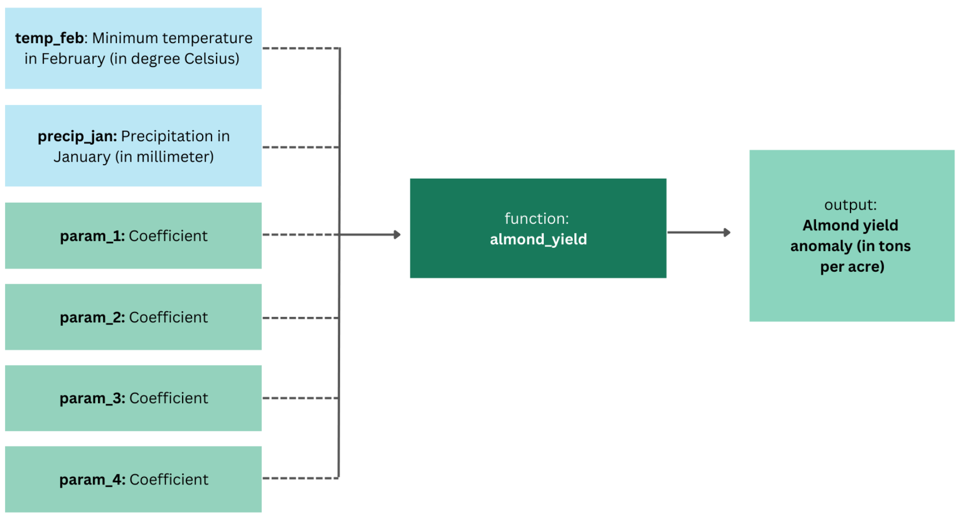
Use Case of Almond Yield

2023-05-02

Conceptual Modeling



Application

Let's start by loading and tidying the data:

```
# define column names
col_names <- c("day", "month", "year", "wy", "tmax_c", "tmin_c", "precip")

# load data frame with column names
clim <- read.table("src/clim.txt", header = TRUE, col.names = col_names)

# start data wrangling
clim_dat <- clim %>%
  # convert to numeric type
  mutate(tmin_c = as.numeric(tmin_c),
         precip = as.numeric(precip)) %>%
  # filter to relevant months of observation
  filter(month == c(1, 2))

# create temperature data frame
temp_dat <- clim_dat %>%
  # filter to relevant month
  filter(month == 2) %>%
  # group daily observations by year
  group_by(year) %>%
```

```r
  # summarize for mean and minimum values
  summarize(mean_tmin_feb = mean(tmin_c),
            min_tmin_feb = min(tmin_c))

# create precipitation data frame
precip_dat <- clim_dat %>%
  # filter to relevant month
  filter(month == 1) %>%
  # group daily observations by year
  group_by(year) %>%
  # summarize for sum value
  summarize(sum_precip_jan = sum(precip))

# create final data frame
dat <- left_join(temp_dat, precip_dat, by = "year")
```

And let's apply the function:

```r
almond_yield(temp_feb = dat$mean_tmin_feb, precip_jan = dat$sum_precip_jan)
```

```
##  [1]  -0.3376743   3.4746214  23.4925030  -0.6466091  13.5671802  -0.5358260
##  [7] 942.6254696  -0.3982105  69.9370592  -0.6834963  -0.1323562   3.8340802
## [13] 114.8615148   0.1120878  -0.2467511  -0.1220926 152.4966585   4.5323641
## [19]   1.7581422 244.5750772   0.1380106  41.8074462
```

Let's extract the minimum, mean, and maximum value of the list:

```r
# extract minimum yield anomaly value
min(almond_yield_results)
```

```
## [1] -0.6834963
```

```r
# extract mean yield anomaly value
mean(almond_yield_results)
```

```
## [1] 73.3686
```

```r
# extract maximum yield anomaly value
max(almond_yield_results)
```

```
## [1] 942.6255
```

Sensitivity Analysis

Next, let's do some informal sensitivity analysis on our parameters.

```r
# define param_1 from almond_yield function
param_1 <- as.numeric(-0.015)
# define param_3 from almond_yield function
param_3 <- as.numeric(-0.07)
```

