Implications of Climate Volatility for Agricultural Commodity Markets Under Alternative Energy Futures

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Based on joint work with
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Commodity Price *Volatility* is Important

- **Greatest concern is for low income households:**
  - **Commodity costs a large share of total food costs**
  - **Food costs large share of budget, so little room for adjustment in expenditures, consume less food**
  - **Can lead to political instability**
  - **Governments respond to pressures with counter-productive policies (e.g., export bans)**
- **Active debate over whether *volatility* has increased recently (Brian Wright)**
- **Focus here on volatility as driven by climate – historically, and in future**
- **Contrasts sharply with research on long run climate impacts on food markets**

Exploring the climate-agriculture-markets-energy policy nexus

- **Agricultural production depends on climate**
- **Frequency and Intensity of extreme events is anticipated to increase in the future**
- **Crops are sensitive to climate extremes, but these can be quite localized**
- **Capitalize on recent *high resolution* climate results for the US**
- **Combine with estimated yield function for maize in US**
- **Integrate within economic model to assess interplay with energy policies/energy futures**

Climate model experiment

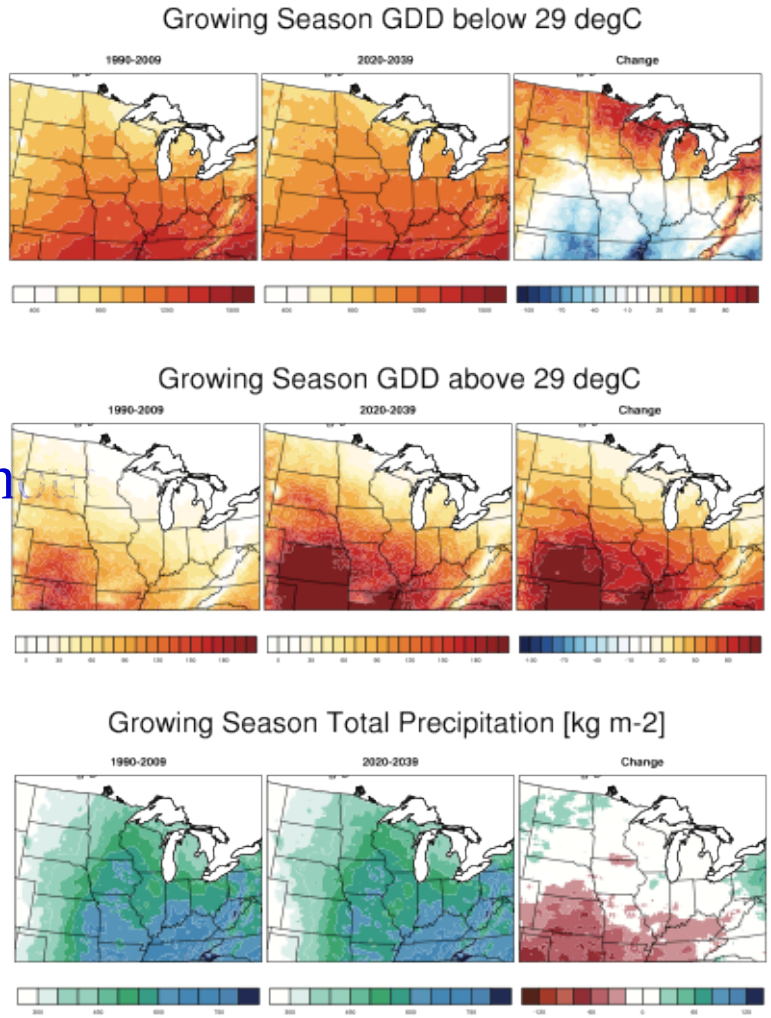
- **RegCM3 nested in CCSM3**
- **High resolution (25km)**
- **Domain covering the continental US**
- **A1B Scenario**
- **Five (physically uniform) realizations: difference between the realizations arises due to internal climate system variability**
- **Average results across five realizations**
- ***Compare:***
  - ***1980-2000 (current climate) to***
  - ***2020-2040 (future climate)***

Climate is changing in Corn Belt where crops are sensitive to heat

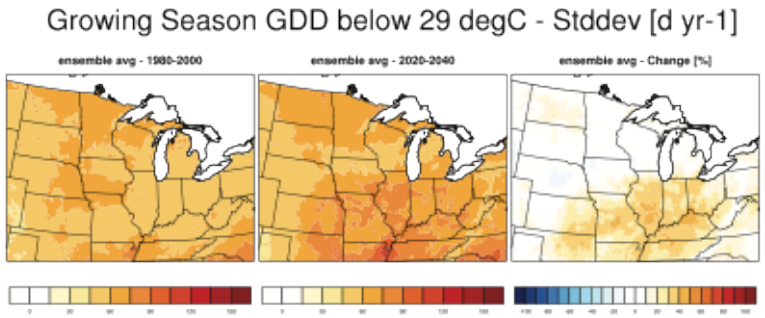
GDD below 29 rise in Northern regions; improves growing conditions

