# ECOL 610: NEON Assignment 1

Group - Santa Rita Experimental Range (SRER)

15 September, 2022

## Contents



## Group Members


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## Setup

First, load in the needed packages. Install the packages if needed.

```
library(tidyverse)
library(lubridate)
library(viridis)
library(scales)
library(latex2exp)
remove(list=ls())
```

## Introduction

*Net ecosystem exchange (NEE) is defined, by convention, as $CO_2$ flux from the ecosystem to the atmosphere. It corresponds to a negative carbon input to ecosystems. NEE is defined in this way because atmospheric scientists, who originated the term, seek to document net sources of $CO_2$ to the atmosphere (i.e., NEE) that account for rising atmospheric $CO_2$ concentration. Therefore, $CO_2$ input to the ecosystem is a negative NEE.*

Chapin, F. S., Matson, P. A., Mooney, H. A., & Vitousek, P. M. (2002). Principles of terrestrial ecosystem ecology. p.208

Key point: $CO_2$ **input to the ecosystem is a negative NEE**

$$NEE = R_E - GPP$$

$$GPP = R_E - NEE$$

$$NEP = GPP - R_E$$

## Load Data

```
# what is your site name?
site <- "Santa Rita Experimental Range"
# load 30 min data
  # I put both CPER and SRER data in this directory
  # all data will be loaded in the same R data set
f_list <- list.files(path = "../data/", pattern="*30 min.csv")
for (i in 1:length(f_list)){
  nm <- stringr::word(f_list[i], start = 1, sep = "30 min") %>%
    stringr::str_replace_all(pattern = "[[:punct:]]", replacement = "") %>%
    stringr::str_trim() %>%
    stringr::str_squish()
  temp <- read.csv(paste0("../data/", f_list[i])) %>%
    dplyr::mutate(neon_site_name = nm) %>%
    dplyr::relocate(neon_site_name) %>%
    dplyr::rename_with(~ tolower(
      gsub(" ", "_",
```

```
        str_trim(gsub("\\s+", " ", .x))
      )
    ))
  if(i==1){
    dta_30min <- temp
  }else{
    dta_30min <- dplyr::union_all(dta_30min, temp)
  }
  remove(temp)
}
# load daily data
f_list <- list.files(path = "../data/", pattern="*daily.csv")
for (i in 1:length(f_list)){
  nm <- stringr::word(f_list[i], start = 1, sep = "daily") %>%
    stringr::str_replace_all(pattern = "[[:punct:]]", replacement = "") %>%
    stringr::str_trim() %>%
    stringr::str_squish()
  temp <- read.csv(paste0("../data/", f_list[i])) %>%
    dplyr::mutate(neon_site_name = nm) %>%
    dplyr::relocate(neon_site_name) %>%
    dplyr::rename_with(~ tolower(
      gsub(" ", "_",
         str_trim(gsub("\\s+", " ", .x))
      )
    ))
  if(i==1){
    dta_1day <- temp
  }else{
    dta_1day <- dplyr::union_all(dta_1day, temp)
  }
  remove(temp)
}
# create dates and record counts
# 1-day
dta_1day <- dta_1day %>%
  dplyr::mutate(
    date_id = lubridate::make_date(year = year, month = month, day = day)
    , week = lubridate::week(date_id)
    , has_gpp = ifelse(!is.na(gpp), 1, 0)
    , season =
        dplyr::case_when(
          month %in% c(1:3, 12) ~ "Winter"
          , month %in% c(6:8) ~ "Summer"
          , TRUE  ~ "Other")
  ) %>%
  dplyr::group_by(neon_site_name, week, year) %>%
  dplyr::mutate(is_full_week = sum(has_gpp)==7) %>%
  dplyr::ungroup()
# 30-min
dta_30min <- dta_30min %>%
  dplyr::mutate(
    date_id = lubridate::make_date(year = year, month = month, day = day)
    , time_id = lubridate::make_datetime(year = year, month = month, day = day
```

```
                        , hour = floor(hour)
                        , min = (hour-floor(hour))*60
                )
    , week = lubridate::week(date_id)
    , has_gpp = ifelse(!is.na(gpp), 1, 0)
    , season =
        dplyr::case_when(
          month %in% c(1:3, 12) ~ "Winter"
          , month %in% c(6:8) ~ "Summer"
          , TRUE  ~ "other")
  ) %>%
  dplyr::group_by(neon_site_name, week, year) %>%
  dplyr::mutate(is_full_week = sum(has_gpp)==24*2*7) %>%
  dplyr::ungroup()
```

## Assignment

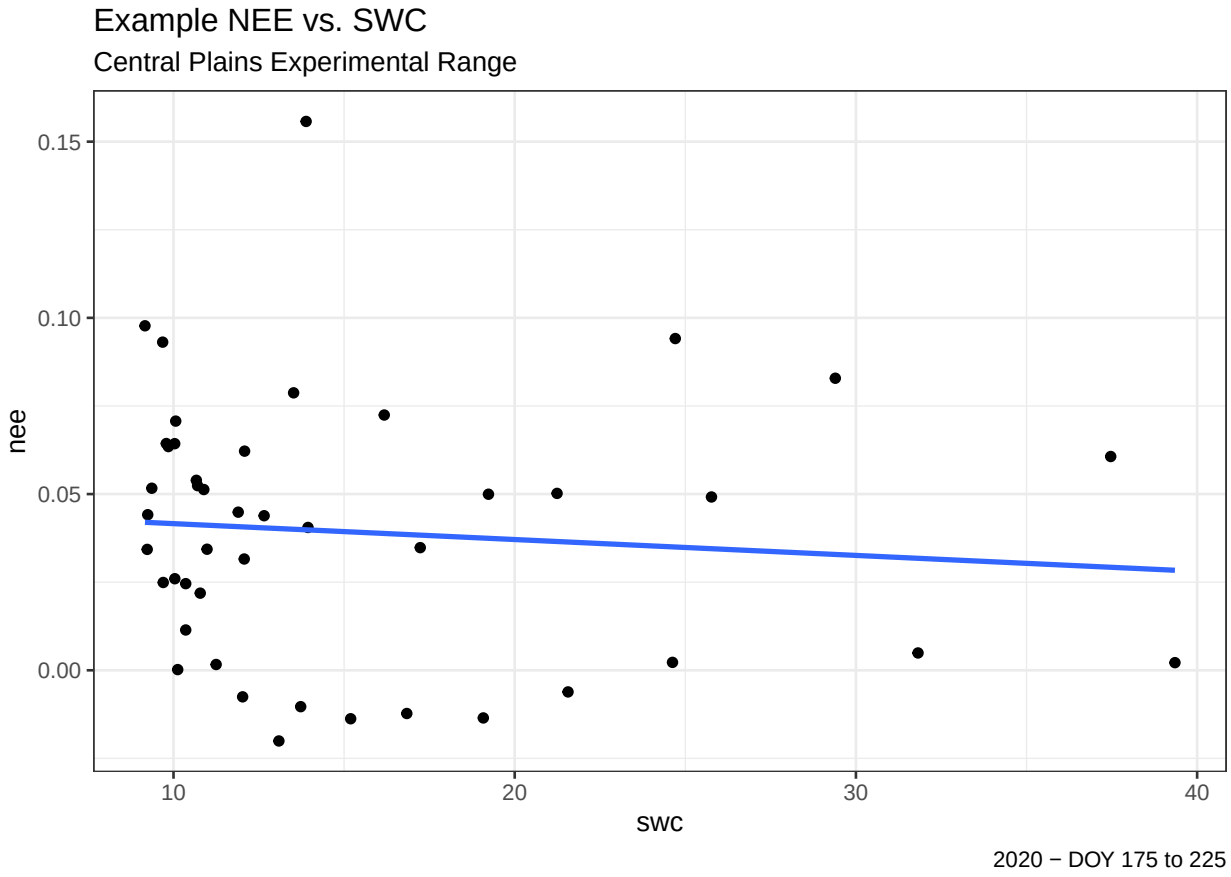
Make some plots for class on September 20, 2022. For these plots, please use the CPER daily data for 2020 from DOY 175 to 225. Make four plots:

- NEE, GPP, Re (all on y-axis) vs soil water content (x-axis)
- NEE, GPP, Re (all on y-axis) vs air temperature (x-axis)
- NEE, GPP, Re (all on y-axis) vs soil temperature (x-axis)
- NEE, GPP, Re (all on y-axis) vs photon flux density (x-axis)

Remember there is more info about these variables in the metadata file

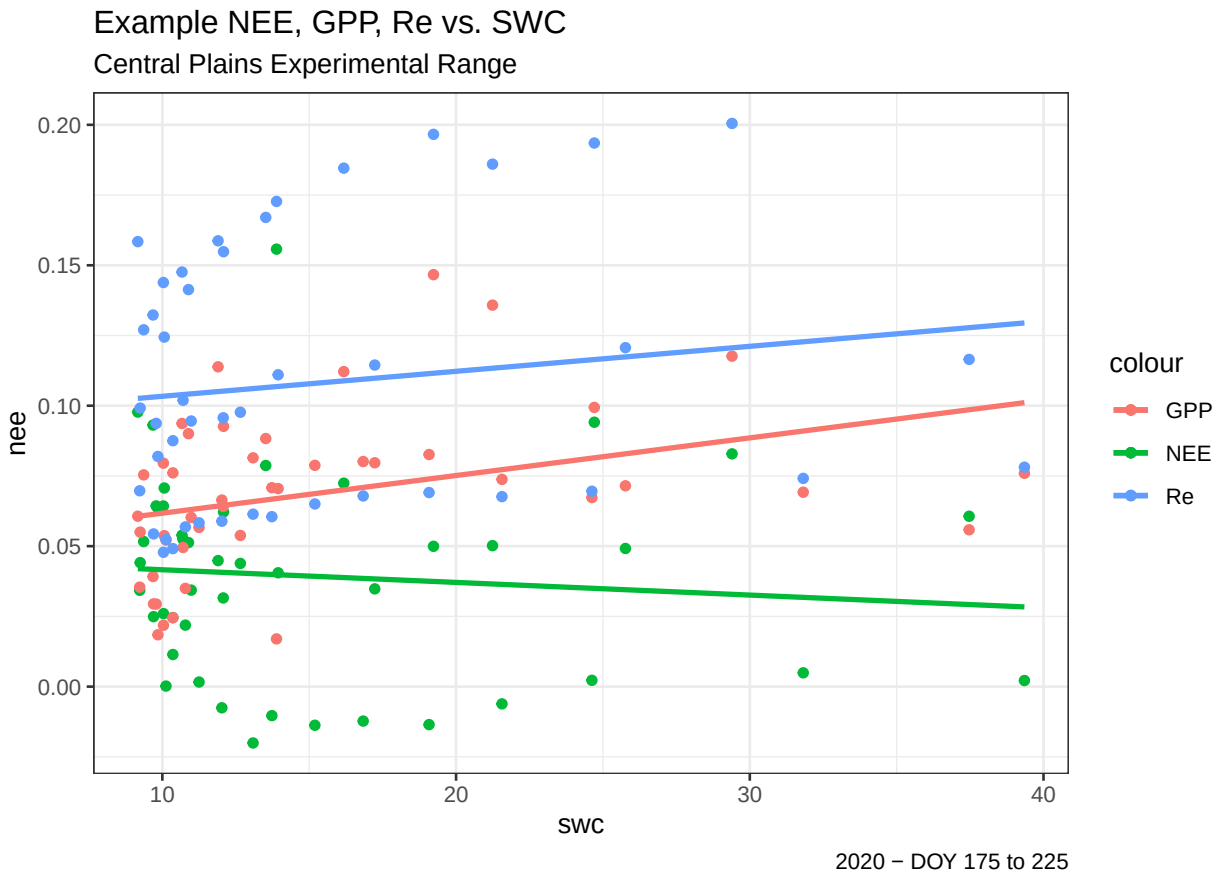
### Example plot for 1 dependent variable & 1 independent variable

```
dta_1day %>%
    dplyr::filter(
      year == 2020
      & doy %in% c(175:225)
      & neon_site_name %in% c("Central Plains Experimental Range")
    ) %>%
  ggplot(., aes(x = swc, y = nee)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "Example NEE vs. SWC"
    , subtitle = "Central Plains Experimental Range"
    , caption = "2020 - DOY 175 to 225"
  ) +
  theme_bw()
```