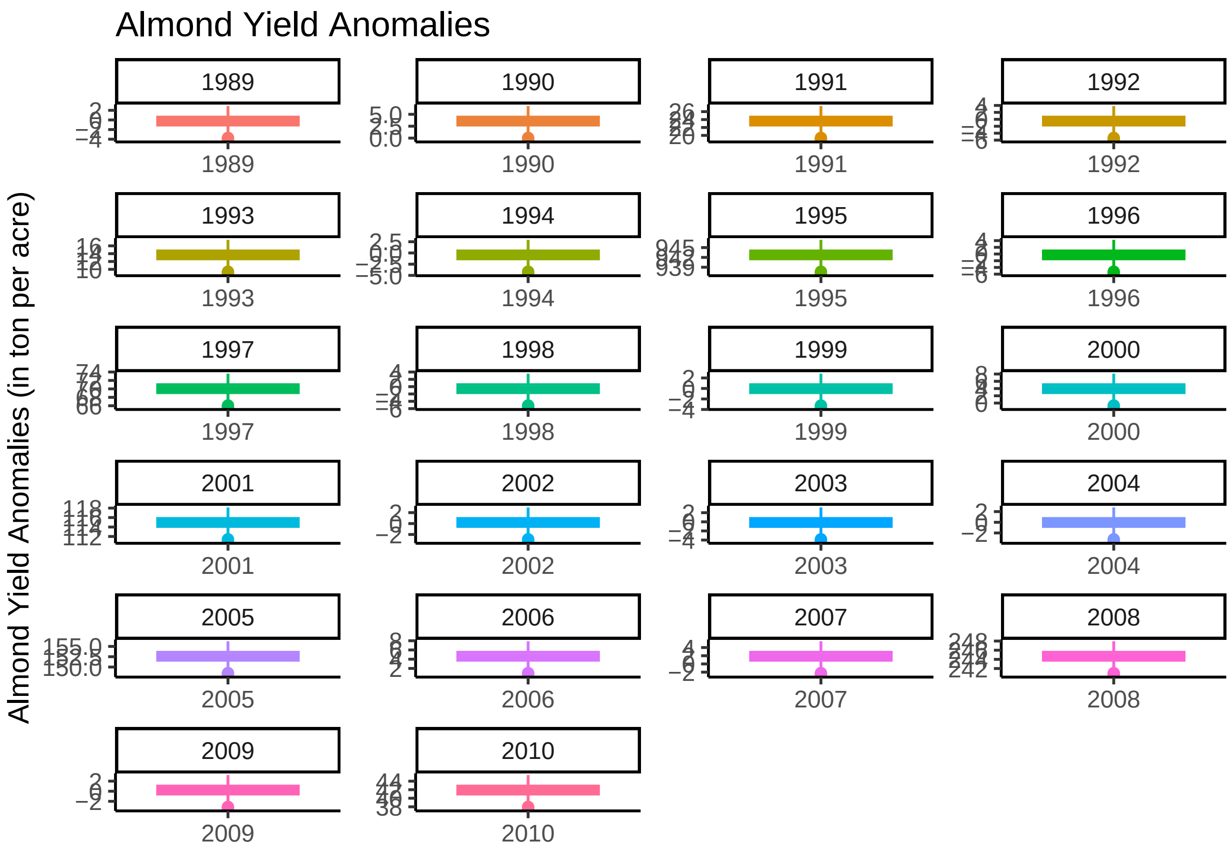
Parameter 1

```r
# create 300 samples of param_1
param_1_samples <- rnorm(mean = param_1, sd = 0.15, n = 300)

# use map() to apply function to the 300 samples
almond_yield_param_1 <- param_1_samples %>% map(
```

```r
  ~almond_yield(precip_jan = dat$sum_precip_jan,
               temp_feb = dat$mean_tmin_feb, param_1 = .x))
```

```r
# create data frames by concatenating list as rows
sensitivty_dat_param_1 <- as.data.frame(do.call(rbind,
                                        lapply(almond_yield_param_1, as.vector)))

# set column names as year
colnames(sensitivty_dat_param_1) <- as.character(dat$year)

# start data wrangling
sensitivty_dat_param_1 <- sensitivty_dat_param_1 %>%
  # add param_1 samples as column
  mutate(param_1 = param_1_samples) %>%
  # relocate param_1 column before year columns
  relocate(param_1, .before = `1989`)

# pivot longer data frame
sensitivty_dat_param_1 <- sensitivty_dat_param_1 %>%
  pivot_longer(cols = !param_1, # select all columns except param_1
              names_to = "year", # pivot column names to year column
              values_to = "yield_anom") # pivot rows to yield_anom column
```

```r
# plot sensitivity of parameter 1
ggplot(sensitivty_dat_param_1, aes(year, yield_anom, group = year, col = year)) +
  geom_boxplot(show.legend = FALSE) +
  labs(y = "Almond Yield Anomalies (in ton per acre)",
       title = "Almond Yield Anomalies") +
  facet_wrap(~year, scales = "free", ncol = 4) +
  theme_classic() +
  theme(axis.title.x = element_blank())
```



