Group I: Almond Yield Model

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```
library(tidyverse)
library(here)
library(janitor)
```

Almond Yield Function

This environmental model was completed as an assignment for the course, Environmental Data Science 230 | Environmental Science & Management: Modeling Environmental Systems. The goal of this assignment was to build a model of almond yield in California between the years 1989 and 2010. The source data and model design is based on research published in the paper, Impacts of future climate change on California perennial crop yields: Model projections with climate and crop uncertainties (Lobell 2006).

Data and Source Function

```
#read in the data
clim <- read.table(here("data/clim.txt"), header = TRUE) %>%
  clean_names()

#source function(s):
#almond_model()
source(here("R/almond_model.R"))
```

Subset the data

```
#subset the clim data for monthly averages
clim_avg <- clim %>%
  group_by(year, month) %>%
  summarize(mean_temp = mean(tmin_c),
            tot_precip = sum(precip)) %>%
  filter(month %in% c(1, 2))

# create a variable for avg. February temp. data
Tn2 <- clim_avg %>%
  group_by(year) %>%
  mutate(Tn2 = case_when(month == 2 ~ mean_temp)) %>%
  select(year, Tn2) %>%
  drop_na()
```

```r
# create a variable for avg. January precipitation data
P1 <- clim_avg %>%
  group_by(year) %>%
  mutate(P1 = case_when(month == 1 ~ tot_precip)) %>%
  select(year, P1) %>%
  drop_na

# create a variable combined temp and precip data
func_vars <- cbind(Tn2, P1 = P1$P1)
```

Run Model

```r
#run almond_model() on subsetted clim data
almond_yield_anmly <- func_vars %>%
  mutate(yield_anmly = almond_model(Tn2 = Tn2, P1 = P1))
```

Check Answers

```r
# check values with those provided in the assignment for years 2000, 2001, 2002
ya2000 <- almond_yield_anmly %>%
  filter(year == 2000) %>%
  select(yield_anmly)

print(paste("In 2000, the almond yield anomaly was",
            round(ya2000$yield_anmly, 3), "tons acre-1"))
```

```
## [1] "In 2000, the almond yield anomaly was 9.6 tons acre-1"
```

```r
ya2001 <- almond_yield_anmly %>%
  filter(year == 2001) %>%
  select(yield_anmly)

print(paste("In 2001, the almond yield anomaly was",
            round(ya2001$yield_anmly, 2), "tons acre-1"))
```

```
## [1] "In 2001, the almond yield anomaly was 159.51 tons acre-1"
```

```r
ya2002 <- almond_yield_anmly %>%
  filter(year == 2002) %>%
  select(yield_anmly)

print(paste("In 2002, the almond yield anomaly was",
            round(ya2002$yield_anmly, 2), "tons acre-1"))
```

```
## [1] "In 2002, the almond yield anomaly was 0.25 tons acre-1"
```

```r
# create statistical variables
yield_min <- min(almond_yield_anmly$yield_anmly)
yield_max <- max(almond_yield_anmly$yield_anmly)
avg_yield <- mean(almond_yield_anmly$yield_anmly)
```

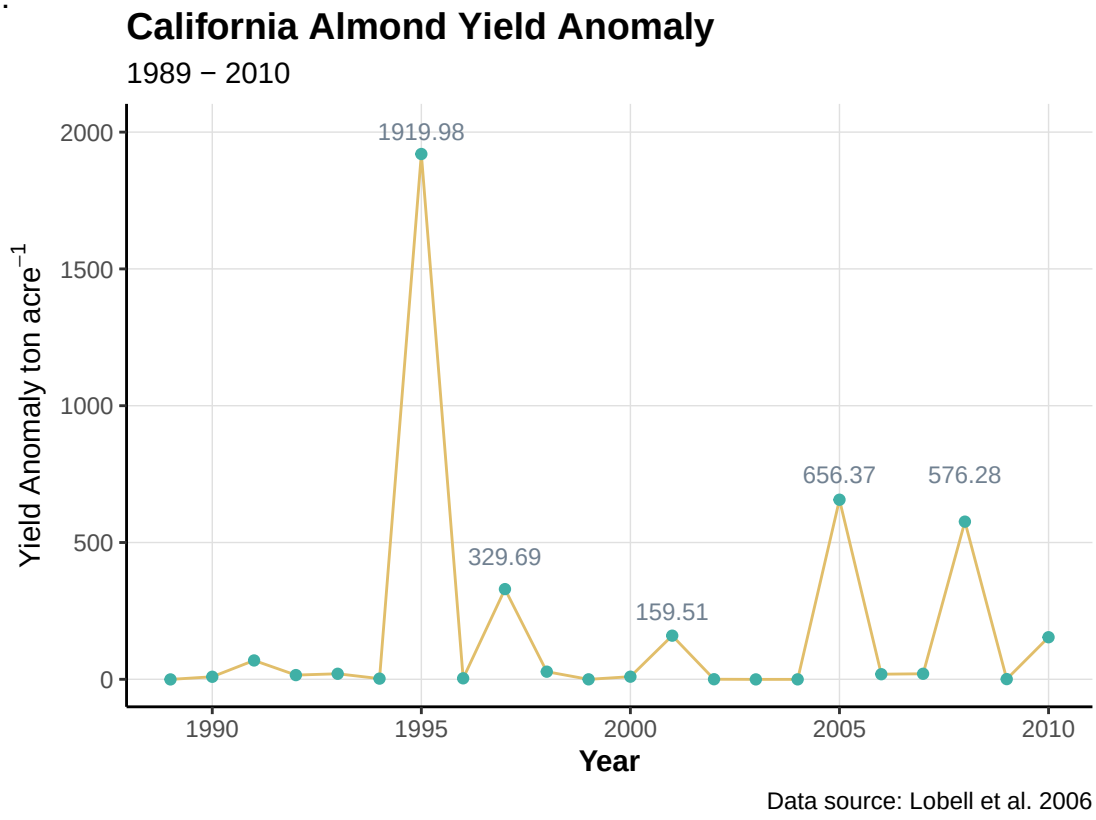
Visualize Results

