# Assigment 2 - ESM 232 Climate Modeling

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## Background

### Almond conceptual model

The almond model derived from Lobell et al. (2006) is a statistical model calculating annual yield anomaly of almonds in California, which is based on February minimum temperature (Celsius degree) and January accumulated precipitation (mm).

### Load function(s)

Load the almond model function!

The function will process:

- Turn the daily minimum temperature and daily precipitation into monthly results
- Calculate annual almond yield conceptual model

### Read input data

Read the climate data in a txt format.

- There is a column containing time information
- It includes two variables: minimum temperature and precipitation

### Calculate almond yearly yield anomaly

Use the defined function to calculate almond yield of each year in California (units: ton/acre).

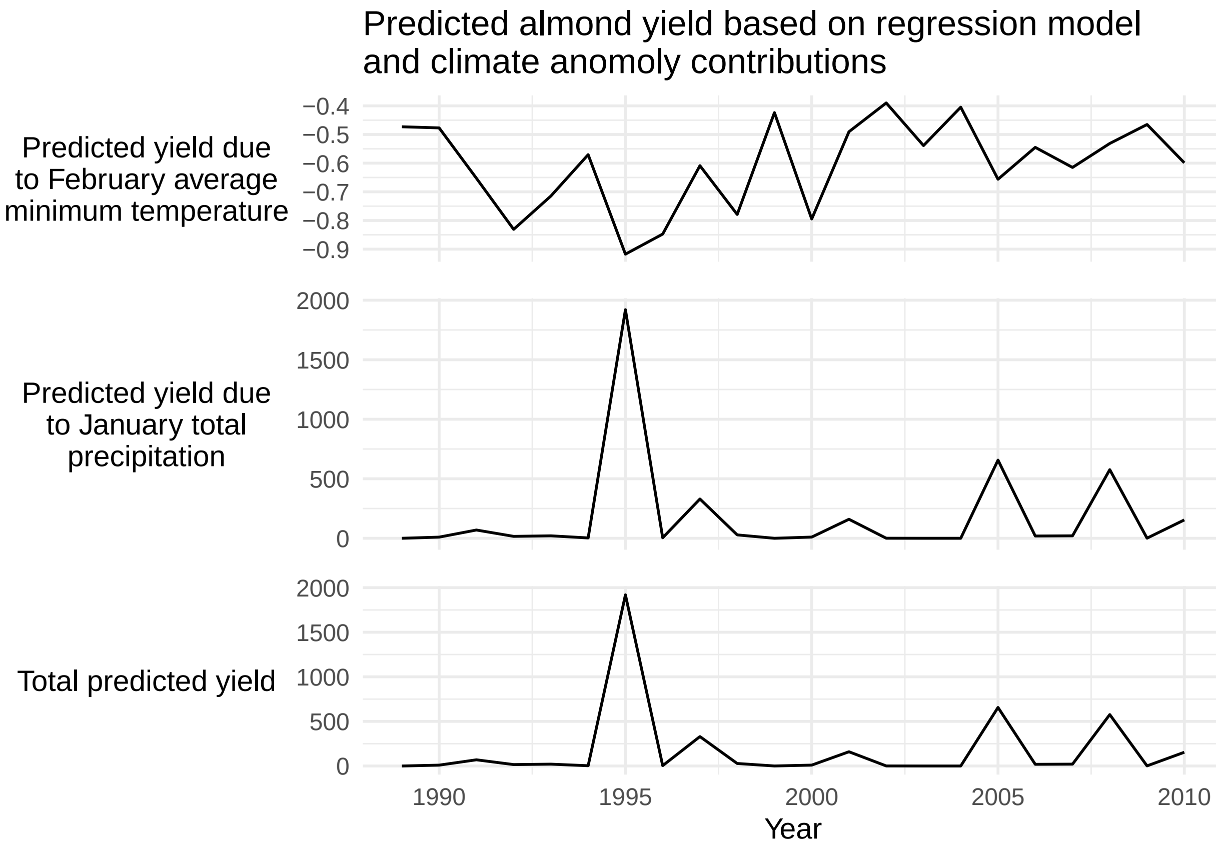
The almond yield equation (Lobell et al. 2006) is:

Y = -0.015* (Tn,2) - 0.0046* (Tn,2)^2 - 0.07* (P1) + 0.0043* (P1)^2 + 0.28

where Y is almond yield anomaly (ton/acre); Tn,2 is February minimum temperature (C); P1 is January precipitation (mm)

The yearly yield results will be returned to **yeild_outcomes**

## Results




## Discussion

## References


Lobell D B, Field C B, Cahill K N, et al. Impacts of future climate change on California perennial crop yields: Model projections with climate and crop uncertainties[J]. *Agricultural and Forest Meteorology*, 2006, **141(2-4)**: 208-218.