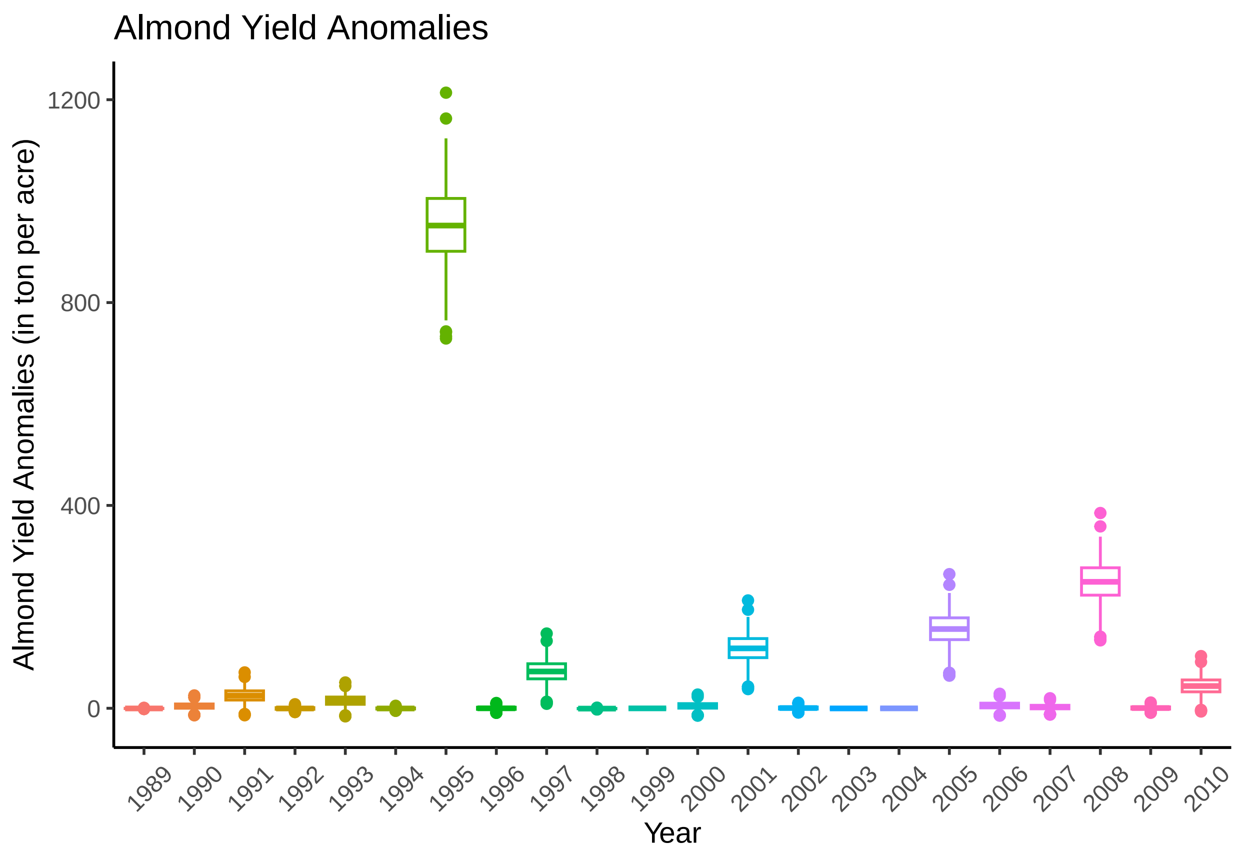
Parameter 3

```r
# create 300 samples of mean total precipitation in January
param_3_samples <- rnorm(param_3, sd = 0.15, n = 300)

# use map() to apply function to the 300 samples
almond_yield_param_3 <- param_3_samples %>% map(
  ~almond_yield(temp_feb = dat$mean_tmin_feb,
                precip_jan = dat$sum_precip_jan, param_3 = .x))
```

```r
# create data frames by concatenating list as rows
sensitivty_dat_param_3 <- as.data.frame(do.call(rbind,
                                        lapply(almond_yield_param_3, as.vector)))

# set column names as year
colnames(sensitivty_dat_param_3) <- as.character(dat$year)

# data wrangling
sensitivty_dat_param_3 <- sensitivty_dat_param_3 %>%
  # add param_3 samples
  mutate(param_3 = param_3_samples) %>%
  # relocate param_3 column
  relocate(param_3, .before = `1989`)

# pivot longer
sensitivty_dat_param_3 <- sensitivty_dat_param_3 %>%
  pivot_longer(cols = !param_3,
```

```
                names_to = "year",
                values_to = "yield_anom_param_3")
```

```
# plot sensitivity of parameter 3
ggplot(sensitivty_dat_param_3,
       aes(year, yield_anom_param_3, group = year, col = year)) +
  geom_boxplot(show.legend = FALSE) +
  labs(y = "Almond Yield Anomalies (in ton per acre)",
       x = "Year",
       title = "Almond Yield Anomalies") +
  theme_classic() +
  theme(axis.text.x = element_text(angle = 45, vjust = 0.3, hjust = 0.3))
```