**Example plot for 3 dependent variables & 1 independent variable**

```
dta_1day %>%
    dplyr::filter(
      year == 2020
      & doy %in% c(175:225)
      & neon_site_name %in% c("Central Plains Experimental Range")
    ) %>%
  ggplot(.) +
  geom_point(aes(x = swc, y = nee, color = "NEE")) +
  geom_point(aes(x = swc, y = gpp, color = "GPP")) +
  geom_point(aes(x = swc, y = re, color = "Re")) +
  geom_smooth(aes(x = swc, y = nee, color = "NEE"), method = "lm", se = FALSE) +
  geom_smooth(aes(x = swc, y = gpp, color = "GPP"), method = "lm", se = FALSE) +
  geom_smooth(aes(x = swc, y = re, color = "Re"), method = "lm", se = FALSE) +
  labs(
    title = "Example NEE, GPP, Re vs. SWC"
    , subtitle = "Central Plains Experimental Range"
    , caption = "2020 - DOY 175 to 225"
  ) +
  theme_bw()
```




## Define Function for Extendable Plotting

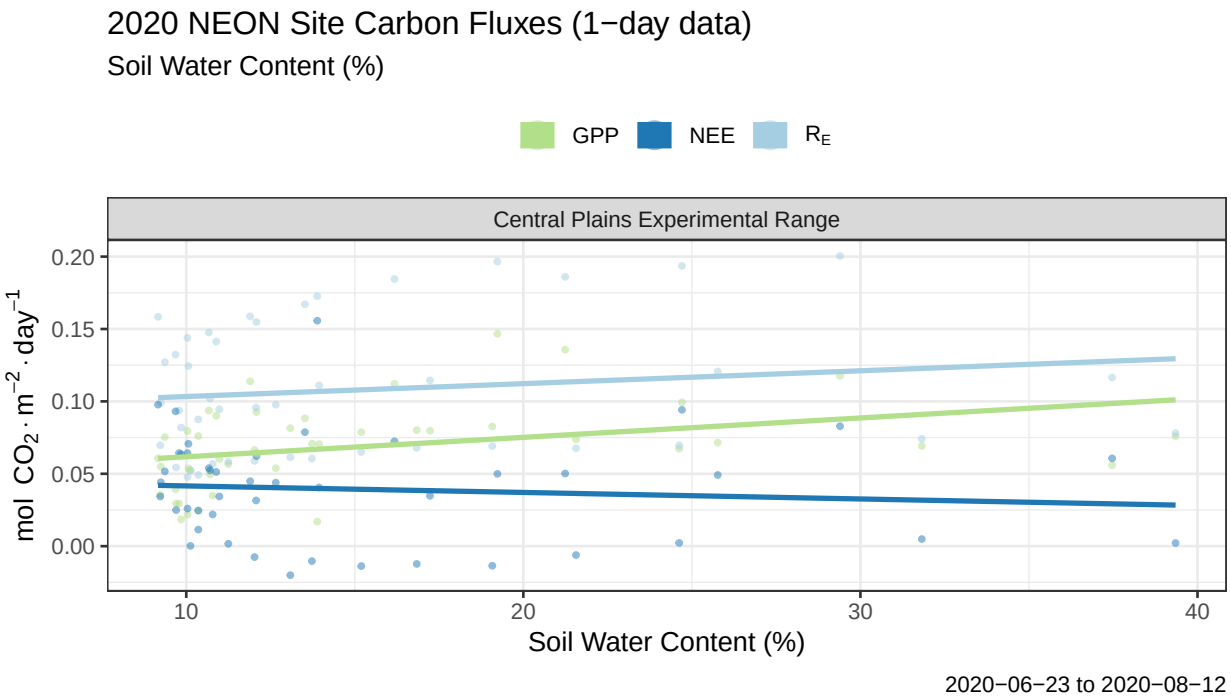
```
# define dependent vars
my_plot_function <- function(
  dep_vars = c("gpp", "nee", "re")
  , dep_vars_lab = c(latex2exp::TeX("$GPP$"), latex2exp::TeX("$NEE$"), latex2exp::TeX("$R_E$"))
  , st_doy = 175
  , end_doy = 225
  , yr = 2020
  , my_cov = "swc"
  , my_cov_lab = "SWC"
  , sites = c("Central Plains Experimental Range")
){
  (
  # filter data
    dta_1day %>%
      dplyr::filter(
        year == yr
        & doy %in% c(st_doy:end_doy)
        & neon_site_name %in% sites
      ) %>%
  # pivot dependent vars
    tidyr::pivot_longer(
```

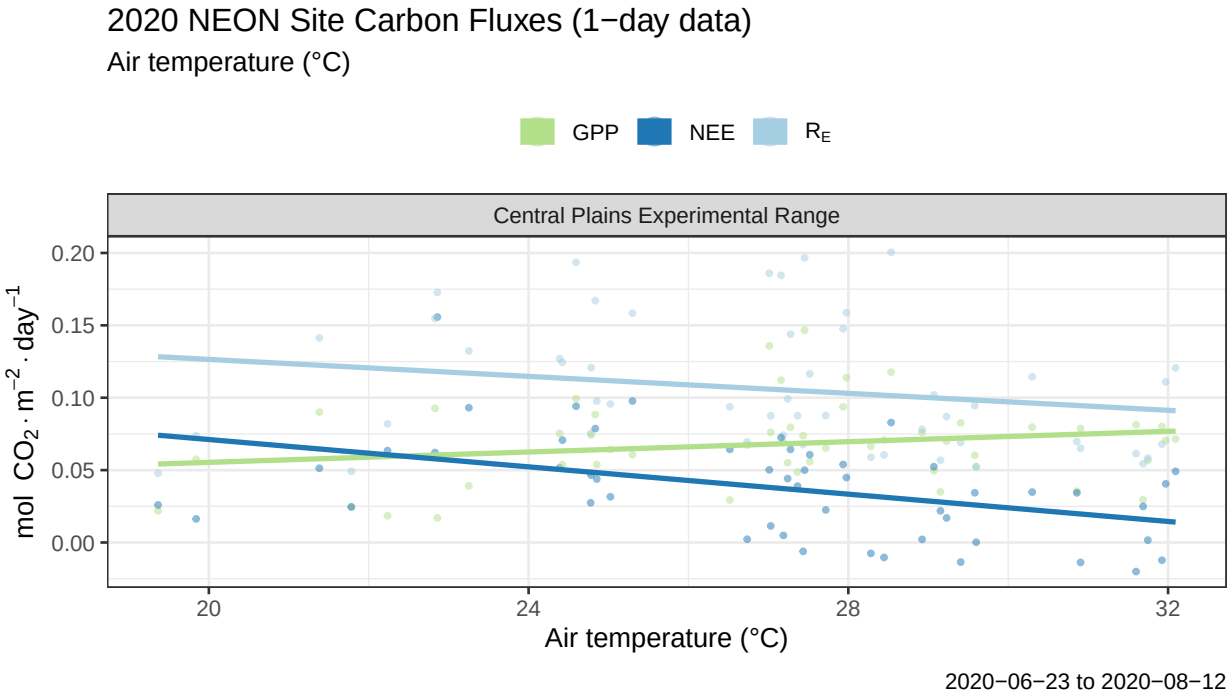
```
    cols = tidyselect::all_of(dep_vars)
    , names_to = "dependent_var_name"
    , values_to = "dependent_var_value"
    , values_drop_na = FALSE
  ) %>%
  dplyr::arrange(
    neon_site_name
    , date_id
    , dependent_var_name
  ) %>%
# plot
  ggplot(
    data = . # "." means the data that is passed to ggplot via the pipe "%>%"
    , mapping = aes_string(
      x = my_cov
      , y = "dependent_var_value"
      , color = "dependent_var_name"
    )
  ) +
  geom_point(
    alpha = 0.5
    , size = 0.8
  ) +
  geom_smooth(
    method = "lm"
    , se = FALSE
    , lwd = 1
    , alpha = 0.8
  ) +
  facet_wrap(~neon_site_name, scales = "free") +
  scale_color_brewer(
    type = "qual"
    , palette = "Paired"
    , direction = -1
    , labels = dep_vars_lab
  ) +
  xlab(my_cov_lab) +
  ylab(latex2exp::TeX("$mol \\; CO_{2} \\cdot m^{-2} \\cdot day^{-1}$")) +
  labs(
    title = paste0(yr, " NEON Site Carbon Fluxes (1-day data)")
    , subtitle = my_cov_lab
    , caption = paste0(
        as.Date(st_doy-1, origin = paste0(yr,"-01-01"))
        , " to "
        , as.Date(end_doy-1, origin = paste0(yr,"-01-01"))
    )
  ) +
  theme_bw() +
  theme(
    legend.position = "top"
    , legend.direction = "horizontal"
    , legend.title = element_blank()
  ) +
```

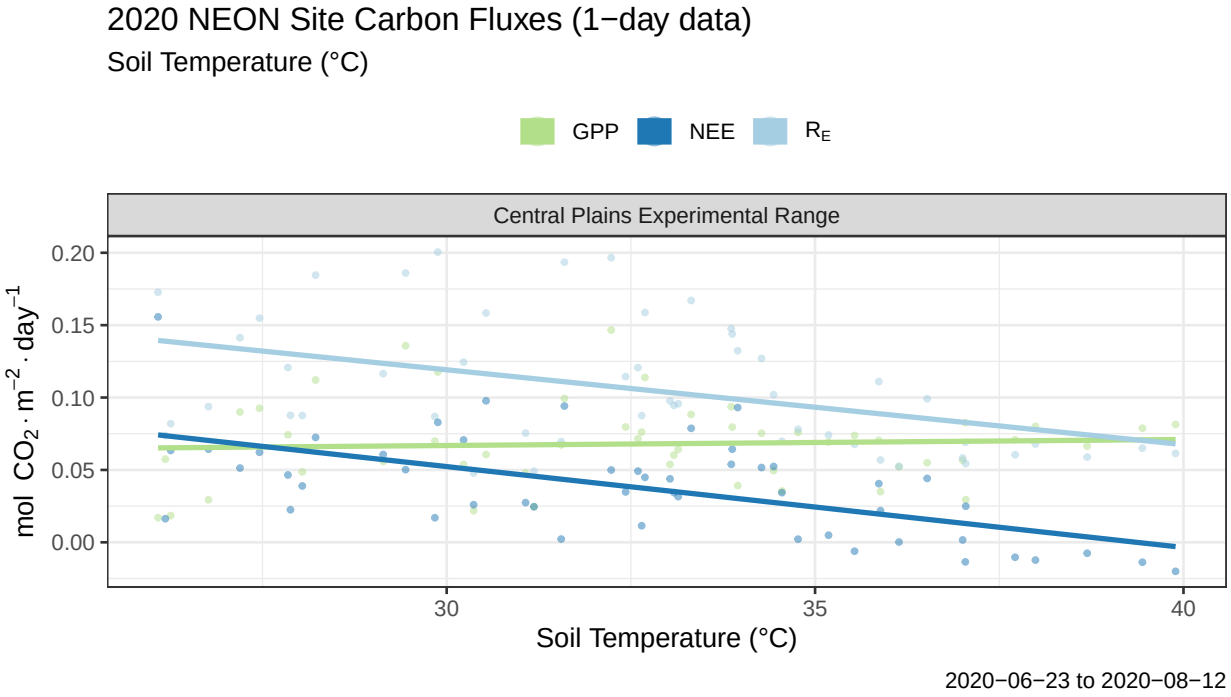
```
    guides(color = guide_legend(override.aes = list(size = 5)))
  )
}
```

