EDS 230 / ESM 232 Assignment - Almond Anomaly Summary

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Read in climate data and almond anomaly function:

```
# read in the climate data
data <- read.table("clim.txt", sep = " ", header = T)
```

```
# load in almond_anomaly.R function
source(here("almond_anomaly.R"))
```

Run `almond_anomaly()` function on climate data, with default values for all arguments besides `data`:

```
almond_anom <- almond_anomaly(data = data)
```

```
## `summarise()` has grouped output by 'year'. You can override using the `.groups`
## argument.

## [1] "The data is now wrangled. Starting anomaly calculation."

## Warning: `data_frame()` was deprecated in tibble 1.1.0.
## Please use `tibble()` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was generated.
```

```
almond_anom
```

```
##    year almond_anomaly
## 1  1989    0.043215637
## 2  1990    9.674775390
## 3  1991   69.316413161
## 4  1992   15.823461393
## 5  1993   20.494519263
## 6  1994    2.859873636
## 7  1995 1920.308404976
## 8  1996    4.185522127
## 9  1997  329.980539034
## 10 1998   28.199926134
## 11 1999    0.108694002
## 12 2000    9.812790398
## 13 2001  159.753067643
## 14 2002    0.463661251
## 15 2003   -0.026823712
## 16 2004   -0.008045354
```

```
## 17 2005  656.721768859
## 18 2006   18.957258195
## 19 2007   20.508883045
## 20 2008  576.539253888
## 21 2009    0.982102752
## 22 2010  153.997779529
```

Visually Summarize Results

```
almond_anom_table <- almond_anom %>%
  gt() %>%
  tab_header(
    title = md("**Almond Anomalies 1989 - 2010**")
  ) %>%
  fmt_passthrough(
  columns = c(year)
  ) %>%
  fmt_number(
  columns = c(almond_anomaly)
  ) %>%
  cols_label(year = "Year" ,
           almond_anomaly = "Almond Anomaly") %>%
  tab_style(
    style = list(
      cell_fill(color = "#F8766D"),
      cell_text(weight = "bold")
      ),
    locations = cells_body(
      columns = c(year, almond_anomaly))
  ) %>%
tab_style(
  style = list(
    cell_fill(color = "#00BFC4"),
    cell_text(weight = "bold")
    ),
  locations = cells_body(
    columns = c(year, almond_anomaly),
    rows = year == "1995")
 ) %>%
  tab_source_note(source_note = "Data Source: Lobell et all. 2006: https://naomitague.github.io/ESM232_
  opt_align_table_header(align = "center") %>%
  cols_width(
    year ~ px(150),
    almond_anomaly ~ px(150)
  ) %>%
  cols_align(align = "center")

almond_anom_table
```

Almond Anomalies 1989 - 2010

Year	Almond Anomaly
1989	0.04

1990	9.67
1991	69.32
1992	15.82
1993	20.49
1994	2.86
1995	1,920.31
1996	4.19
1997	329.98
1998	28.20
1999	0.11
2000	9.81
2001	159.75
2002	0.46
2003	−0.03
2004	−0.01
2005	656.72
2006	18.96
2007	20.51
2008	576.54
2009	0.98
2010	154.00

Data Source: Lobell et all. 2006: https://naomitague.github.io/ESM232_ course/assignments/lobell.2006.pdf

Figure 1: Annual almond anomalies 1989-2010. 1995 is a year of interest, because the anomaly is much larger than that of other years. Other years of interest include 2003 and 2004, because these are the only negative values.

```
ggplot(data = almond_anom, aes(x = year, y = almond_anomaly)) +
  geom_line() +
  theme_classic() +
  ggtitle("Almond Yield Anomaly, 1989-2010") +
   xlab("Year") +
   ylab("Almond Yield Anomaly (tons/acre)") +
   theme(axis.title.x = element_text(color = "black", size = 11, face = "bold"),
         axis.text.x = element_text(face = "bold", color = "black", size = 10, angle = 25),
         axis.title.y = element_text(color = "black", size = 11, face = "bold"),
         axis.text.y = element_text(face = "bold", color = "black", size = 10),
         plot.title = element_text(color="black", size = 15, face = "bold"),
         panel.border = element_rect(colour = "black", fill = NA, size = 2)) +
  scale_x_continuous(breaks = seq(1989, 2010, by = 1)) +
  geom_vline(xintercept = 1995,
              size = 0.3,
             color = "firebrick",
             linetype = "dotdash") +
   geom_text(aes(x = 1995,
                 label = "largest almond anomaly",
                 y = 340),
             angle = 90,
             vjust = 1.3,
             size = 3,
             color = "firebrick")
```