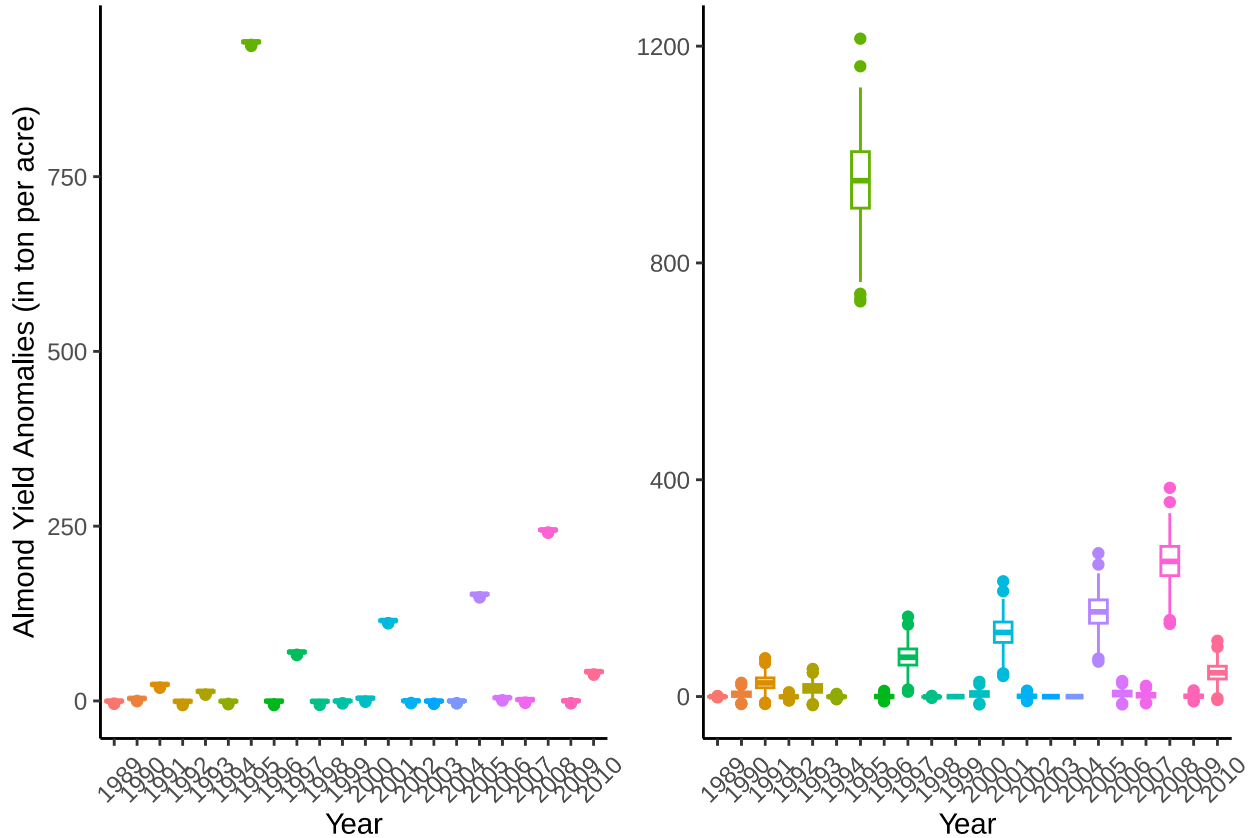


Almond Yield Model Uncertainty

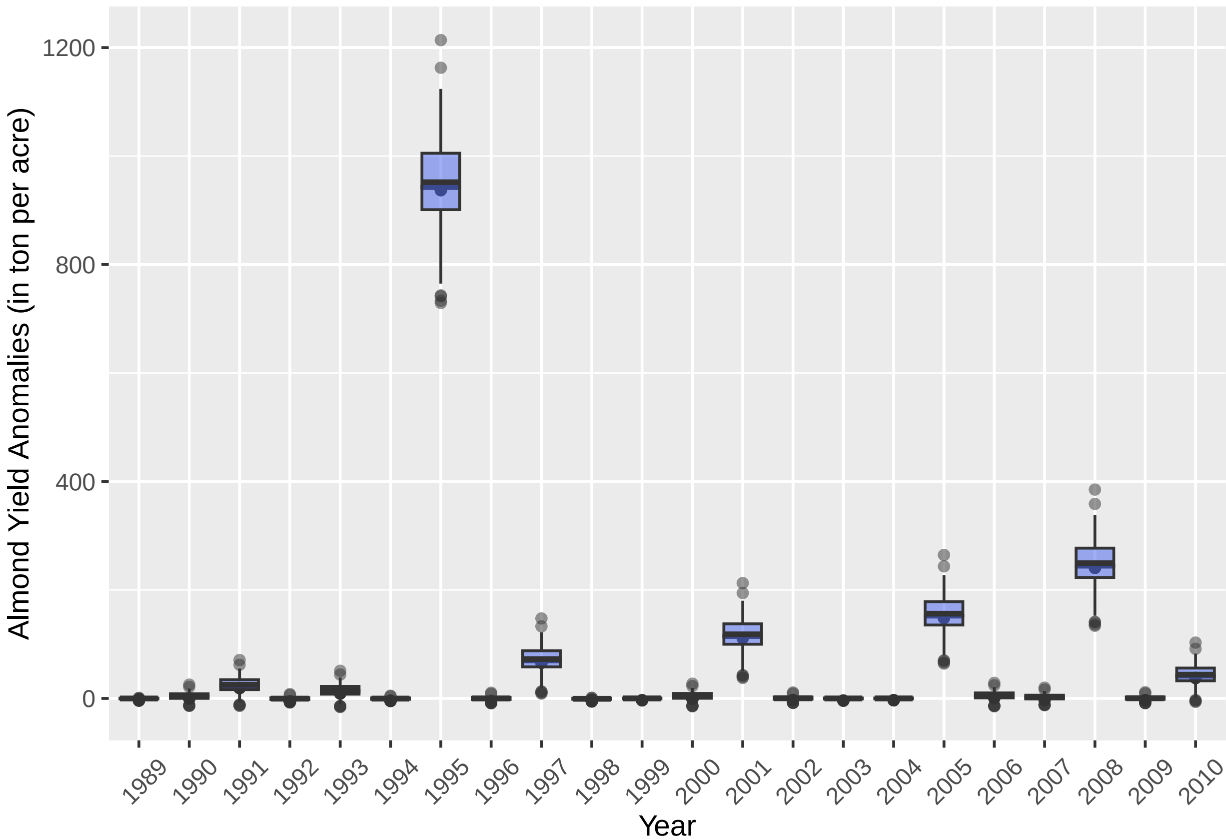
Now, we combine uncertainty of parameters.

```
# plot sensitivity for parameter 1
a <- ggplot(sensitivty_dat_param_1,
            aes(year, yield_anom, group = year, col = year)) +
  geom_boxplot(show.legend = FALSE) +
  labs(y = "Almond Yield Anomalies (in ton per acre)",
       x = "Year") +
  theme_classic() +
  theme(axis.text.x = element_text(angle = 45, vjust = 0.3, hjust = 0.3))

# plot sensitivity for parameter 3
b <- ggplot(sensitivty_dat_param_3,
```

```
            aes(year, yield_anom_param_3, group = year, col = year)) +
  geom_boxplot(show.legend = FALSE) +
  labs(y = "Almond Yield Anomalies (in ton per acre)",
       x = "Year") +
  theme_classic() +
  theme(axis.title.y = element_blank(),
        axis.text.x = element_text(angle = 45, vjust = 0.3, hjust = 0.3))

ggarrange(a, b)
```