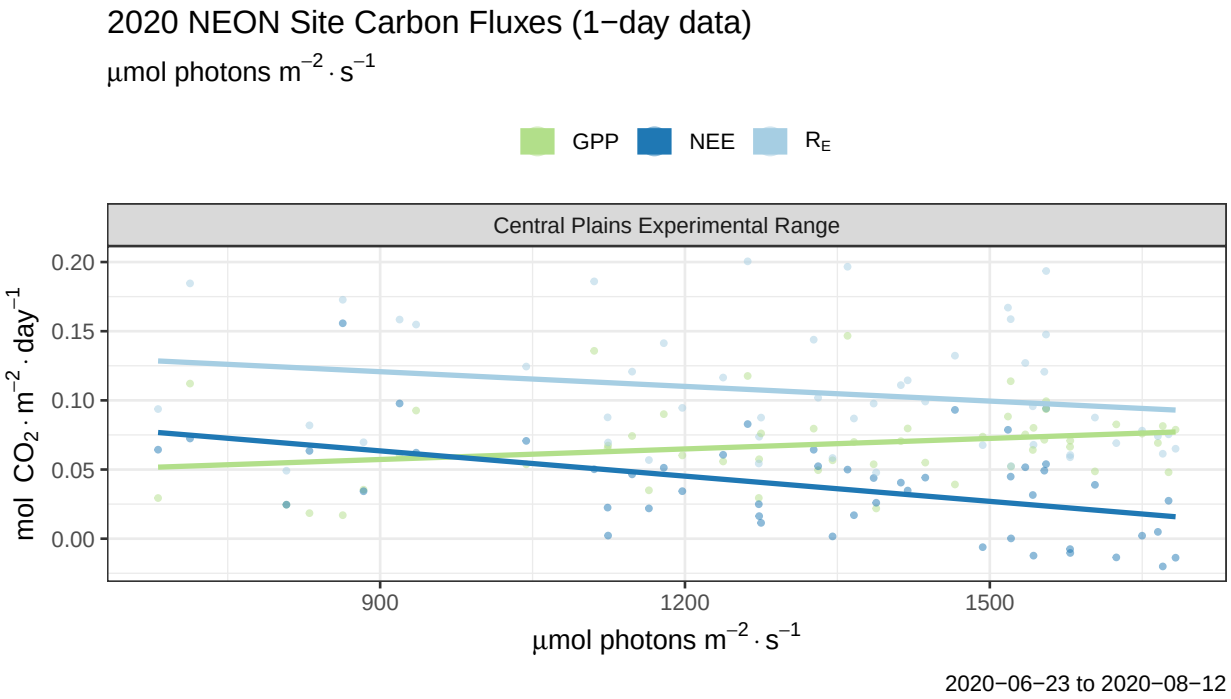
### All covariates 2020 DOY 175-225

```
v <- c("swc", "ta", "ts", "ppfd_in")
t <- c(
  "Soil Water Content (%)"
  , "Air temperature (\u00B0C)"
  , "Soil Temperature (\u00B0C)"
  , latex2exp::TeX("$\\mu$mol photons $m^{-2} \\cdot s^{-1}$")
)
for (i in 1:length(v)) {
  print(
    my_plot_function(
      dep_vars = c("gpp", "nee", "re")
      , dep_vars_lab = c(latex2exp::TeX("$GPP$"), latex2exp::TeX("$NEE$"), latex2exp::TeX("$R_E$"))
      , st_doy = 175
      , end_doy = 225
      , yr = 2020
      , my_cov = v[i]
      , my_cov_lab = t[i]
      , sites = c("Central Plains Experimental Range")
    )
  )
}
```




2020 NEON Site Carbon Fluxes (1−day data)
Air temperature (°C)
GPP
NEE
$R_E$
Central Plains Experimental Range
0.20
0.15
0.10
0.05
0.00
mol $CO_2 \cdot m^{-2} \cdot day^{-1}$
20
24
28
32
Air temperature (°C)
2020−06−23 to 2020−08−12


2020 NEON Site Carbon Fluxes (1−day data)
Soil Temperature (°C)
GPP
NEE
$R_E$
Central Plains Experimental Range
0.20
0.15
0.10
0.05
0.00
mol $CO_2 \cdot m^{-2} \cdot day^{-1}$
30
35
40
Soil Temperature (°C)
2020−06−23 to 2020−08−12

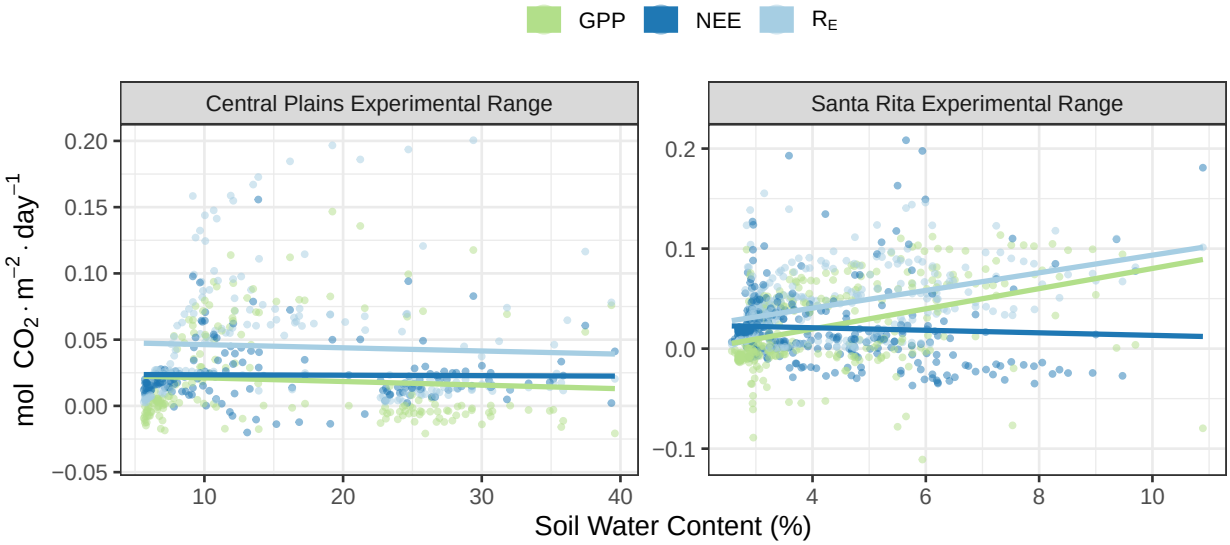



## Compare CPER to SRER 2020 full year

```
v <- c("swc", "ta", "ts", "ppfd_in")
t <- c(
  "Soil Water Content (%)"
  , "Air temperature (\u00B0C)"
  , "Soil Temperature (\u00B0C)"
  , latex2exp::TeX("$\\mu$mol photons $m^{-2} \\cdot s^{-1}$")
)
for (i in 1:length(v)) {
  print(
    my_plot_function(
      dep_vars = c("gpp", "nee", "re")
      , dep_vars_lab = c(latex2exp::TeX("$GPP$"), latex2exp::TeX("$NEE$"), latex2exp::TeX("$R_E$"))
      , st_doy = 1
      , end_doy = 366
      , yr = 2020
      , my_cov = v[i]
      , my_cov_lab = t[i]
      , sites = c("Central Plains Experimental Range", "Santa Rita Experimental Range")
    )
  )
}
```

## 2020 NEON Site Carbon Fluxes (1−day data)

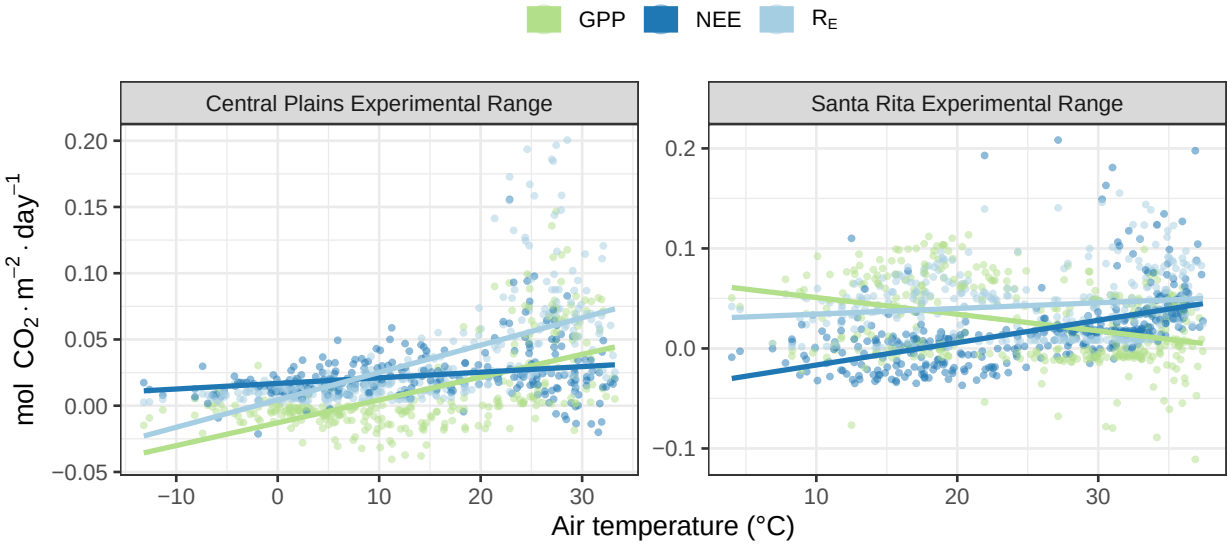
Soil Water Content (%)