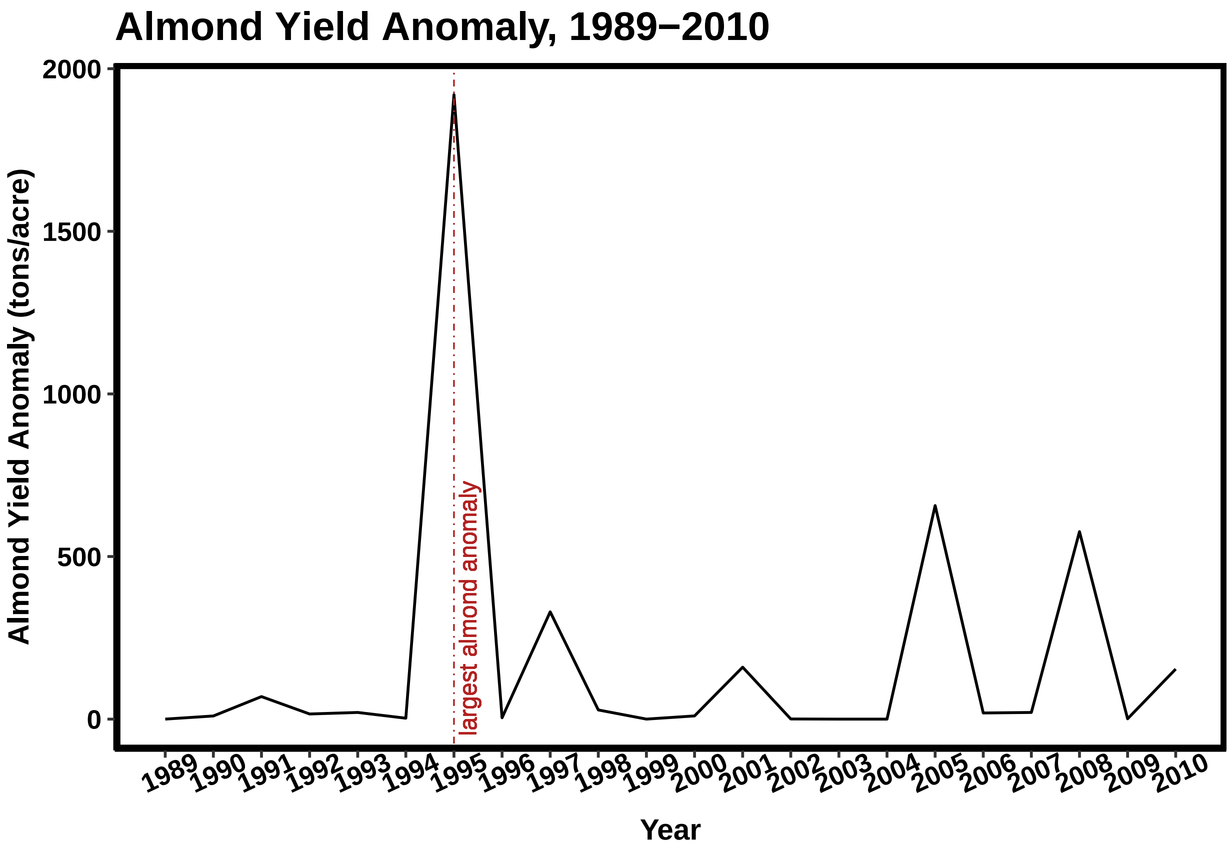

Figure 2: Almond anomaly for each year, 1989-2010. The data shows spikes in 1995, 1997, 2005, and 2008, with the largest being 1995 by a large margin.

```
data_total_precip <- data %>%
  select(year, precip) %>%
  group_by(year) %>%
  summarize(total_precip = sum(precip)) %>%
  filter(year != 1988)

ggplot(data = data_total_precip, aes(x = year, y = total_precip)) +
  geom_line() +
  theme_classic() +
  ggtitle("Precipitation, 1989-2010") +
   xlab("Year") +
   ylab("Precipitation (mm)") +
   theme(axis.title.x = element_text(color = "black", size = 11, face = "bold"),
         axis.text.x = element_text(face = "bold", color = "black", size = 10, angle = 25),
         axis.title.y = element_text(color = "black", size = 11, face = "bold"),
         axis.text.y = element_text(face = "bold", color = "black", size = 10),
         plot.title = element_text(color="black", size = 15, face = "bold"),
         panel.border = element_rect(colour = "black", fill = NA, size = 2)) +
  scale_x_continuous(breaks = seq(1989, 2010, by = 1)) +
  geom_vline(xintercept = 1995,
              size = 0.3,
             color = "firebrick",
             linetype = "dotdash") +
   geom_text(aes(x = 1995,
                 label = "largest precipitation",
```

```
    y = 340),
  angle = 90,
  vjust = 1.3,
  size = 3,
  color = "firebrick")
```