GDD above 29 rise sharply through the corn belt; can lead to drop in yields

Precipitation changes are less pronounced

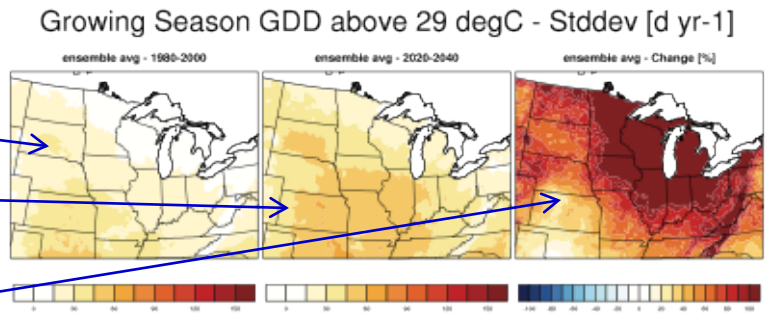


Climate variability also increases, particularly for GDD over 29C

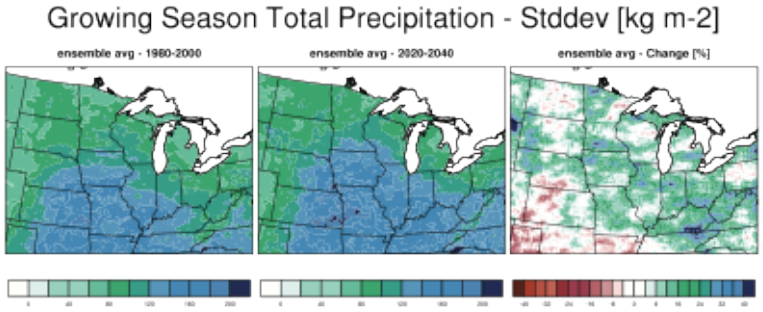


Std deviation of GDD above 29:

- Historical
- Future
- And change in std deviation

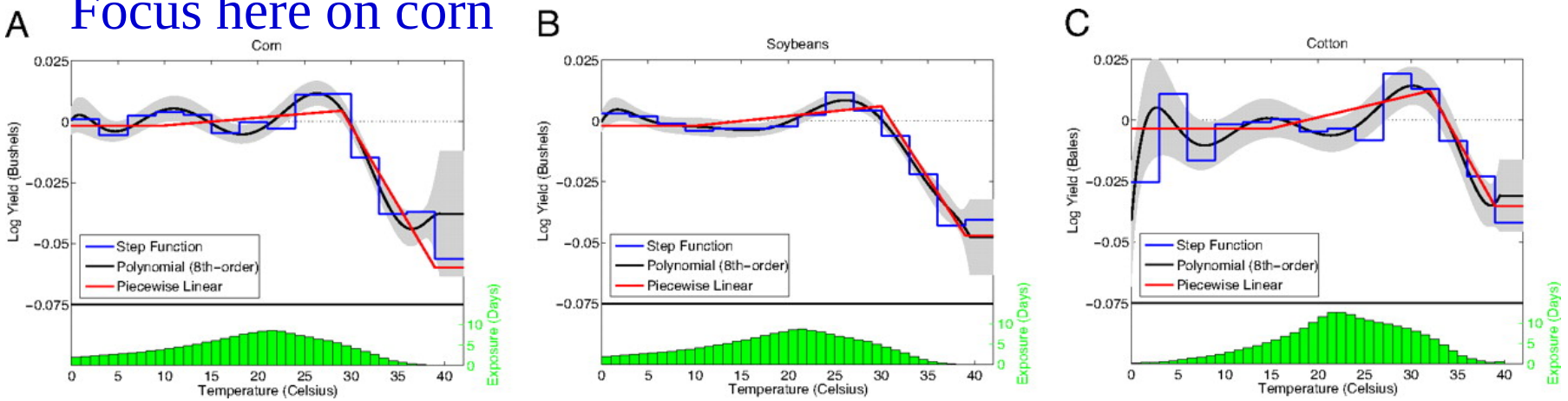


Greatest increase in volatility is for excessive heat



Combined with temperature sensitivity of yields ..