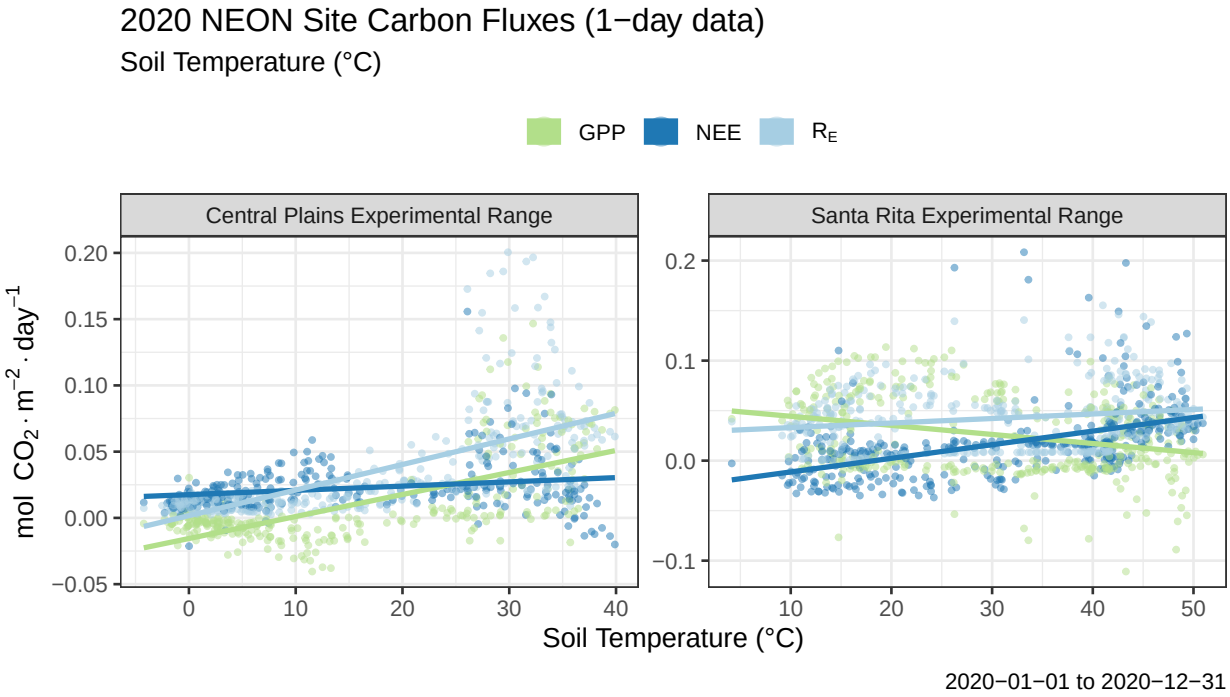

2020−01−01 to 2020−12−31

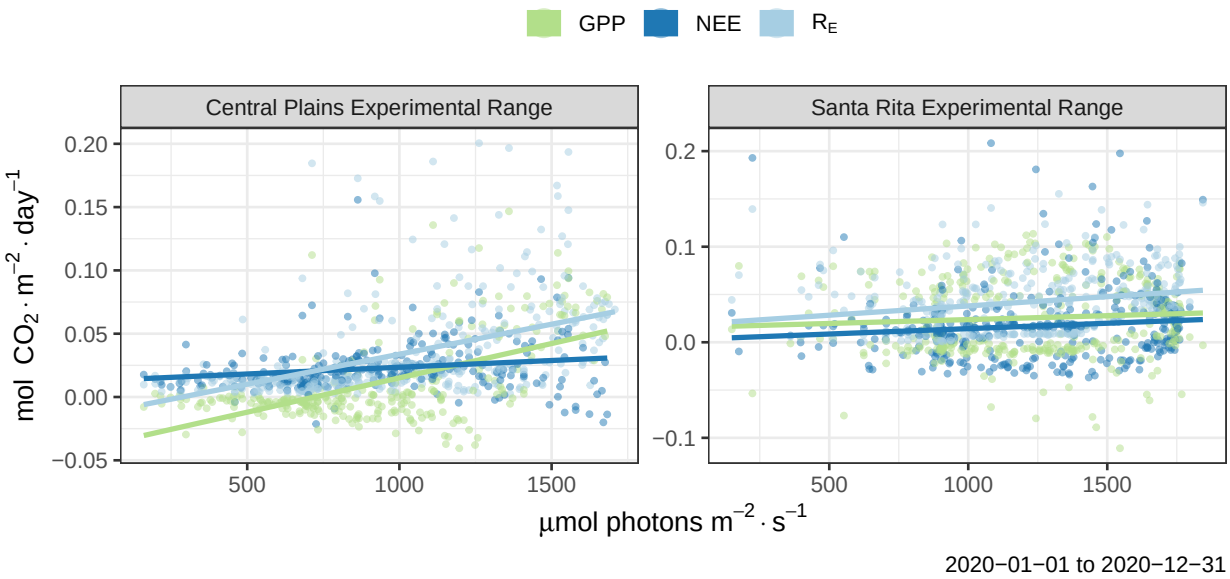
## 2020 NEON Site Carbon Fluxes (1−day data)

Air temperature (°C)




2020−01−01 to 2020−12−31



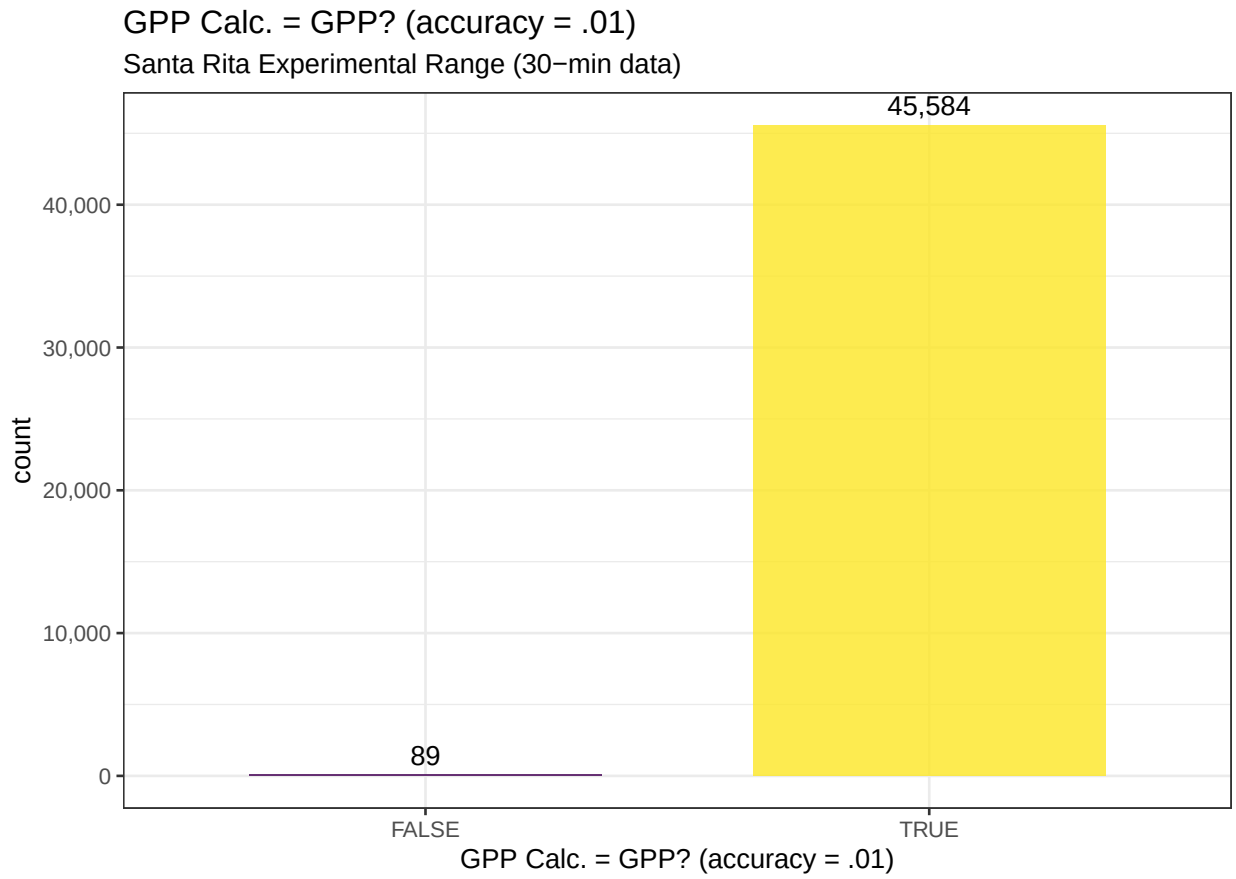

## Draft Assignment (posted via announcement)

See "Announcements" on Canvas from Joe titled "Updated info September 13"

## Question 1

Using the 30 minute data. Calculate GPP for your site.

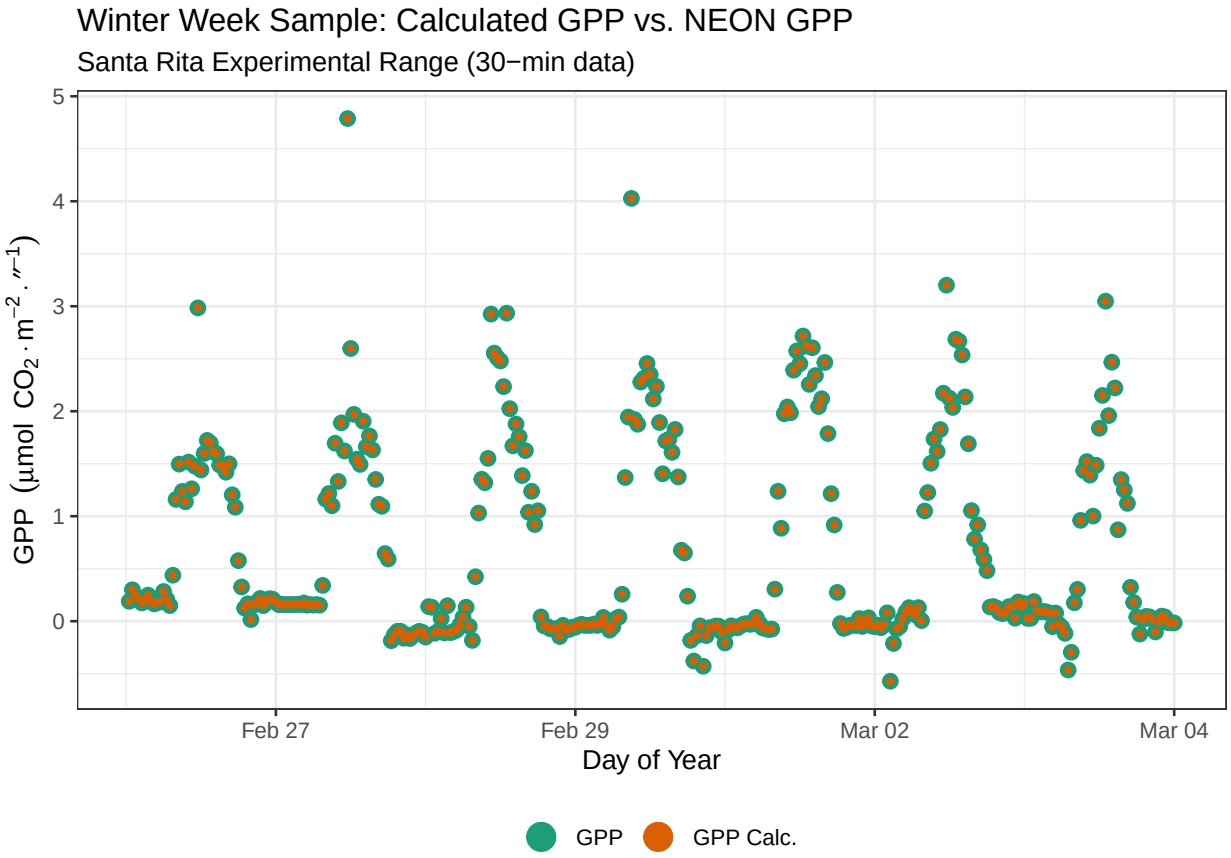
```
dta_30min <- dta_30min %>%
  dplyr::mutate(
    gpp_calc = as.numeric(re - nee)
    , gpp_is_equal = round(gpp_calc, 2) == round(gpp, 2)
  )
# quick plot of gpp equality
dta_30min %>%
  dplyr::filter(
    neon_site_name == site
    & !is.na(gpp)
  ) %>%
ggplot(., aes(x = gpp_is_equal)) +
  geom_bar(
    aes(fill = gpp_is_equal)
    , width = 0.7
  ) +
  geom_text(
    aes(label = scales::comma(..count..))
    , stat = "count"
    , vjust = -0.5
    , color = "black"
  ) +
  scale_fill_viridis_d(alpha = 0.8) +
  scale_y_continuous(labels = scales::comma) +
  xlab("GPP Calc. = GPP? (accuracy = .01)") +
  labs(
    title = "GPP Calc. = GPP? (accuracy = .01)"
    , subtitle = paste0(site, " (30-min data)")
  ) +
  theme_bw() +
  theme(
    legend.position = "none"
  )
```




Choose a winter and summer week in your dataset. Create a plot with both your calculated GPP and the NEON GPP.