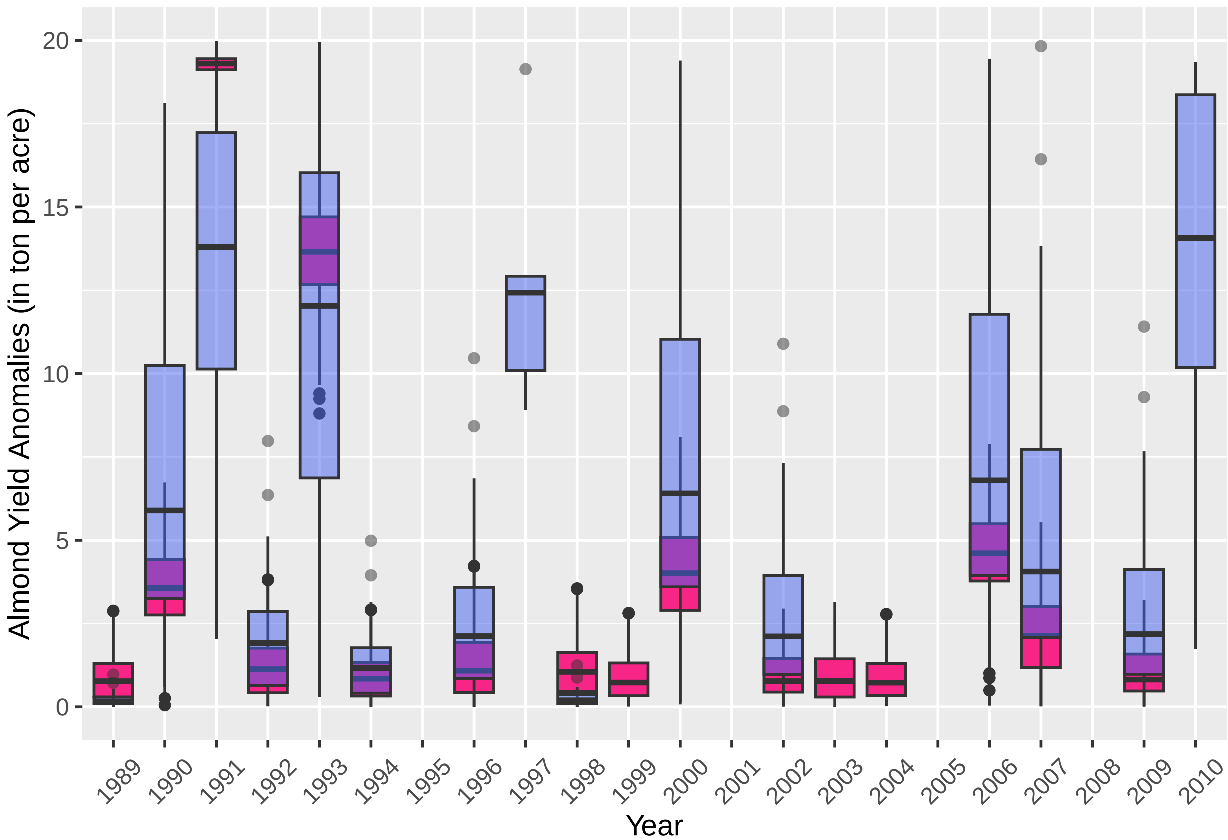



```
ggplot() +
  geom_boxplot(data = sensitivty_dat_param_1,
               aes(year, yield_anom, group = year), fill = "#f72585") +
  geom_boxplot(data = sensitivty_dat_param_3,
               aes(year, yield_anom_param_3, group = year),
               fill = "#4361ee", alpha = 0.5) +
  labs(y = "Almond Yield Anomalies (in ton per acre)",
       x = "Year") +
  theme(axis.text.x = element_text(angle = 45, vjust = 0.3, hjust = 0.3))
```




```r
# 5 years that are outliers?
```

```r
# To display variance in Parameter 1 and overlap with Parameter 3
ggplot() +
  geom_boxplot(data = sensitivty_dat_param_1,
               aes(year, yield_anom, group = year), fill = "#f72585") +
  geom_boxplot(data = sensitivty_dat_param_3,
               aes(year, yield_anom_param_3, group = year),
               fill = "#4361ee", alpha = 0.5) +
  labs(y = "Almond Yield Anomalies (in ton per acre)",
       x = "Year") +
  theme(axis.text.x = element_text(angle = 45, vjust = 0.3, hjust = 0.3)) +
  ylim(0, 20)
```