Focus here on corn

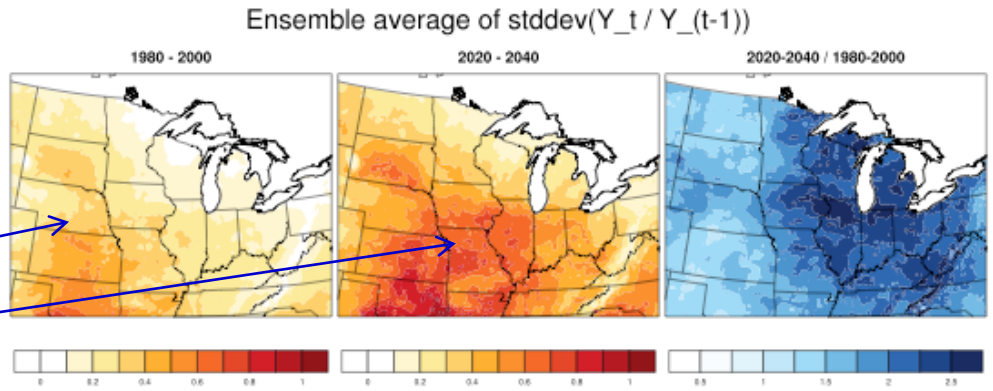


Source: Schlenker and Roberts, PNAS, 2009

this translates into increased year on year yield volatility

Std deviation of yield t/yield t-1

- Historical
- Future



Ratio of std deviations of yield t/yield t-1

Most of the grid cell variability comes from excess heat

Portion due to GDD less than 29C

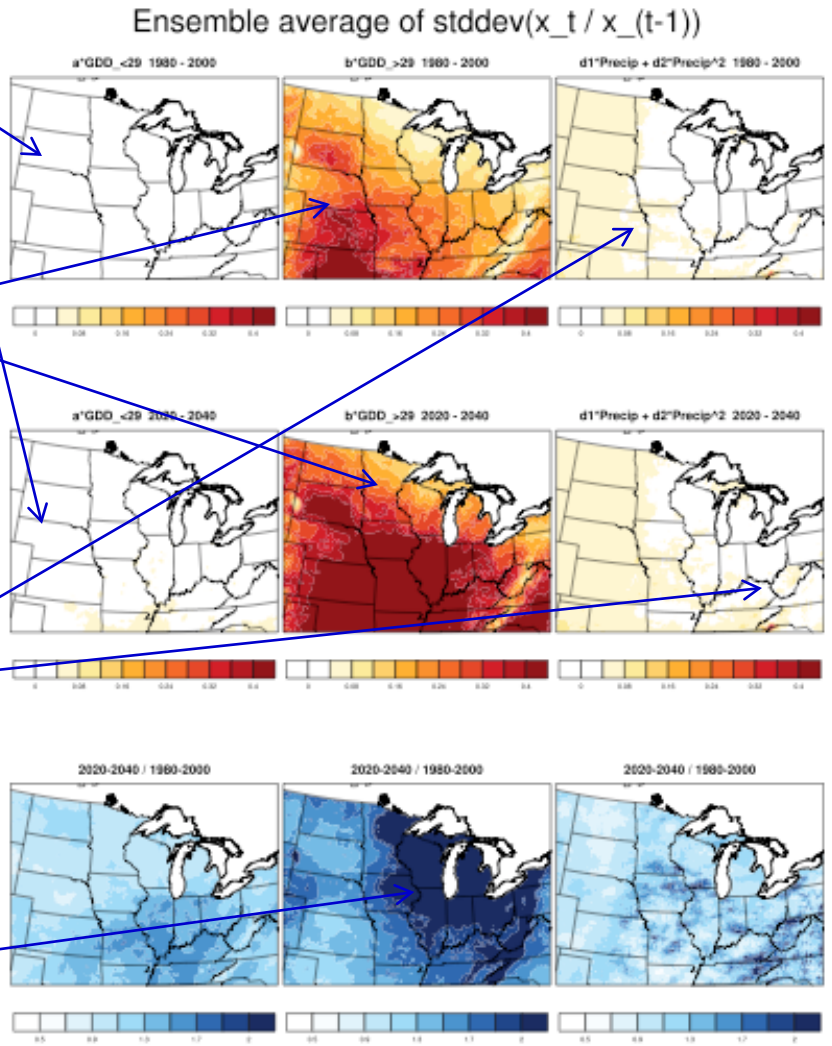
Sources of historical volatility

Portion due to GDD above 29C

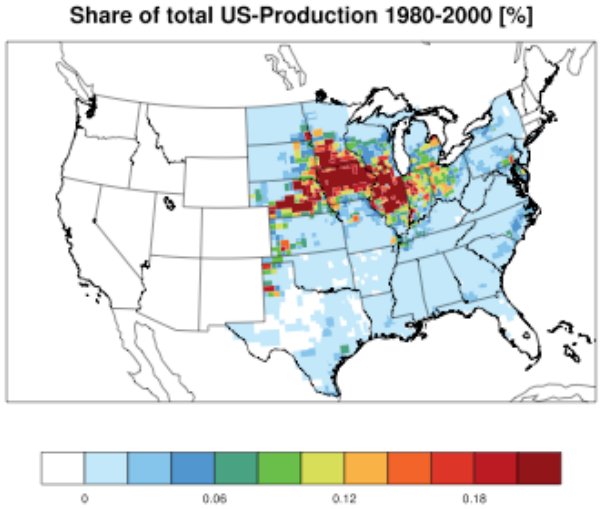
Sources of future yield volatility

Portion due to Precipitation

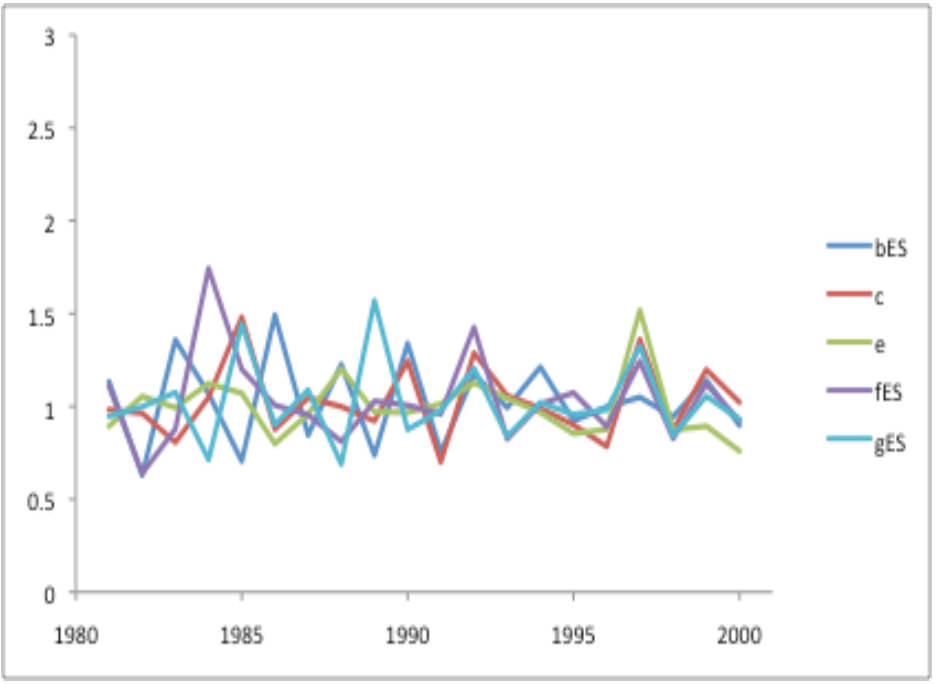
Sources of ***change*** in yield volatility:
GDD above 29C is dominant