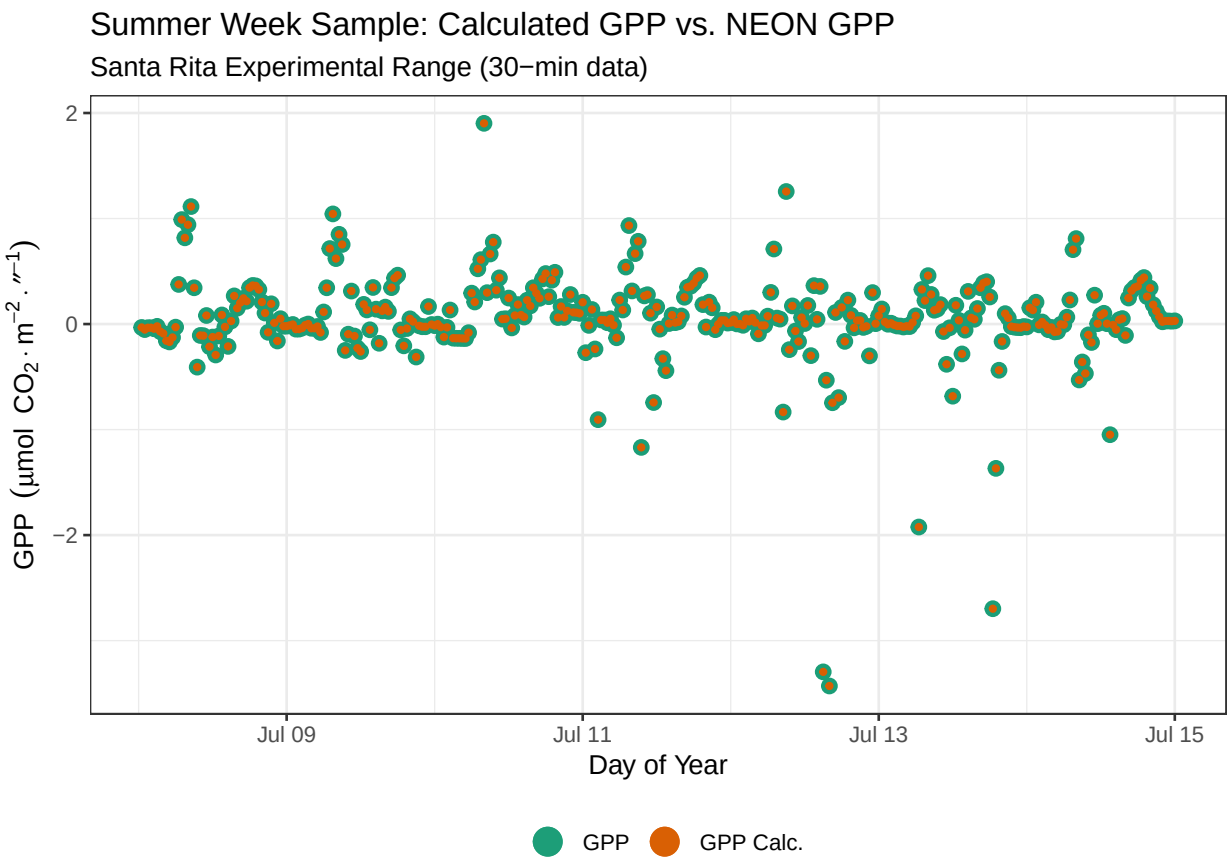
```
# select week with full data for winter and summer
sum_wk <- dta_30min %>%
  dplyr::filter(
    neon_site_name == site
    & season == "Summer"
    & year == 2020
    & is_full_week == TRUE
  ) %>%
  dplyr::slice_sample(n = 1)
wint_wk <- dta_30min %>%
  dplyr::filter(
    neon_site_name == site
    & season == "Winter"
    & year == 2020
    & is_full_week == TRUE
  ) %>%
  dplyr::slice_sample(n = 1)

# plot winter week
dta_30min %>%
  dplyr::filter(
    neon_site_name == site
```

```
    & year == 2020
    & week == wint_wk$week[1]
  ) %>%
ggplot(., aes(x = time_id)) +
  geom_point(
    aes(y = gpp, color = "GPP")
    , size = 2.5
  ) +
  geom_point(
    aes(y = gpp_calc, color = "GPP Calc.")
    , size = 0.9
  ) +
  scale_color_brewer(type = "qual", palette = "Dark2") +
  xlab("Day of Year") +
  ylab(latex2exp::TeX("$GPP \\; (\\mu mol \\; CO_{2} \\cdot m^{-2} \\cdot second^{-1})$")) +
  labs(
    title = "Winter Week Sample: Calculated GPP vs. NEON GPP"
    , subtitle = paste0(site, " (30-min data)")
  ) +
  theme_bw() +
  theme(
    legend.position = "bottom"
    , legend.direction = "horizontal"
    , legend.title = element_blank()
  ) +
  guides(color = guide_legend(override.aes = list(size=5, alpha = 0.9)))
```




```
# plot summer week
dta_30min %>%
  dplyr::filter(
    neon_site_name == site
    & year == 2020
    & week == sum_wk$week[1]
  ) %>%
ggplot(., aes(x = time_id)) +
  geom_point(
    aes(y = gpp, color = "GPP")
    , size = 2.5
  ) +
  geom_point(
    aes(y = gpp_calc, color = "GPP Calc.")
    , size = 0.9
  ) +
  scale_color_brewer(type = "qual", palette = "Dark2") +
  xlab("Day of Year") +
  ylab(latex2exp::TeX("$GPP \\; (\\mu mol \\; CO_{2} \\cdot m^{-2} \\cdot second^{-1})$")) +
  labs(
    title = "Summer Week Sample: Calculated GPP vs. NEON GPP"
    , subtitle = paste0(site, " (30-min data)")
  ) +
  theme_bw() +
  theme(
```

```
    legend.position = "bottom"
    , legend.direction = "horizontal"
    , legend.title = element_blank()
  ) +
  guides(color = guide_legend(override.aes = list(size=5, alpha = 0.9)))
```




**a.**

How do the calculated and NEON GPP's compare for your site? Why are they the same or different? (Note: NEON uses eddy covariance to calculate these metrics - more about that here).

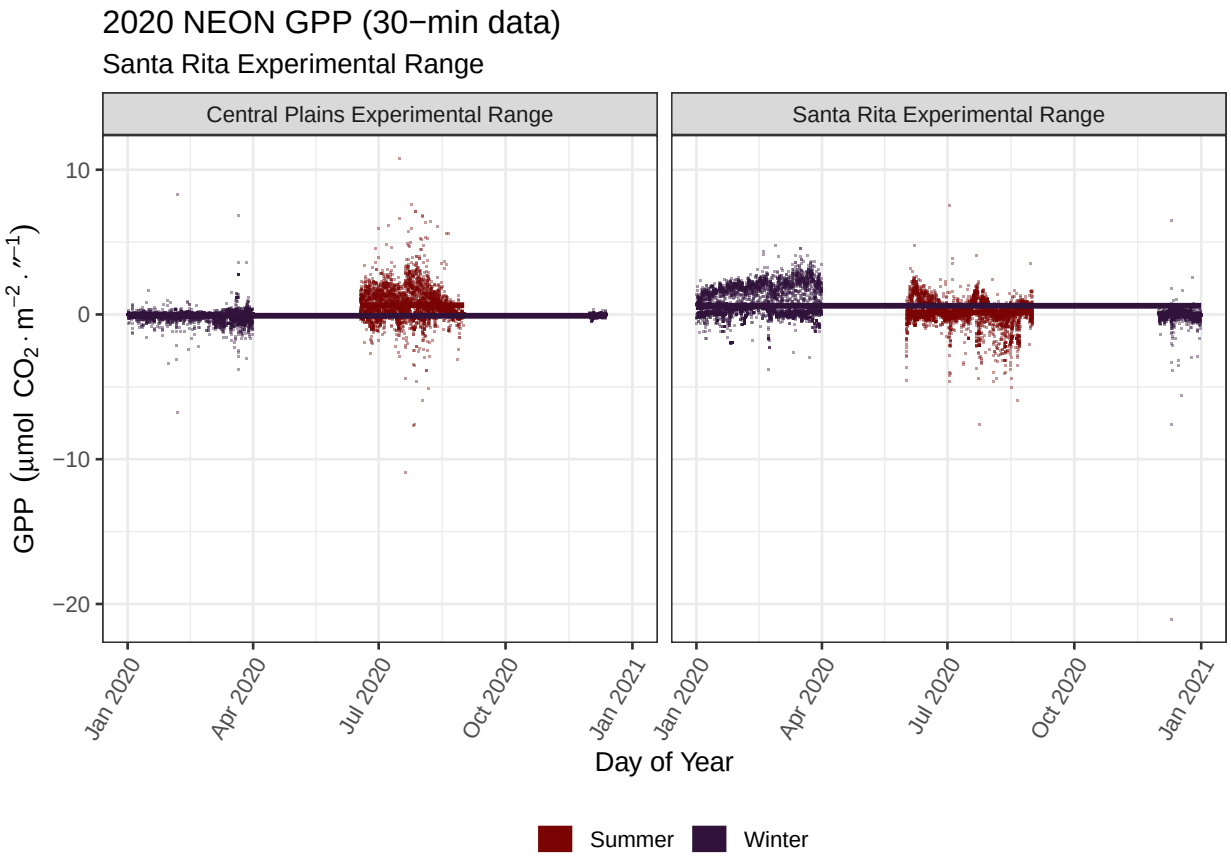
The majority of data points have a calculated GPP ($GPP = R_E - NEE$) equal to the NEON GPP. There are 45,584 records for which the GPP is equal (accuracy = 0.01) and 89 records for which the GPP is not equal. In cases where the GPP is not equal, the difference is negligible and likely due to rounding due to number accuracy.

**b.**

How do your sites GPP values vary between summer and winter? What do you think is driving these differences?

```
# plot points
dta_30min %>%
```

```
  dplyr::filter(
    # neon_site_name == site
    year == 2020
    & season %in% c("Summer", "Winter")
  ) %>%
ggplot(., aes(x = time_id, y = gpp, color = season)) +
  geom_point(
    # size = 0.2
    alpha = 0.4
    , shape = "."
  ) +
  geom_smooth(
    method = "lm"
    , formula=y~1
    , se = FALSE
    , lwd = 1.1
    , linetype = "solid"
    , alpha = 1
  ) +
  facet_wrap(~neon_site_name) +
  scale_color_viridis_d(option = "turbo", direction = -1) +
  xlab("Day of Year") +
  ylab(latex2exp::TeX("$GPP \\; (\\mu mol \\; CO_{2} \\cdot m^{-2} \\cdot second^{-1})$")) +
  labs(
    title = "2020 NEON GPP (30-min data)"
    , subtitle = paste0(site)
  ) +
  theme_bw() +
  theme(
    legend.position = "bottom"
    , legend.direction = "horizontal"
    , legend.title = element_blank()
    , axis.text.x = element_text(angle = 60, hjust=1)
  ) +
  guides(color = guide_legend(override.aes = list(size=5, alpha = 0.9)))
```



