## Panel models of the relationship between maize yields and precipitation and temperature

**Time period:** 1999- 2014

At the moment, the aggregated climate/weather data which I was using are for the period 1999-2018. The yields data are from 1970-2014

**Weather data:**

1. Precipitation:
   * z-score at the location where precipitation corresponds to 10th percentile of each county (I opted for z-scores rather than the raw data because the maximum likelihood algorithm often fails to converge with the raw data as their range is too big)
   * monthly frequency
2. Temperature
   * z-score at the location where temperature corresponds to 90th percentile of each county
   * monthly frequency

**Maize Yields data:**

* MT (= metric tons) /hectare
* Early frequency
* Obtained from Gideon Galu from the FEWS NET, the original source of the most of them is probably the Ministry of Agriculture

**Precipitation and Temperature data aggregation:**

* The yields data are yearly while the weather data are monthly. For the panel models, both of them need to be at the same frequency.

-> temperature and precipitation need to be aggregated to obtain yearly values

* We decided to consider weather during the months of planting and growing
* Growing and planting months according to the harvesting seasonal calendar: <http://fews.net/east-africa/kenya/seasonal-calendar/december-2013>
* According to the seasonal calendar above, the counties can be divided into two groups: Eastern counties and Western counties
  + Western counties:
    - Include provinces: Rift Valley, Western, Nyanza, Central
    - One harvesting and planting season
    - Yearly climate measures obtained as average over **May, June, July, August and September** (planting and growing, see http://fews.net/east-africa/kenya/seasonal-calendar/december-2013)
  + Eastern counties:
    - Include provinces: Eastern, North Eastern, Coast
    - two planting and harvesting seasons
    - Yearly climate measures obtained as average over **November and December of previous year and January, February, March, April, May, June, July, August and September of the current year** (planting and growing, see <http://fews.net/east-africa/kenya/seasonal-calendar/december-2013>)
* Besides the average climate measures above, I also calculated coefficients of variation for both climate and temperature over the same months as described above (according to the seasonal calendar <http://fews.net/east-africa/kenya/seasonal-calendar/december-2013>)
  + However, the coefficients of variation turned out to be insignificant in the models

# The best mixed-effects models:

**1. No weights**

The best specifications of the error structure based on LR tests of serial correlation, and LR tests of random effects:

**a)** AR(1) errors

lme(Yield~1+PrecZscore +TempZscore , random= ~ PrecZscore + TempZscore|ID, correlation=corAR1(0,form= ~ as.numeric(Year)|ID))

**b)** MA(3) errors

lme(Yield~1+PrecZscore +TempZscore , random= ~ PrecZscore + TempZscore|ID, correlation=corARMA(0,form= ~ as.numeric(Year)|ID, p=0,q=3))

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| ***No weights*** |  |  |  | *pvcm from plm package (no AR or MA)* | |
| *Fixed effects* | **No AR** | **AR(1)** | **MA(3)** | **Swamy 1970** | **Counties separately (mean)** |
| *Intercept* | 1.647\*\*\* | 1.685\*\*\* | 1.692\*\*\* | 1.610\*\*\* | 1.636 |
| *Precipitation (Z – score)* | 0.171\*\*\* | 0.155\*\*\* | 0.162\*\*\* | 0.196\*\*\* | 0.200 |
| *Temperature (Z – score)* | -0.109\* | -0.137\*\* | -0.141\*\* | -0.089 (p-val= 0.141) | -0.106 |
| *AIC* | 1180.105 | 1130.211 | 1122.896 |  |  |
| *BIC* | 1225.9 | 1180.522 | 1182.354 |  |  |

ANOVA: Precipitation explains much more than temperature (F tests: 44.4 and 7.8)

**1. Weights = Area of cropland**

lme(Yield~1+PrecZscore +cv\_Prec, random= ~PrecZscore+TempZscore|ID , weights=~Area, correlation= corARMA(form = ~ as.numeric(Year)|ID, p=2,q=2))

The best specification of the error structure based on LR tests of serial correlation, and LR tests of random effects:

ARMA(2,2) errors:

**AIC:** 1817.509 **BIC:** 1881.509

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Weights = Area*** |  |  | *pvcm from plm package (no AR or MA)* | |
| *Fixed effects* | **No AR** | **ARMA(2,2)** | **Swamy (1970)** | **Counties separately (mean)** |
| *Intercept* | 1.237\*\*\* | 1.036\*\*\* | 1.515\*\*\* | 1.519 |
| *Precipitation*  *(Z – score)* | 0.214\*\*\* | 0.187\*\*\* | 0.218\*\*\* | 0.224 |
| *Precipitation – coef. of variation* | 0.207\*\* | 0.143\* | 0.107 | 0.198 |
| *AIC* | 1868.164 | 1817.509 |  |  |
| *BIC* | 1913.9 | 1881.54 |  |  |