7    9.65
## 12 2020 XH_warmed_air_1m       21.9   10.9
## 13 2021 XH_ambient_air_1m      19.4    8.56
## 14 2021 XH_warmed_air_1m       22.6    9.85

# avg temps in the chambers on hot days
UMBS_avg_hot_day <- UMBS_season %>%
  filter(XH_ambient_air_1m > 27) %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

# avg temps from march-april and july-august (early season vs late season)
UMBS_early <- UMBS_season %>%
  filter(month == "03" | month == "04") %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

print(UMBS_early)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_air_1m      6.93    6.93
## 2 XH_warmed_air_1m      9.53    8.46

UMBS_late <- UMBS_season %>%
  filter(month == "07" | month == "08") %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

print(UMBS_late)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_air_1m     24.3    5.39
## 2 XH_warmed_air_1m     27.4    7.12

# winter warming?
UMBS_winter <- UMBS
UMBS_winter$month <- format(UMBS_winter$Date_Time, format="%m")
UMBS_winter$year <- format(UMBS_winter$Date_Time, format="%Y")
UMBS_winter$hour <- format(UMBS_winter$Date_Time, format="%H")
UMBS_winter <- UMBS_winter %>%
  filter(month > "10" | month < "03") %>%
  filter(hour > "06") %>%
```

```

    filter(hour < "20") %>%
    select(Date_Time, year, month, hour, XH_warmed_air_1m, XH_ambient_air_1m)
UMBS_avg_winter <- UMBS_winter %>%
    gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
    group_by(year, treatment) %>%
    summarize(mean_temp = mean(temp, na.rm = T),
               sd_temp = sd(temp, na.rm = T))

```

```
## `summarise()` regrouping output by 'year' (override with `.groups` argument)
```

```
print(UMBS_avg_winter)
```

```
## # A tibble: 14 x 4
## # Groups:   year [7]
##   year treatment      mean_temp sd_temp
##   <chr> <chr>          <dbl>   <dbl>
## 1 2015 XH_ambient_air_1m    3.75    5.70
## 2 2015 XH_warmed_air_1m    4.12    6.12
## 3 2016 XH_ambient_air_1m   -1.15    7.25
## 4 2016 XH_warmed_air_1m   -0.605   7.45
## 5 2017 XH_ambient_air_1m   -2.47    6.46
## 6 2017 XH_warmed_air_1m   -1.90    6.55
## 7 2018 XH_ambient_air_1m   -3.18    6.02
## 8 2018 XH_warmed_air_1m   -2.73    6.23
## 9 2019 XH_ambient_air_1m   -4.27    6.28
##10 2019 XH_warmed_air_1m   -3.81    6.25
##11 2020 XH_ambient_air_1m   -0.649   6.43
##12 2020 XH_warmed_air_1m    0.0331   6.67
##13 2021 XH_ambient_air_1m   -2.77    7.14
##14 2021 XH_warmed_air_1m   -1.62    7.50

```

```
#nighttime warming?
```

```

UMBS_night <- UMBS
UMBS_night$month <- format(UMBS_night$Date_Time,format="%m")
UMBS_night$year <- format(UMBS_night$Date_Time,format="%Y")
UMBS_night$hour <- format(UMBS_night$Date_Time, format="%H")
UMBS_night <- UMBS_night %>%
    filter(month > "03" | month < "09") %>%
    filter(hour > "20" | hour < "06") %>%
    select(Date_Time, year, month, hour, XH_warmed_air_1m, XH_ambient_air_1m)
UMBS_avg_night <- UMBS_night %>%
    gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time) %>%
    group_by(year, treatment) %>%
    summarize(mean_temp = mean(temp, na.rm = T),
               sd_temp = sd(temp, na.rm = T))

```

```
## `summarise()` regrouping output by 'year' (override with `.groups` argument)
```

```
print(UMBS_avg_night)
```

```

## # A tibble: 14 x 4
## # Groups:   year [7]
##   year treatment      mean_temp sd_temp
##   <chr> <chr>          <dbl>   <dbl>
## 1 2015 XH_ambient_air_1m    9.82    7.52
## 2 2015 XH_warmed_air_1m    9.55    7.55

```



```
## 3 2016 XH_ambient_air_1m      5.38    9.79
## 4 2016 XH_warmed_air_1m       5.16    9.61
## 5 2017 XH_ambient_air_1m      4.84    9.61
## 6 2017 XH_warmed_air_1m       4.61    9.47
## 7 2018 XH_ambient_air_1m      4.23   10.8
## 8 2018 XH_warmed_air_1m       4.02   10.7
## 9 2019 XH_ambient_air_1m      3.44   10.3
## 10 2019 XH_warmed_air_1m      3.12   10.1
## 11 2020 XH_ambient_air_1m     5.13    9.19
## 12 2020 XH_warmed_air_1m      4.74    9.09
## 13 2021 XH_ambient_air_1m     6.60   10.0
## 14 2021 XH_warmed_air_1m      6.20    9.93
```

KBS soil temp & moisture

```
# merge the data + filter data for only the daytime during the growing season
KBS_season_soil <- KBS
KBS_season_soil$month <- format(KBS_season_soil$Date_Time,format="%m")
KBS_season_soil$year <- format(KBS_season_soil$Date_Time,format="%y")
KBS_season_soil$hour <- format(KBS_season_soil$Date_Time, format="%H")

KBS_season_soil <- KBS_season_soil[!(KBS_season_soil$sensor == 1 & KBS_season_soil$year == "2021" ),]