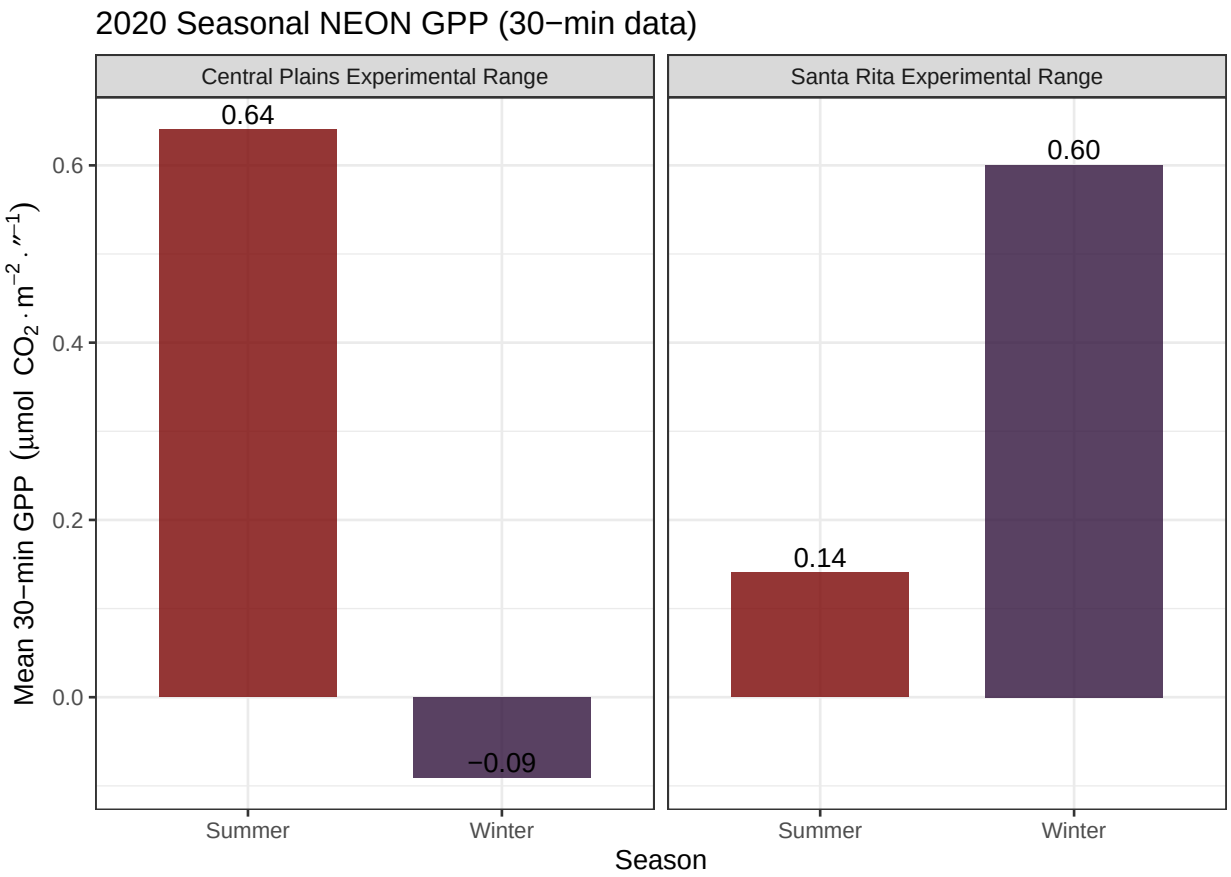

Based on 2020 data, The average 30-minute GPP for the NEON site Santa Rita Experimental Range is higher in the winter months than in the summer months. This is opposite of the pattern for GPP seen at the CPER site. At the Santa Rita Experimental Range, this pattern is likely driven by low summer precipitation and high summer temperatures to the winter.

**c.**

CPER is a semi-arid grassland. Compare GPP values between your site and CPER - why might they be different or similar?

```
# plot points
dta_30min %>%
  dplyr::filter(
    # neon_site_name == site
    year == 2020
    & season %in% c("Summer", "Winter")
  ) %>%
  dplyr::group_by(neon_site_name, season, year) %>%
  dplyr::summarise(mean_gpp = mean(gpp, na.rm = TRUE)) %>%
ggplot(., aes(x = season, y = mean_gpp, fill = season)) +
  geom_col(
    width = 0.7
    , alpha = 0.8
  ) +
  geom_text(
```

```
  aes(label = scales::comma(mean_gpp, accuracy = 0.01))
  , vjust = -0.3
  , color = "black"
) +
facet_wrap(~neon_site_name) +
scale_fill_viridis_d(option = "turbo", direction = -1) +
xlab("Season") +
ylab(latex2exp::TeX("Mean 30-min $GPP \\; (\\mu mol \\; CO_{2} \\cdot m^{-2} \\cdot second^{-1})$")) +
labs(
  title = "2020 Seasonal NEON GPP (30-min data)"
) +
theme_bw() +
theme(
  legend.position = "none"
)
```

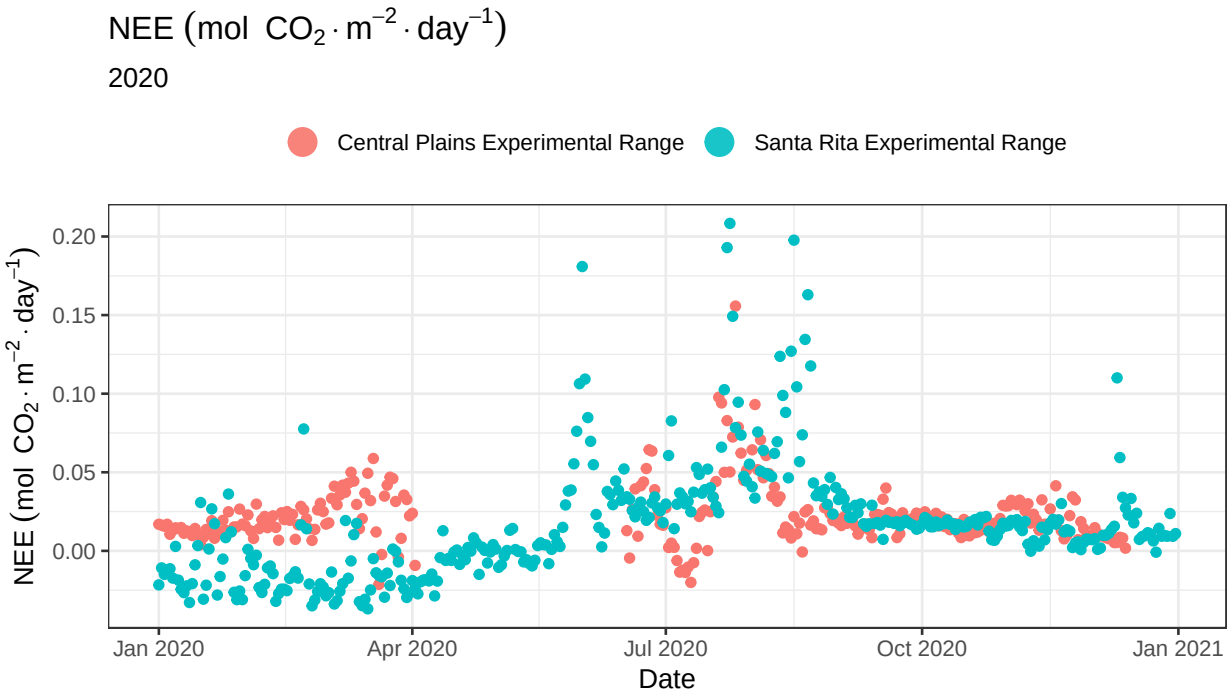


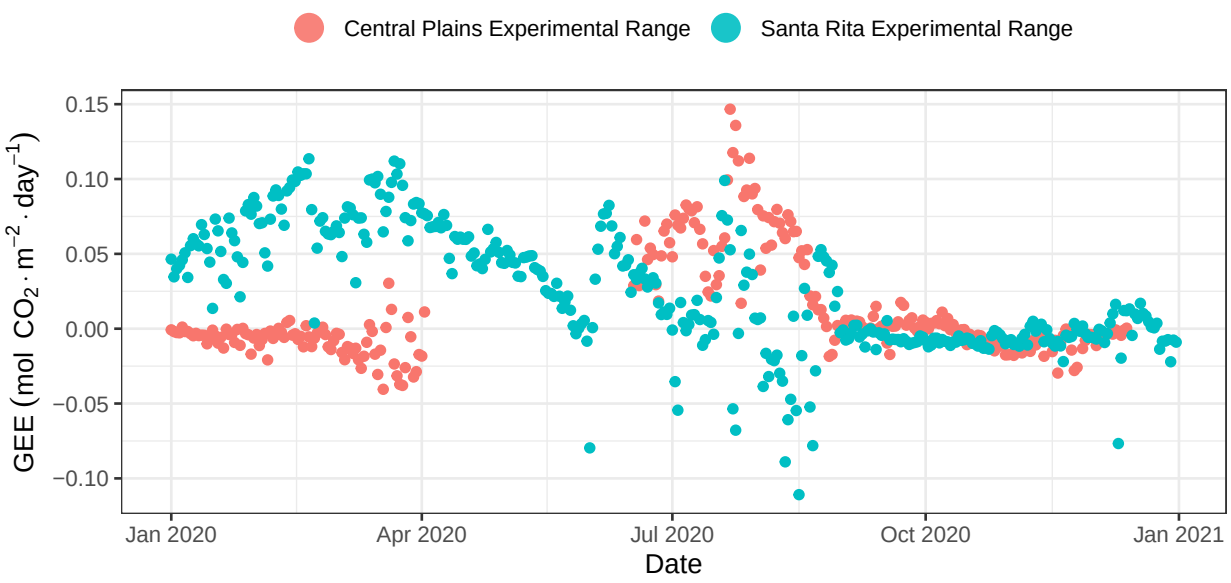

Based on 2020 data, The average 30-minute GPP for the NEON site Santa Rita Experimental Range is higher in the winter months (0.60) than in the summer months (0.14). This is opposite of the pattern for GPP seen at the CPER site. At the Santa Rita Experimental Range, this pattern is likely driven by low summer precipitation and high summer temperatures to the winter.

## Question 2

Using the daily data. Select a single year of data for your site. Plot NEE, GPP, Re, soil temperature, air temperature, and soil water content against Day of Year.

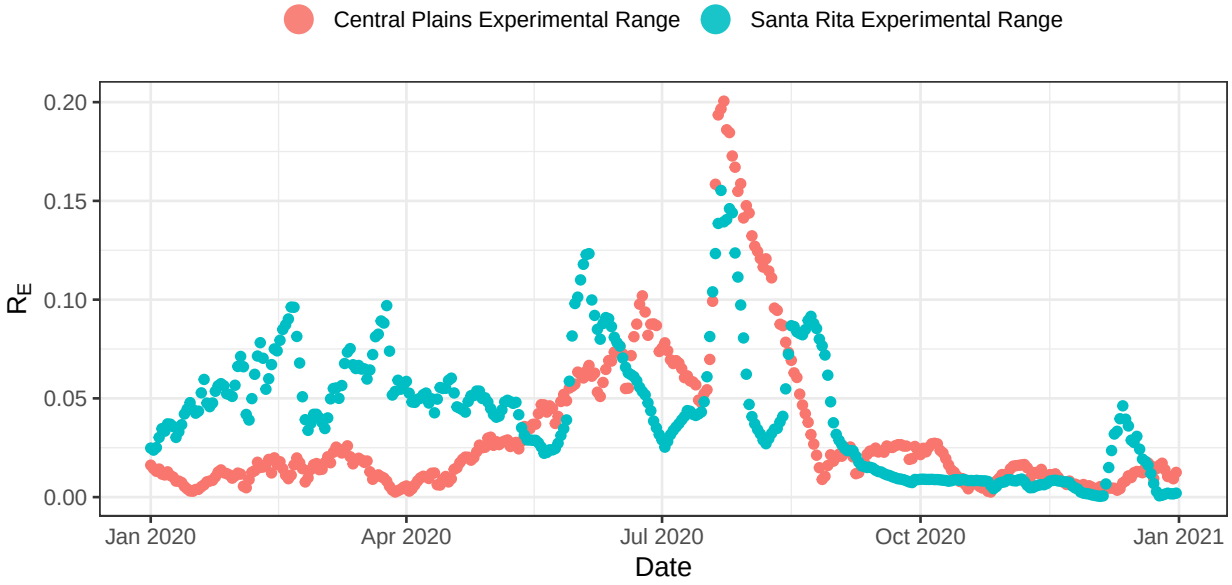
```
p_fn <- function(my_var, my_year) {
  #plot
  (
    dta_1day %>%
    dplyr::filter(
      year == my_year
    ) %>%
    ggplot(., aes_string(x = "date_id", y = my_var, color = "neon_site_name")) +
      geom_point() +
      xlab("Date") +
      ylab(t[i]) +
      labs(
        title = t[i]
        , subtitle = my_year
      ) +
      scale_fill_brewer(type = "qual", palette = "Dark2", direction = -1) +
      theme_bw() +
      theme(
        legend.position = "top"
        , legend.direction = "horizontal"
        , legend.title = element_blank()
      ) +
      guides(color = guide_legend(override.aes = list(size=5, alpha = 0.9)))
  )

}
# vars
v <- c("nee", "gpp", "re", "ts", "ta", "swc")
t <- c(
  latex2exp::TeX("NEE $( mol \\; CO_{2} \\cdot m^{-2} \\cdot day^{-1})$")
   , latex2exp::TeX("GEE $( mol \\; CO_{2} \\cdot m^{-2} \\cdot day^{-1})$")
   , latex2exp::TeX("$R_E$")
   , "Soil Temperature (\u00B0C)"
   , "Air temperature (\u00B0C)"
    , "Soil Water Content"
)
for (i in 1:length(v)) {
  print( p_fn(my_var = v[i], my_year = 2020) )
}
```