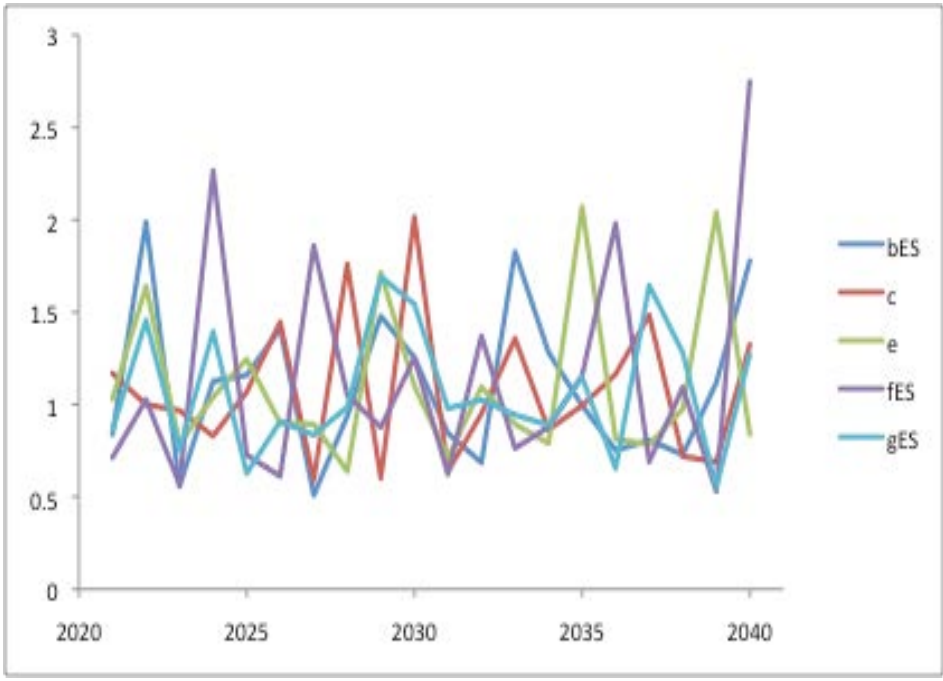


Weighting grid cell volatility by long run production shares ….



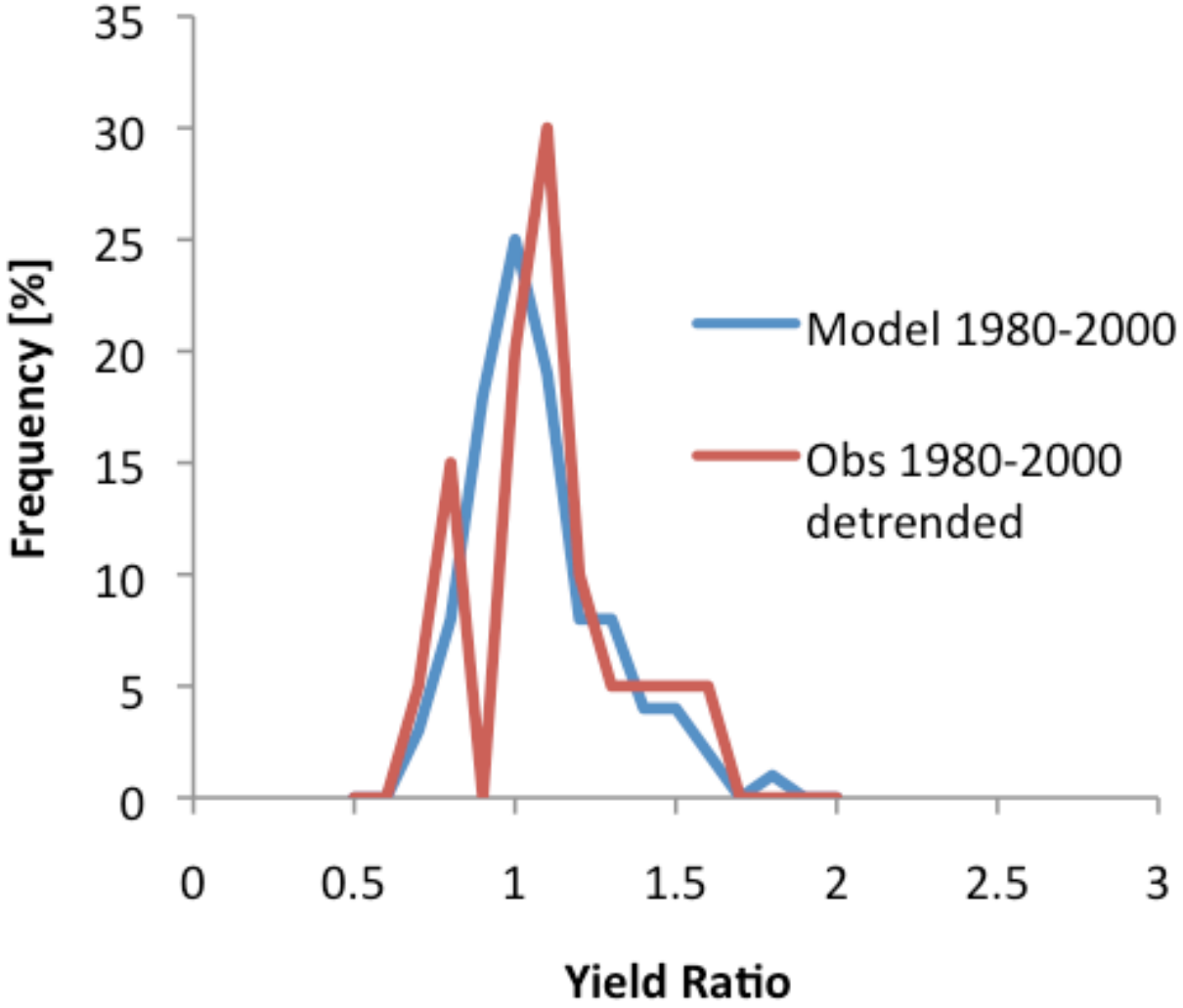
Gives greater national volatility in maize yields