KBS_season_soil <- KBS_season_soil %>%
  filter(month > "03") %>%
  filter(month < "09") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  dplyr::select(Date_Time, year, month, hour, XU_warmed_soil_temp_5cm, XU_ambient_soil_temp_5cm)

# create new dataframes for temperatures averaged by year & averaged by month and year
KBS_avg_soil <- KBS_season_soil %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time)

# test for outliers - some extreme, go back and remove ?
outliers <- KBS_avg_soil %>%
  group_by(treatment, year) %>%
  identify_outliers(temp)

# avg soil temps in the chambers during the daytime
KBS_avg_soil_temp <- KBS_avg_soil %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)

print(KBS_avg_soil_temp)

## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XU_ambient_soil_temp_5cm    17.2    5.61
## 2 XU_warmed_soil_temp_5cm    17.5    6.04
```

```

# merge the data + filter data for only the daytime during the growing season
KBS_season_moist <- KBS
KBS_season_moist$month <- format(KBS_season_moist$Date_Time,format="%m")
KBS_season_moist$year <- format(KBS_season_moist$Date_Time,format="%y")
KBS_season_moist$hour <- format(KBS_season_moist$Date_Time, format="%H")

KBS_season_moist <- KBS_season_moist[!(KBS_season_moist$sensor == 1 & KBS_season_moist$year == "2021" ),]

KBS_season_moist <- KBS_season_moist %>%
  filter(month > "03") %>%
  filter(month < "09") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  dplyr::select(Date_Time, year, month, hour, XH_warmed_soil_moisture_5cm, XH_ambient_soil_moisture_5cm)

# create new dataframes for temperatures averaged by year & averaged by month and year
KBS_avg_moist <- KBS_season_moist %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time)

# test for outliers - some extreme, but they seem like reasonable values
outliers <- KBS_avg_moist %>%
  group_by(treatment, year) %>%
  identify_outliers(temp)

# avg soil temps in the chambers during the daytime
KBS_avg_soil_moist <- KBS_avg_moist %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))

## `summarise()` ungrouping output (override with `.groups` argument)
print(KBS_avg_soil_moist)

```

```

## # A tibble: 2 x 3
##   treatment                mean_temp sd_temp
##   <chr>                  <dbl>   <dbl>
## 1 XH_ambient_soil_moisture_5cm    0.179  0.0564
## 2 XH_warmed_soil_moisture_5cm    0.169  0.0592

```

UMBS soil temp & moisture

```

# merge the data + filter data for only the daytime during the growing season
UMBS_season_soil <- UMBS
UMBS_season_soil$month <- format(UMBS_season_soil$Date_Time,format="%m")
UMBS_season_soil$year <- format(UMBS_season_soil$Date_Time,format="%y")
UMBS_season_soil$hour <- format(UMBS_season_soil$Date_Time, format="%H")

UMBS_season_soil <- UMBS_season_soil %>%
  filter(month > "03") %>%
  filter(month < "09") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  select(Date_Time, year, month, hour, XU_warmed_soil_temp_5cm, XU_ambient_soil_temp_5cm)

```

```
# create new dataframes for temperatures averaged by year & averaged by month and year
UMBS_avg_soil <- UMBS_season_soil %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time)
```

```
# test for outliers - none extreme
outliers <- UMBS_avg_soil %>%
  group_by(treatment, year) %>%
  identify_outliers(temp)
```

```
# avg soil temps in the chambers during the daytime
UMBS_avg_soil_temp <- UMBS_avg_soil %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))
```

```
## `summarise()` ungrouping output (override with `.groups` argument)
print(UMBS_avg_soil_temp)
```

```
## # A tibble: 2 x 3
##   treatment      mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XU_ambient_soil_temp_5cm    17.8    8.28
## 2 XU_warmed_soil_temp_5cm    18.6    8.20
```

```
# merge the data + filter data for only the daytime during the growing season
UMBS_season_moist <- UMBS
UMBS_season_moist$month <- format(UMBS_season_moist$Date_Time, format="%m")
UMBS_season_moist$year <- format(UMBS_season_moist$Date_Time, format="%y")
UMBS_season_moist$hour <- format(UMBS_season_moist$Date_Time, format="%H")
```

```
UMBS_season_moist <- UMBS_season_moist %>%
  filter(month > "03") %>%
  filter(month < "09") %>%
  filter(hour > "06") %>%
  filter(hour < "20") %>%
  select(Date_Time, year, month, hour, XH_warmed_soil_moisture_5cm, XH_ambient_soil_moisture_5cm)
```

```
# create new dataframes for temperatures averaged by year & averaged by month and year
UMBS_avg_moist <- UMBS_season_moist %>%
  gather(key = "treatment", value = "temp", -year, -month, -hour, -Date_Time)
```

```
# test for outliers - some extreme, but they seem like reasonable values
outliers <- UMBS_avg_moist %>%
  group_by(treatment, year) %>%
  identify_outliers(temp)
```

```
# avg soil temps in the chambers during the daytime
UMBS_avg_soil_moist <- UMBS_avg_moist %>%
  group_by(treatment) %>%
  summarize(mean_temp = mean(temp, na.rm = T),
            sd_temp = sd(temp, na.rm = T))
```

```
## `summarise()` ungrouping output (override with `.groups` argument)
```

```
print(UMBS_avg_soil_moist)
```

```
## # A tibble: 2 x 3
##   treatment          mean_temp sd_temp
##   <chr>          <dbl>    <dbl>
## 1 XH_ambient_soil_moisture_5cm  0.0933  0.0493
## 2 XH_warmed_soil_moisture_5cm   0.0903  0.0474
```