In 1991, variability in Parameter 1 versus variability in Parameter 3, caused more of an increase in the anomalies of almond production.

Revenue Model

```
revenue_anom <- compute_revenue(anom_almond_yield_results = almond_yield_results,
                                years = dat$year)

revenue_anom <- revenue_anom %>%
  # relocate year column before anomaly columns
  relocate(year, .before = anom)

knitr::kable(revenue_anom,
             caption = "Revenue for Almond Yield",
             col.names = c("Year", "Anomaly",
                           "Anomaly Revenue",
                           "Total Revenue"),
             digits = 3,
             format.args = list(big.mark = ",", scientific = FALSE))
```

Table 1: Revenue for Almond Yield

Year	Anomaly	Anomaly Revenue	Total Revenue
1989	-0.338	-89,146.02	180,133.98
1990	3.475	917,300.05	1,186,580.05
1991	23.493	6,202,020.79	6,471,300.79
1992	-0.647	-170,704.80	98,575.20
1993	13.567	3,581,735.57	3,851,015.57
1994	-0.536	-141,458.06	127,821.94
1995	942.625	248,853,123.97	249,122,403.97
1996	-0.398	-105,127.58	164,152.42
1997	69.937	18,463,383.63	18,732,663.63
1998	-0.683	-180,443.01	88,836.99
1999	-0.132	-34,942.04	234,337.96
2000	3.834	1,012,197.17	1,281,477.17
2001	114.862	30,323,439.92	30,592,719.92
2002	0.112	29,591.17	298,871.17
2003	-0.247	-65,142.28	204,137.72
2004	-0.122	-32,232.45	237,047.55
2005	152.497	40,259,117.86	40,528,397.86
2006	4.532	1,196,544.13	1,465,824.13
2007	1.758	464,149.53	733,429.53
2008	244.575	64,567,820.38	64,837,100.38
2009	0.138	36,434.80	305,714.80
2010	41.807	11,037,165.80	11,306,445.80