NEE (mol $CO_2 \cdot m^{-2} \cdot day^{-1}$)
2020
Central Plains Experimental Range
Santa Rita Experimental Range
0.20
0.15
0.10
0.05
0.00
NEE (mol $CO_2 \cdot m^{-2} \cdot day^{-1}$)
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Date


GEE (mol $CO_2 \cdot m^{-2} \cdot day^{-1}$)
2020
Central Plains Experimental Range
Santa Rita Experimental Range
0.15
0.10
0.05
0.00
−0.05
−0.10
GEE (mol $CO_2 \cdot m^{-2} \cdot day^{-1}$)
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Date

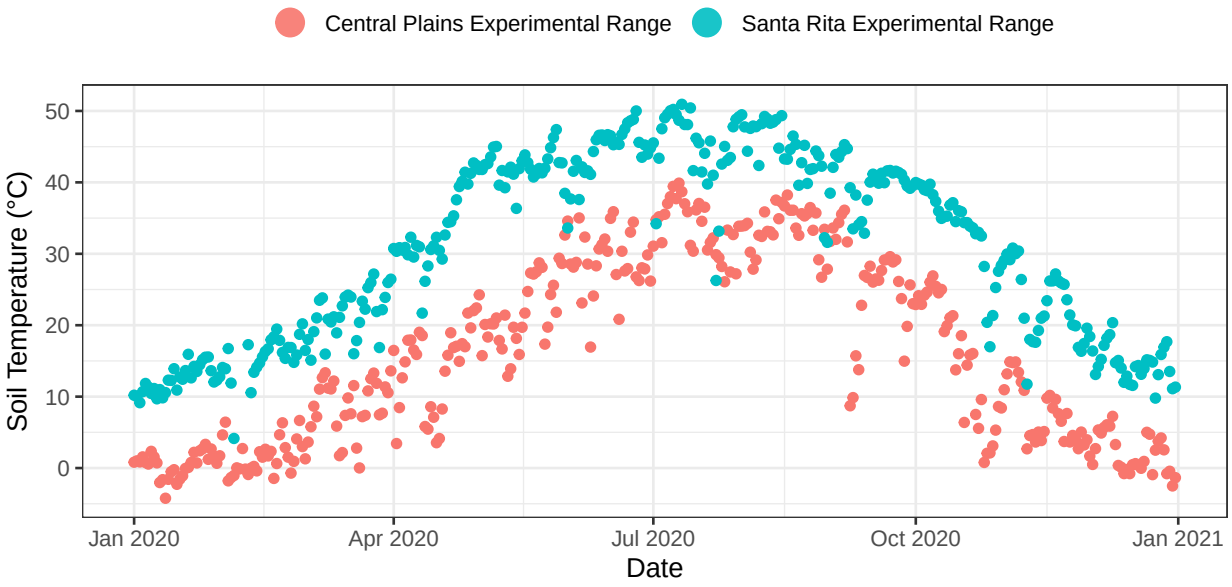
$R_E$

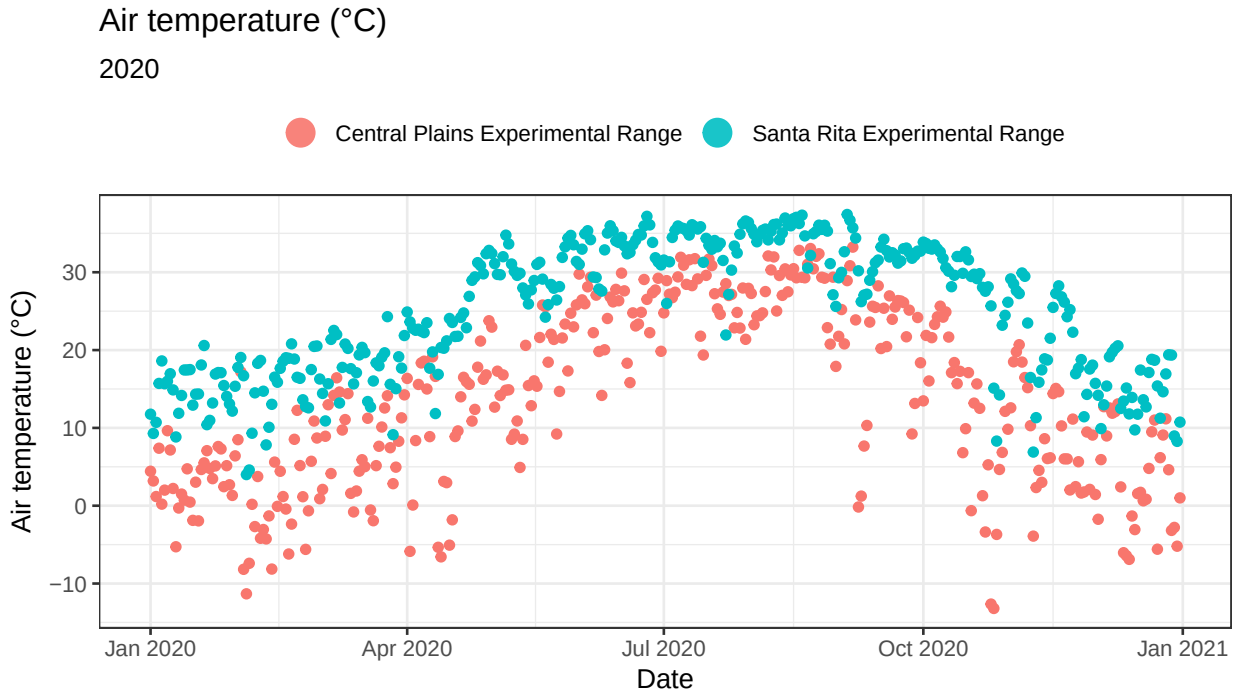
2020

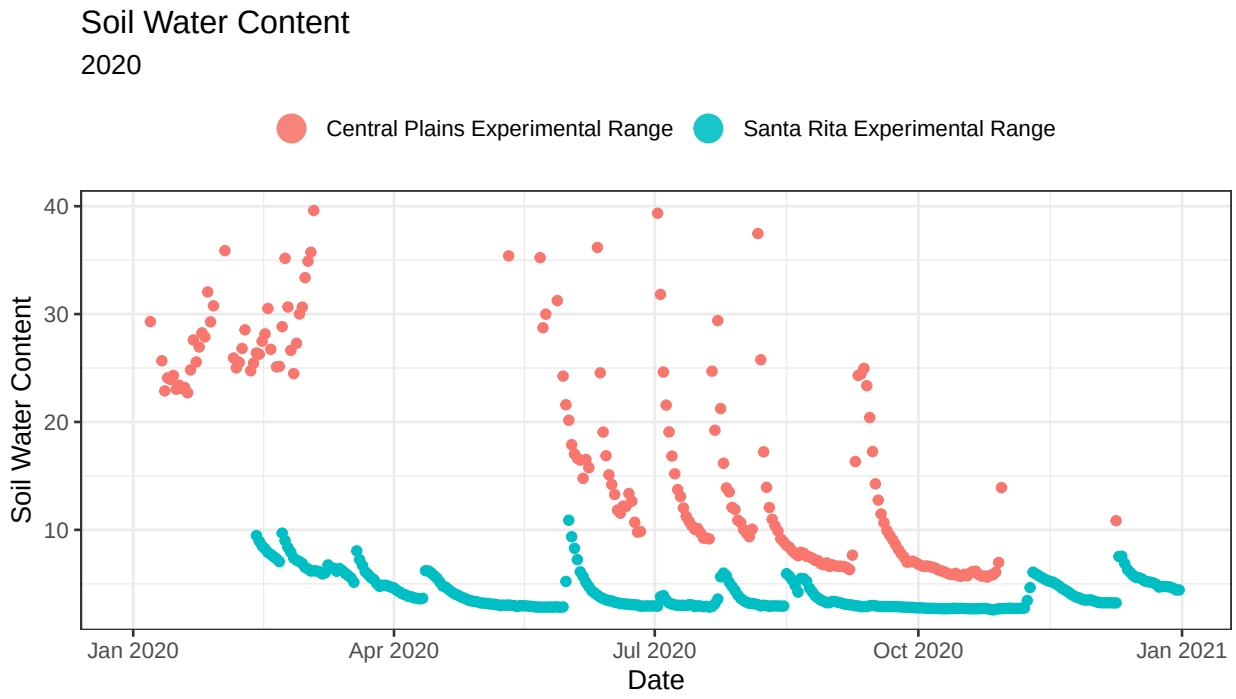



Soil Temperature (°C)

2020





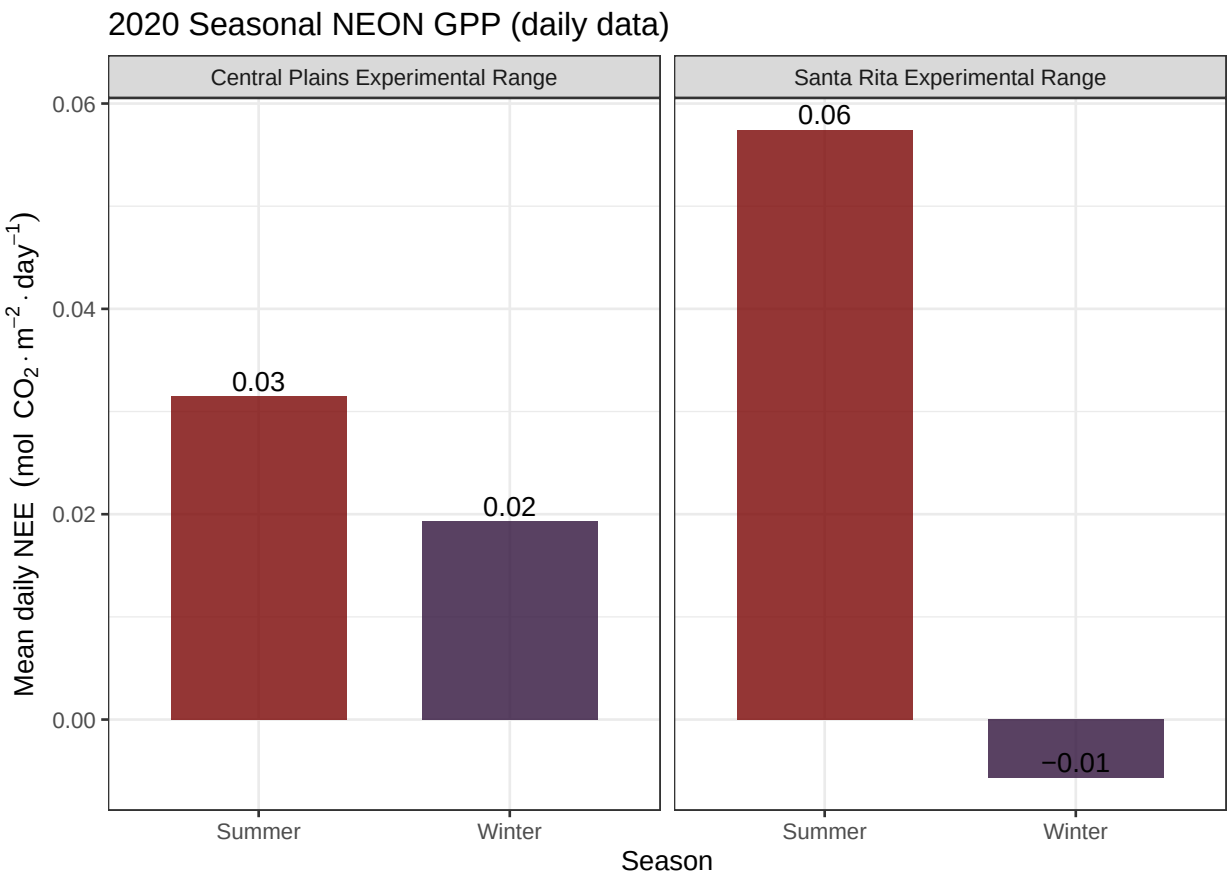

**a.**

Describe the annual patterns in each plot and what you think drives them.