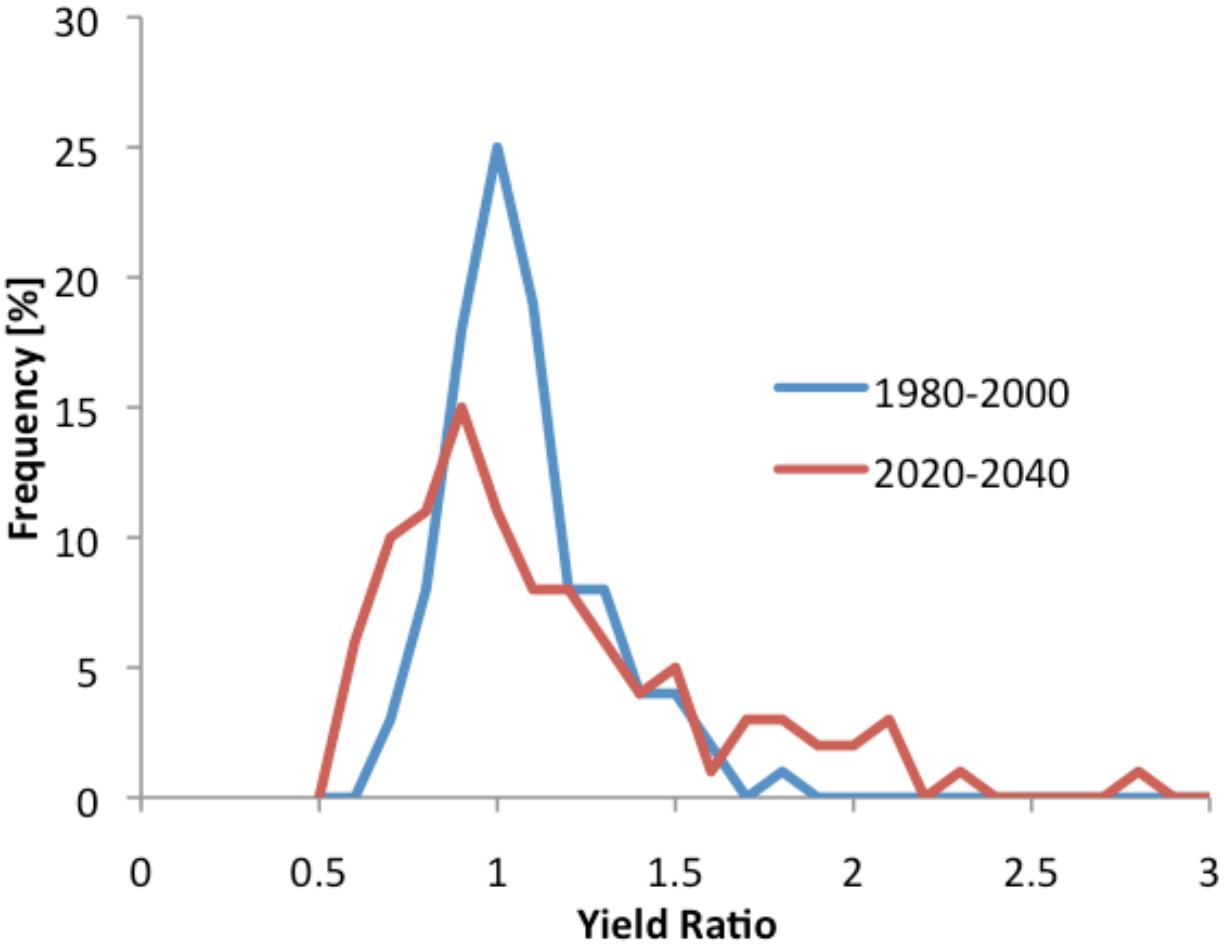


Synthetic yield time series based on five different climate model realizations over historical and future periods