```
#plot data

anmly_plot <- ggplot(data = almond_yield_anmly,
                     aes(x = year, y = yield_anmly)) +
  geom_line(color = "#E1BE6A") +
  geom_point(color = "#40B0A6") +
  geom_text(aes(x = 1995, y = 2003, label = "1919.98"), stat = "unique",
            size = 3, color = "slategrey") +
  geom_text(aes(x = 1997, y = 450, label = "329.69"), stat = "unique",
            size = 3, color = "slategrey") +
  geom_text(aes(x = 2001, y = 250, label = "159.51"), stat = "unique",
            size = 3, color = "slategrey") +
  geom_text(aes(x = 2005, y = 750, label = "656.37"), stat = "unique",
            size = 3, color = "slategrey") +
  geom_text(aes(x = 2008, y = 750, label = "576.28"), stat = "unique",
            size = 3, color = "slategrey") +
  labs(title = "California Almond Yield Anomaly",
       subtitle = "1989 - 2010",
       caption = "Data source: Lobell et al. 2006",
       tag = "Figure 1:",
       x = "Year",
       y = expression(paste("Yield Anomaly ton acre"^-1))) +
  theme(plot.title = element_text(face = "bold", size = 14),
        axis.title.x = element_text(face = "bold", size = 11),
        axis.title.y = element_text(face = "bold", size = 11),
        panel.background = element_rect(fill = "white"),
        panel.border = element_blank(),
        axis.line = element_line(colour = "black"),
        panel.grid.major = element_line(size = 0.25,
                                        linetype = 'solid', colour = "grey88"),
        panel.grid.minor = element_blank())

anmly_plot
```

Figure 1:



Summarize Results

This analysis explored changes in almond crop yield anomaly from 1989 to 2010 as a function of monthly precipitation and average minimum temperature. The minimum yield anomaly from 1989 to 2010 was -0.36, which occurred in 1989. The maximum almond yield anomaly was 1919.98, which occurred in 1995. The average yield anomaly from 1989 to 2010 was 181.45. The differences in precipitation had a positive influence on the yield anomaly as the years with higher precipitation had higher yield anomalies. The large spike in yield anomaly in 1995 could possibly be due to the increased precipitation caused by the 1994 - 1995 El Niño (Muis 2018). Years preceding high crop yield anomalies saw a significant decrease in yields. One factor that may influence this phenomenon is that almonds are alternate bearing, meaning that after a year of high fruit productivity, the following year a tree will have a significantly reduced fruit yield (Boriss 2005). There was not an overall increasing or decreasing trend seen in the yield anomaly from 1989 to 2010.

Reference

Boriss H., Brunke H. (2005). Commodity Profile: Almonds. California, CA: University of California. https://aic.ucdavis.edu/profiles/Almonds-2005.pdf. Last accessed: 2022/04/11

Lobell, D., Field, C., Nicholas, K., & Bonfils, C. (2006). Impacts of future climate change on California perennial crop yields: Model projections with climate and crop uncertainties. Agricultural and Forest Meteorology, 141, 208–218. https://doi.org/10.1016/j.agrformet.2006.10.006

Muis, S., Haigh, I. D., Guimarães Nobre, G., Aerts, J. C. J. H., & Ward, P. J. (2018). Influence of El Niño-Southern Oscillation on Global Coastal Flooding. Earth's Future, 6(9), 1311–1322. https://doi.org/10.1029/2018EF000909