Impact of climate change on insecticide use

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Research Question

- How will climate change, in particular increases in temperature and volatility in temperature fluctuation, affect insecticide application?
- A future extension: How will changes in insecticide application affect incidence of cancer? (probably not within the scope of 2YP)

Motivation

- Insecticide application in the US has been trending downwards from 131 mi lb in 1968 to 29 mi lb in 2008 (USDA - ERS 2014).
- Min and max winter and spring temp trending upwards across continuous US from 1980 - present (NOAA).
- Warmer temp $\rightarrow$ extend the development time window for crop pests and can migrate further northward. Farmers spray more?
- Chronic exposure to low-levels of pesticide drift still not well understood.

Insect Physiology

- Insect rate of development is function of temperature, especially during critical windows during the year.
- Sequencing of temperature and rate of temperature change across days matter.
  - Fall: initiation of diapause (aka insect hibernation)
  - Winter: in diapause. Length of diapause moderated by winter temp. Diapause ends in late winter
  - Spring: development of insects governed by temperature
  - Summer: rate of reproduction governed by temperature

Data

- USGS Pesticide National Synthesis Project
  - Estimated Annual Agricultural Pesticide Use
  - annual pesticide estimates for each chemical compound, 1992 - 2014, county-level
  - 3029 counties, 23 years, 492 unique chemical compounds
- LUGE Harvested Area and Yields of 175 crops dataset
  - county-level crop acreage data from 1960 - 2008
- Berkeley Earth Climate Data
  - gridded daily temperature data, 1992 - 2014
  - max, min and average temp at county centroid

Identification Strategy

- 2SLS
  1. 1st stage: Instrument for crop pest density with temperature
     - $\widehat{pest\_density_{c,y}} =$
       $\alpha_0 + \alpha \cdot temp\_sequence_{c,y} + Z \cdot X_{c,y} + \gamma_c + \delta_y + \epsilon_{c,y}$
  2. 2nd stage:
     - $pesticide\_application_{c,y} =$
       $\beta_0 + \beta \cdot \widehat{pest\_density_{c,y}} + Z \cdot X_{c,y} + \gamma_c + \delta_y + \varepsilon_{c,y}$

$X_{c,y}$ = covariates for that county-year

c = county

y = year