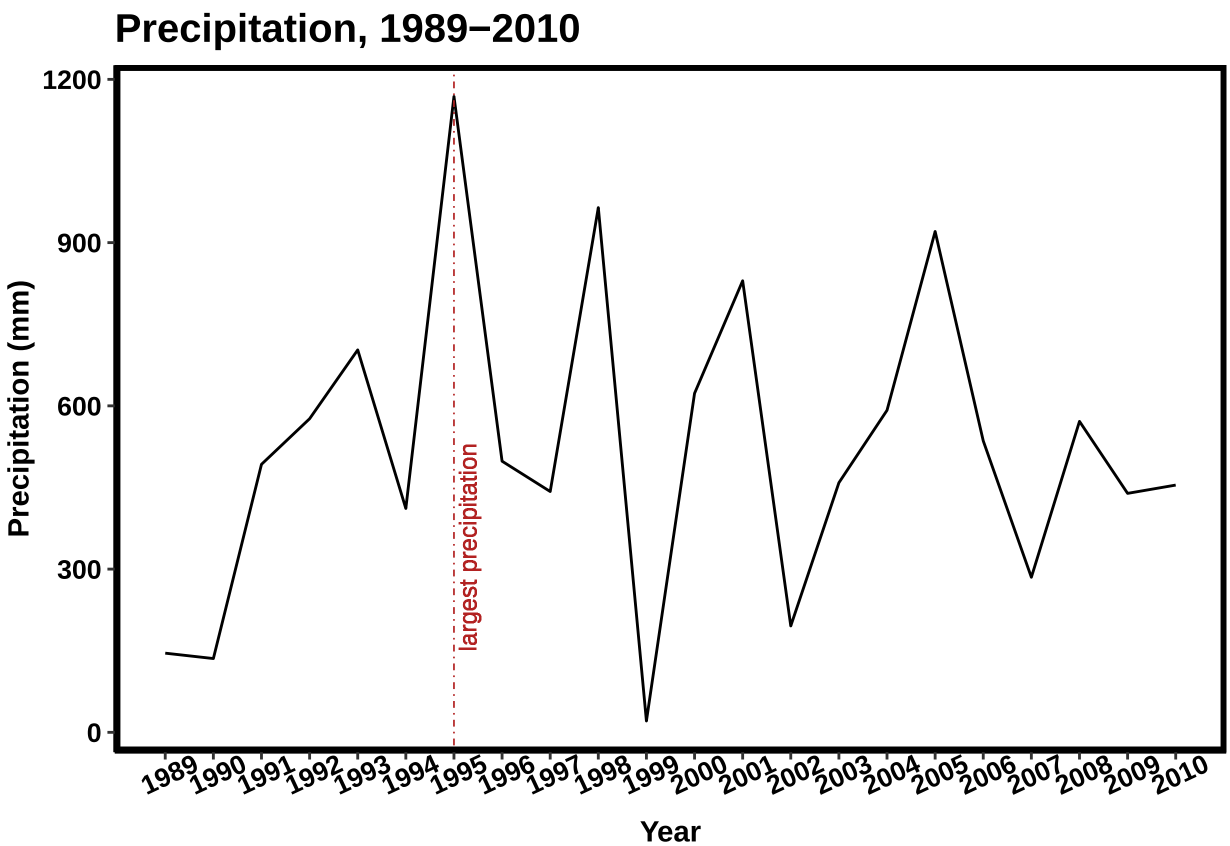

Figure 3: Precipitation summed for each year, 1989-2010. The data shows a spike in precipitation in 1995, which aligns with the spike in almond production in 1995 shown in Figure 2. Precipitation seems to spike every few years.

Almond Anomaly Summary

The calculated anomaly for almond yield between 1989-2010 is displayed above in both a table as well as a time series graph. The almond anomaly graph highlights an interesting pattern of productions spikes against an otherwise relatively constant rate. Spikes in 1997, 2005, 2008, and most notably 1995 show substantial increases of almond yield; these years may act as starting points for future research into the factors that effect almond production such as increased precipitation, new agricultural technology, or a decrease in pest population. To investigate potential factors that contribute to this production spike in 1995, we created a graph of total precipitation by year. The spike in precipitation in 1995 implies that this environmental variable likely contributed to the spike in almond yield in the same year. However, precipitation spikes in other years (to a lesser degree than 1995) do not correlate with spikes in almond anomaly in other years. For example, there is a precipitation spike in 1998, but there is no notable almond anomaly spike in 1998. Future research might investigate the influence of temperature, pests, agricultural technology, or other environmental factors on almond production.

When trying to understand the almond anomaly results, there is another consideration that is highlighted better in the table: every value except for 2003-04 is a positive value. This is a potential area for concern because the nominal calculation we are making here is anomaly, or deviation from the mean. But what mean?

According to the caption for Figure 3 in Lobell et al. 2006, it is percent anomaly from 2000-2003 average yields. Interestingly, in our dataset this 2000-04 average looks more like a floor than a mean (particularly using the graph above). Writing as three people with very limited historical knowledge of the details of almond production, we are concerned that this may give a biased number for what constitutes a 'reasonable' amount of almond production. This is particularly important taken in the context of Lobell's work, which looks at forecasting effects of climate change on agricultural production: if the 2000-03 average yields are interpreted as a true average, then it would be expected that many years would fall below that value without any cause for concern. However, if that number is closer to a minimum expected yield (as the graph above seems to indicate), then any substantial or prolonged drop below the threshold should be much more concerning.

Citations

Climate data and almond anomaly model were sourced from Lobell et al. 2006