The combination of high resolution climate results with the Schlenker-Roberts regression yields performs well vs. history



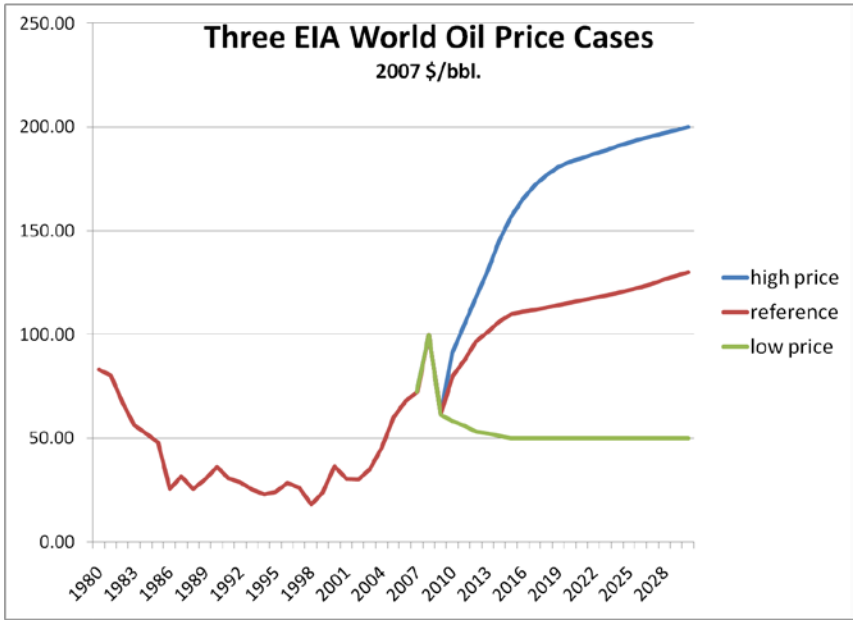
The std deviation of year-on-year predicted maize yields doubles as frequency distribution spreads



Energy prices are another driver of commodity markets

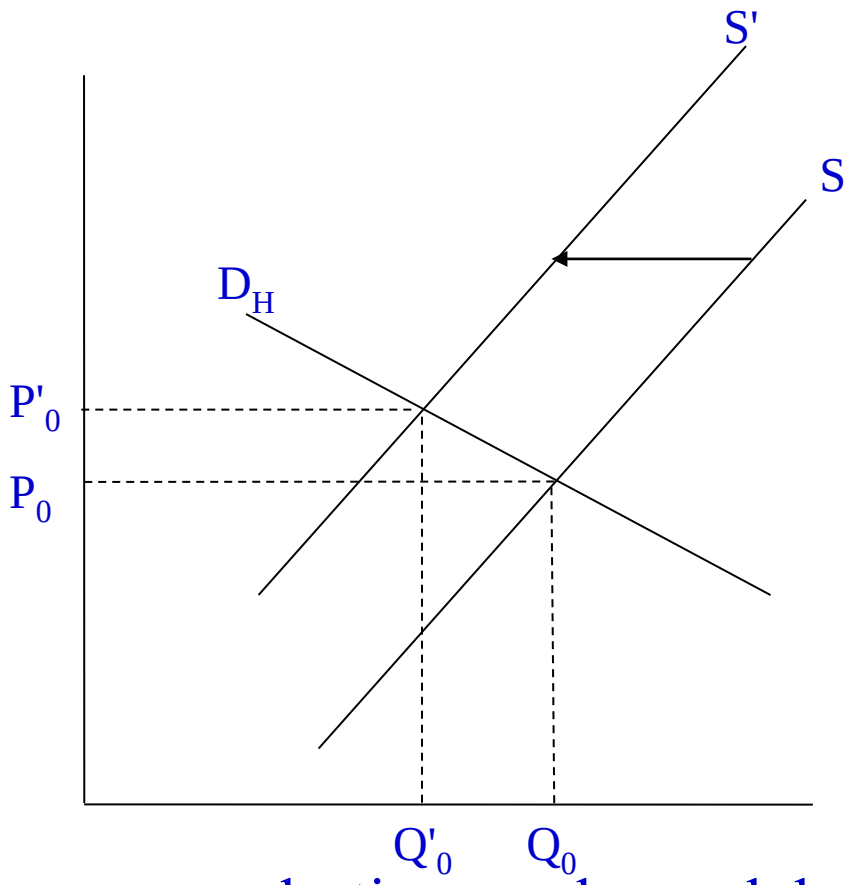
- Historical link has been through production costs – supply side; but linkage was modest
- With rise in oil prices and growth in ethanol use, stronger link – nearly perfect correlation in 2007/08 period
- Then oil prices dropped, RFS became binding and prices separated; now rising again
- As look to future, energy markets have potential to become shock absorber, but also can exacerbate volatility

The impact of future climate-driven volatility will depend importantly on the broader energy environment