## Appendix - `almond_model.R`

```
#' Almond Model
#'
#' This function computes the annual yield of almonds in California
#' based on monthly minimum temperature in February and
#' accumulated precipitation in January (Lobell et al. 2006)
#' @param clim_data file path to climate data that includes fields for
#'   row_number, D, day, month, year, wy, tmax_C, tmin_c, precip, wyd
#' @param k1 coefficient for February minimum temperature changes
#' @param k2 quadratic term coefficient for February minimum temperature changes
#' @param k3 coefficient for January Precipitation changes
#' @param k4 quadratic term coefficient for January Precipitation changes
```

```
#' @param intercept the intercept of the fitted line
#' @author Anthony Luna, Chen Xing, Atefeh Mohseni
#' @examples almond_model(["1" 1991-06-01 1 6 1991 1992 21.232 14.234 1.56 1])
#' @return Almonds yield anomaly (ton acre-1)
#' @references
#' Lobell D B, Field C B, Cahill K N, et al. Impacts of future climate change on
#' California perennial crop yields: Model projections with climate and crop
#' uncertainties[J]. Agricultural and Forest Meteorology, 2006, 141(2-4): 208-218.

almond_model <- function(clim_data,
                         k1=-0.015 ,
                         k2=-0.0046 ,
                         k3=-0.07 ,
                         k4= 0.0043,
                         intercept = 0.28 ) {
  ## Error checking
  ## You can use the library checkmate to
  ## make this easier, or just do it with ifelse statements

  # check clim_data dimensions
  no_col <- max(count.fields(clim_data, sep = " "))
  if (no_col < 10)
  {
    print("The input climate data file should have 10 columns")
  } else {
    # check clim_data column names
    file_header <- read.delim(clim_data, header=TRUE, sep = " ", dec = ".")
    file_headers = colnames(file_header)

    expected_header = c(
      "row_number",
      "D",
      "day",
      "month",
      "year",
      "wy",
      "tmax_c",
      "tmin_c",
      "precip",
      "wyd"
    )

    check_res <- isTRUE(all.equal(file_headers, expected_header))

    if (check_res) {
      # check clim_data column datatypes
      summary <- summary.default(file_header)
      numeric_types = length(summary[which(summary=="numeric")])
      date_types = length(summary[which(summary=="character")])

      if (numeric_types != 9 | date_types!= 1){
        print("There should have 9 numeric data type and 1 date type in the input file!")
      }
    }
```

```r
    else{
      print("The format of the input file header is not as expected!")
    }
  }

  clim_data <- read_delim(file = clim_data, delim=" ")

  # check coefficients and intercept value

  ## End error checking

  # Turn the daily minimum temperature into monthly data through monthly average
  # and calculate monthly accumulated precipitation from daily station
  # precipitation data

  df_summarized <- clim_data %>%
    select(year,month,day,tmin_c,precip) %>%
    group_by(year,month) %>%
    summarize(avg_tmin_c=mean(tmin_c),tot_precip = sum(precip)) %>%
    ungroup()

  # Extract the February minimum temperature from the data summary

  df_temp <- df_summarized %>%
    filter(month==2) %>%
    select(-tot_precip,-month)

  # Extract the January precipitation from the data summary

  df_precip <- df_summarized %>%
    filter(month==1) %>%
    select(-avg_tmin_c,-month)

  # Calculate the almond annual yield from the statistical relationship:
  # Y = k1*(Tn,2) + k2*(Tn,2)^2 + k3*(P1) + k4*(P1)^2 + intercept
  # Y: almond yield anomaly (ton/acre); Tn,2: February minimum temperature (C);
  # P1: January precipitation (mm)

  df_out <- full_join(df_temp,df_precip) %>%
    mutate(yeild = k1*avg_tmin_c+k2*(avg_tmin_c^2)+k3*tot_precip+k4*(tot_precip^2)+intercept) %>%
    mutate(yeild_temp = k1*avg_tmin_c+k2*(avg_tmin_c^2)) %>%
    mutate(yeild_precip = k3*tot_precip+k4*(tot_precip^2)) %>%
    mutate(intercept = intercept)

  # return the yield to the main function

  return(df_out)
}
```