**b.**

Compare annual values of NEE at your site vs. CPER. Which exchanges more carbon? Why do you think that is?

```
# plot
dta_1day %>%
  dplyr::filter(
    # neon_site_name == site
    year == 2020
    & season %in% c("Summer", "Winter")
  ) %>%
  dplyr::group_by(neon_site_name, season, year) %>%
  dplyr::summarise(mean_nee = mean(nee, na.rm = TRUE)) %>%
ggplot(., aes(x = season, y = mean_nee, fill = season)) +
  geom_col(
    width = 0.7
    , alpha = 0.8
  ) +
  geom_text(
    aes(label = scales::comma(mean_nee, accuracy = 0.01))
    , vjust = -0.3
    , color = "black"
  ) +
  facet_wrap(~neon_site_name) +
  scale_fill_viridis_d(option = "turbo", direction = -1) +
  xlab("Season") +
  ylab(latex2exp::TeX("Mean daily $NEE \\; (mol \\; CO_{2} \\cdot m^{-2} \\cdot day^{-1})$")) +
  labs(
    title = "2020 Seasonal NEON GPP (daily data)"
  ) +
  theme_bw() +
  theme(
    legend.position = "none"
  )
```

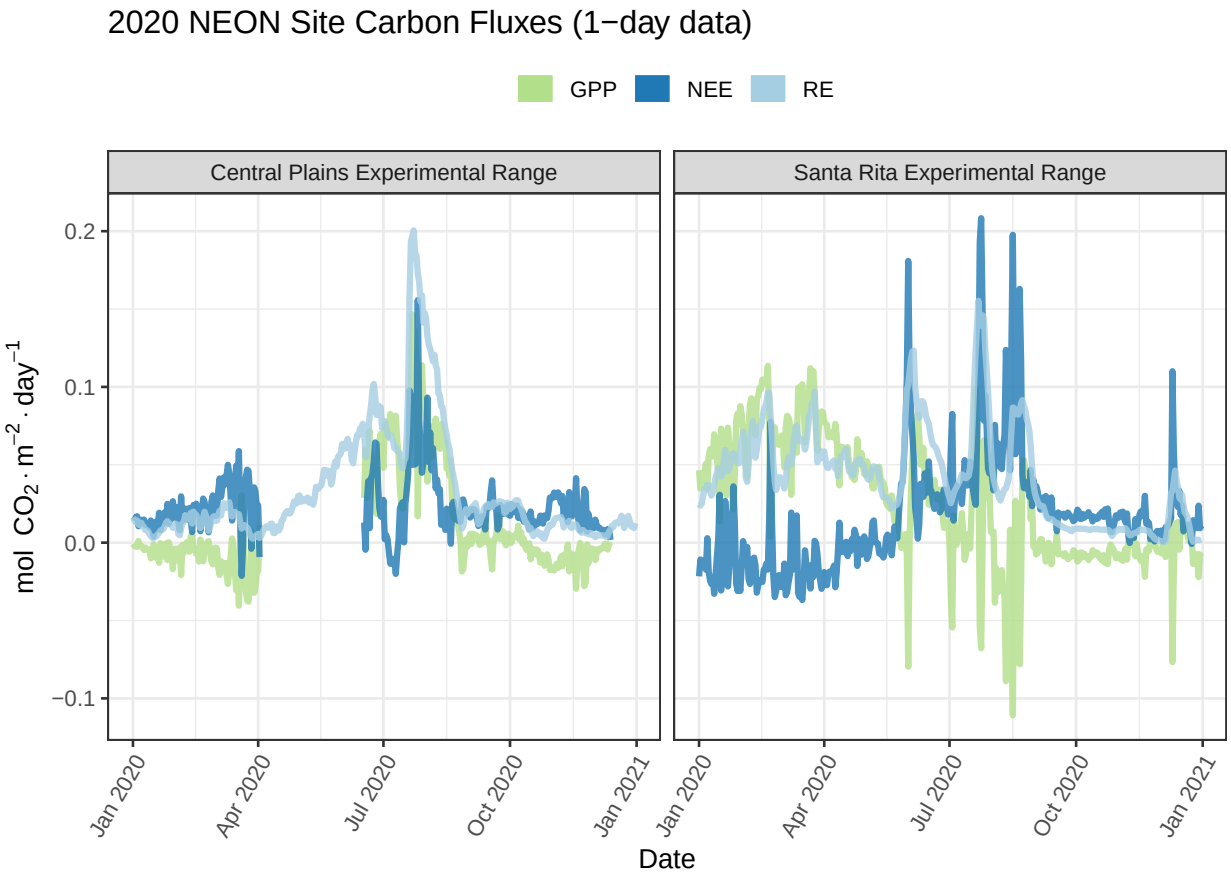



## Extra

Compare annual time-trend of $GPP$, $NEE$, $R_E$ for sites:

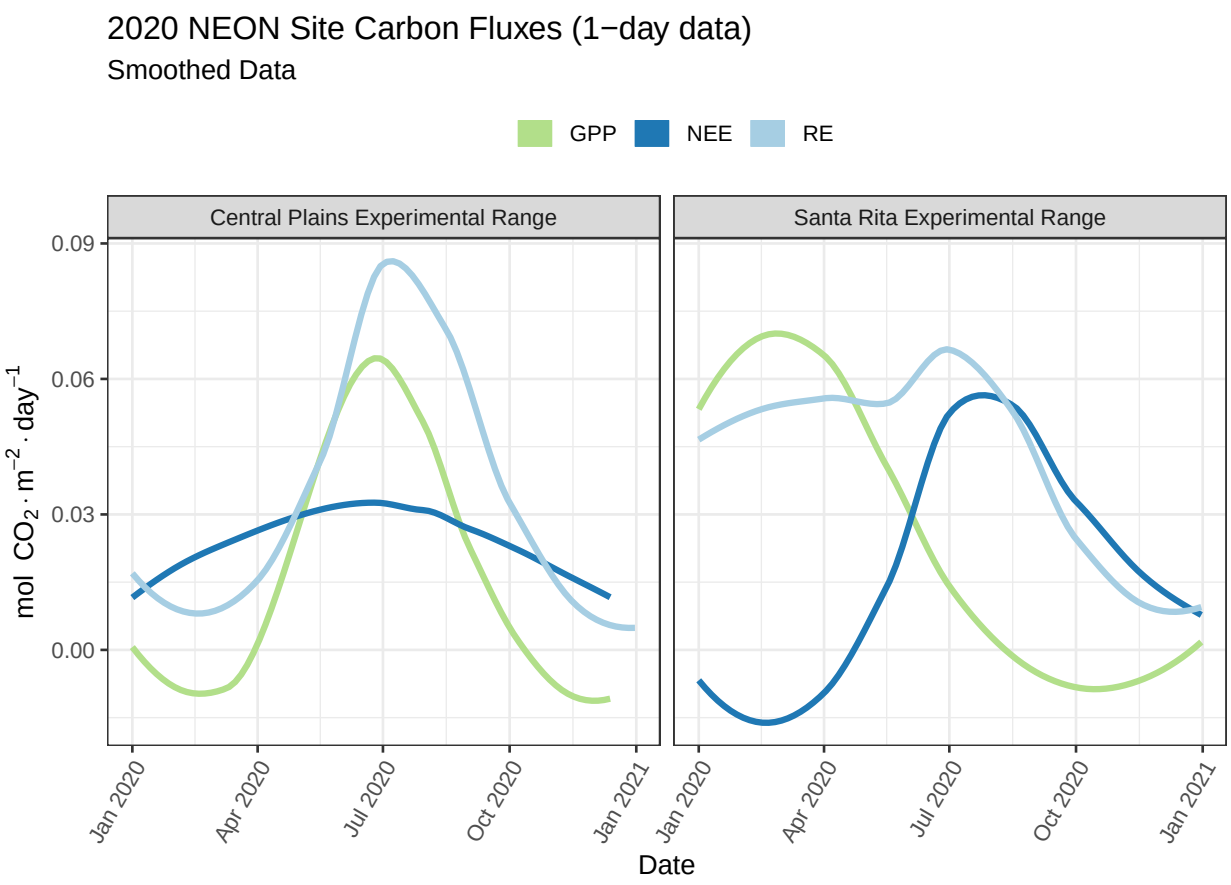
```
# plot daily gpp, nee, re
dta_1day %>%
  dplyr::filter(
    # neon_site_name == site
    year == 2020
  ) %>%
ggplot(., aes(x = date_id)) +
  geom_line(
    aes(y = gpp, color = "GPP")
    , lwd = 1.2
    , alpha = 0.8
  ) +
  geom_line(
    aes(y = nee, color = "NEE")
    , lwd = 1.2
    , alpha = 0.8
  ) +
  geom_line(
    aes(y = re, color = "RE")
    , lwd = 1.2
```

```
    , alpha = 0.8
  ) +
  facet_wrap(~neon_site_name) +
  scale_color_brewer(type = "qual", palette = "Paired", direction = -1) +
  xlab("Date") +
  ylab(latex2exp::TeX("$mol \\; CO_{2} \\cdot m^{-2} \\cdot day^{-1}$")) +
  labs(
    title = "2020 NEON Site Carbon Fluxes (1-day data)"
  ) +
  theme_bw() +
  theme(
    legend.position = "top"
    , legend.direction = "horizontal"
    , legend.title = element_blank()
    , axis.text.x = element_text(angle = 60, hjust=1)
  ) +
  guides(color = guide_legend(override.aes = list(size = 5)))
```




```
# plot daily gpp, nee, re
dta_1day %>%
  dplyr::filter(
    # neon_site_name == site
    year == 2020
  ) %>%
```

```
ggplot(., aes(x = date_id)) +
  geom_smooth(
    aes(y = gpp, color = "GPP")
    , method = "loess"
    , span = 0.7
    , se = FALSE
    , lwd = 1.2
    , alpha = 0.8
  ) +
  geom_smooth(
    aes(y = nee, color = "NEE")
    , method = "loess"
    , span = 0.7
    , se = FALSE
    , lwd = 1.2
    , alpha = 0.8
  ) +
  geom_smooth(
    aes(y = re, color = "RE")
    , method = "loess"
    , span = 0.7
    , se = FALSE
    , lwd = 1.2
    , alpha = 0.8
  ) +
  facet_wrap(~neon_site_name) +
  scale_color_brewer(type = "qual", palette = "Paired", direction = -1) +
  xlab("Date") +
  ylab(latex2exp::TeX("$mol \\; CO_{2} \\cdot m^{-2} \\cdot day^{-1}$")) +
  labs(
    title = "2020 NEON Site Carbon Fluxes (1-day data)"
    , subtitle = "Smoothed Data"
  ) +
  theme_bw() +
  theme(
    legend.position = "top"
    , legend.direction = "horizontal"
    , legend.title = element_blank()
    , axis.text.x = element_text(angle = 60, hjust=1)
  ) +
  guides(color = guide_legend(override.aes = list(size = 5)))
```


2020 NEON Site Carbon Fluxes (1−day data)
Smoothed Data
GPP
NEE
RE
Central Plains Experimental Range
Santa Rita Experimental Range
0.09
0.06
0.03
0.00
mol CO2 · m−2 · day−1
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Date