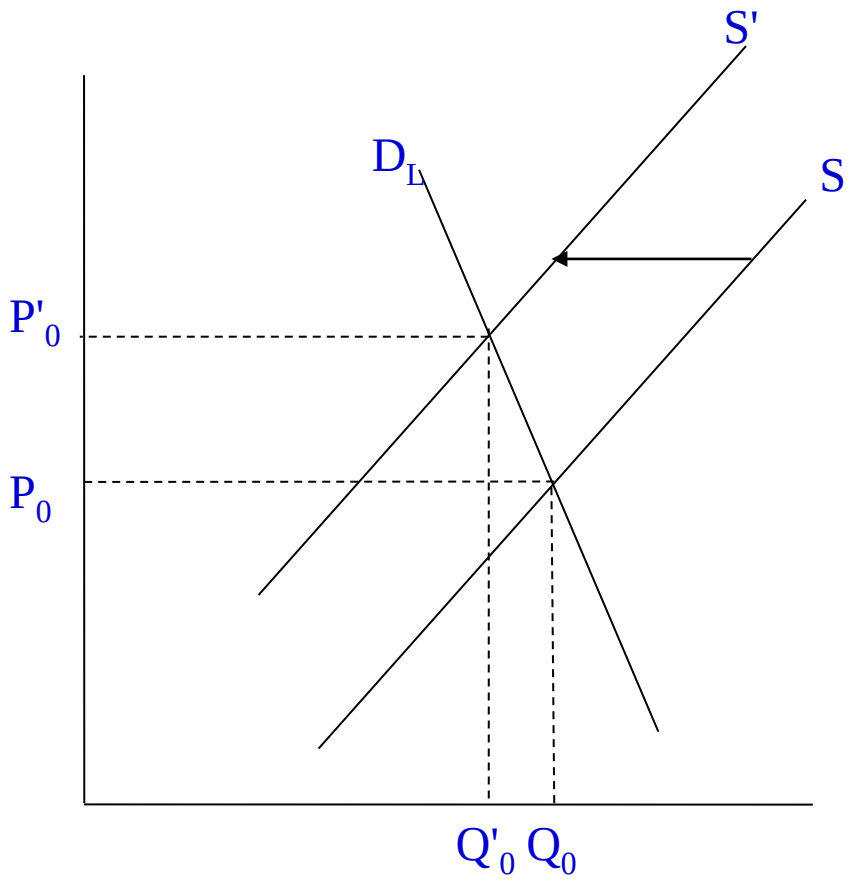
- At high oil prices, larger share of corn production to biofuels, much more elastic demand
- At low oil prices, lower share to biofuels, demand potentially unresponsive to price due to binding mandates

Commodity supply volatility in the context of high oil prices: dampened price volatility



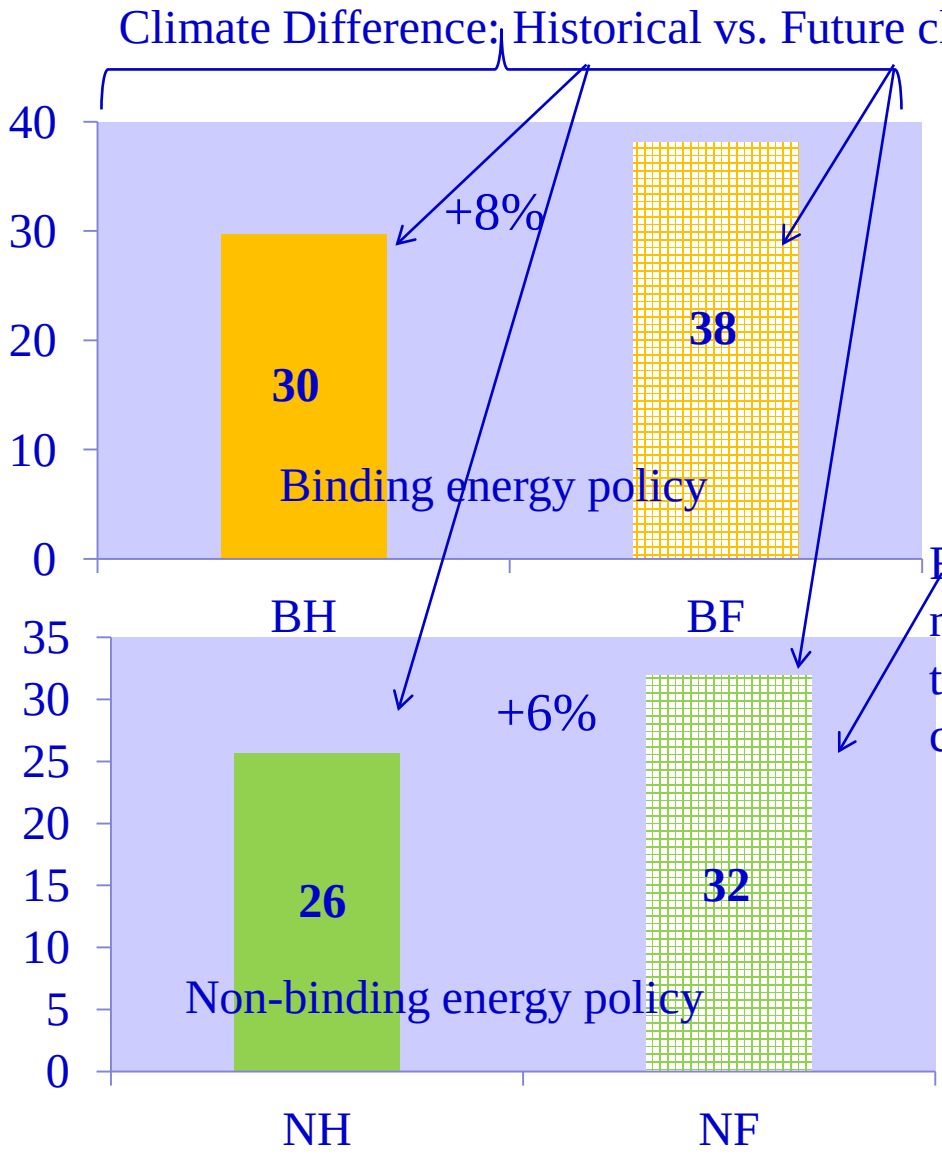
High Oil Prices → more elastic corn demand due to strong participation in liquid fuel market

Commodity supply volatility in the context of low oil prices: heightened price volatility



Low Oil Prices → more inelastic corn demand as ethanol production is dictated by policies instead of markets

Impact of corn supply shocks on US corn price volatility across climate regime, under two energy futures (standard deviation in inter-annual % price change)



Flexible energy policy makes it easier to absorb the impacts of increased climate volatility

Note: these simulations Reflect only a 20% rise In production volatility: See Lobell et al.

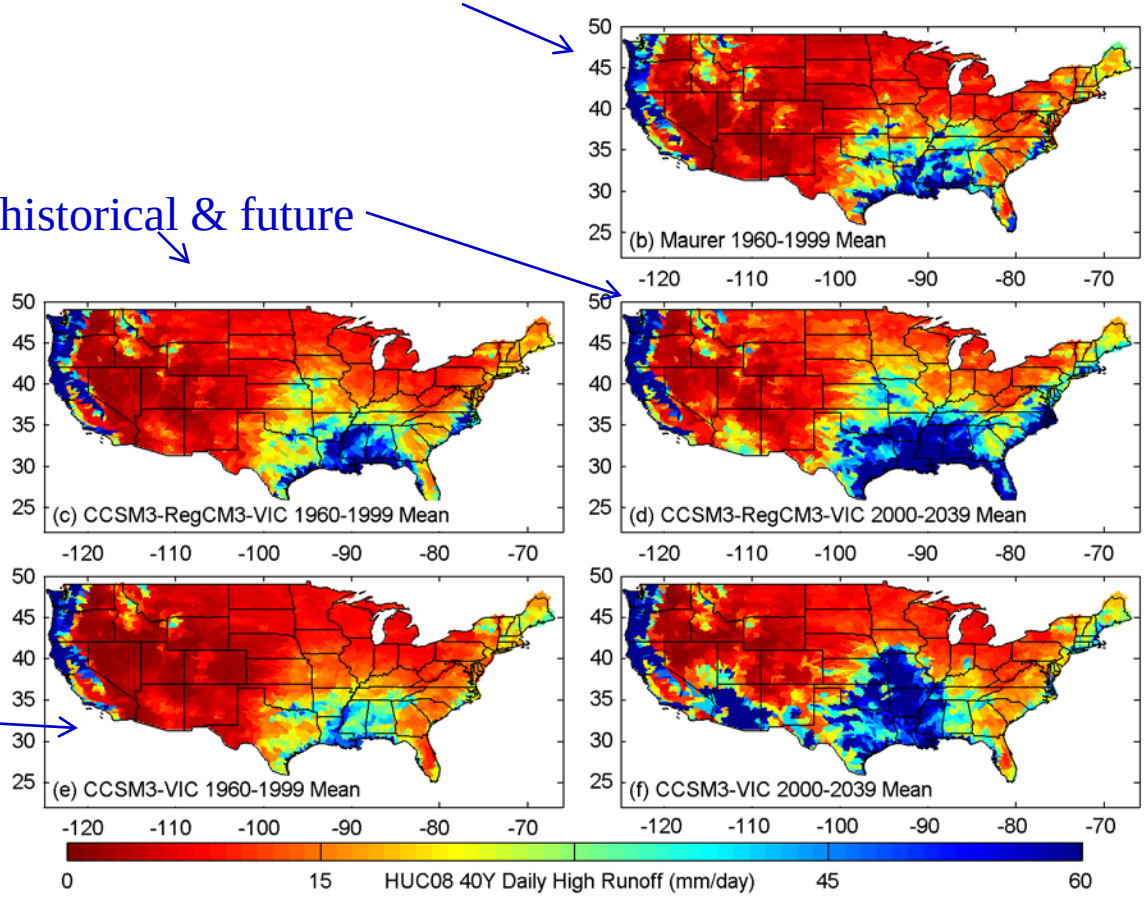
Simulations with GTAP-BIO-AEZ Model

Focus on water availability: Expected intensification of extreme events -- Daily high runoff – High resolution results are key (Diffenbaugh and Ashfaq)

Observed historical

Simulated historical & future

High resolution is important for Getting the right story historically; Std climate results don't capture extremes



Conclusions

- **Evidence suggests increased frequency and intensity of extreme climate events will exacerbate commodity production volatility in future**
- **Impact on commodity price volatility hinges critically on energy regime:**
  - **Low energy prices, binding biofuel mandates, leads to high price volatility**
  - **High energy prices, non-binding mandates, high sales shares, energy demands can serve as a valuable buffer for climate-driven production volatility**