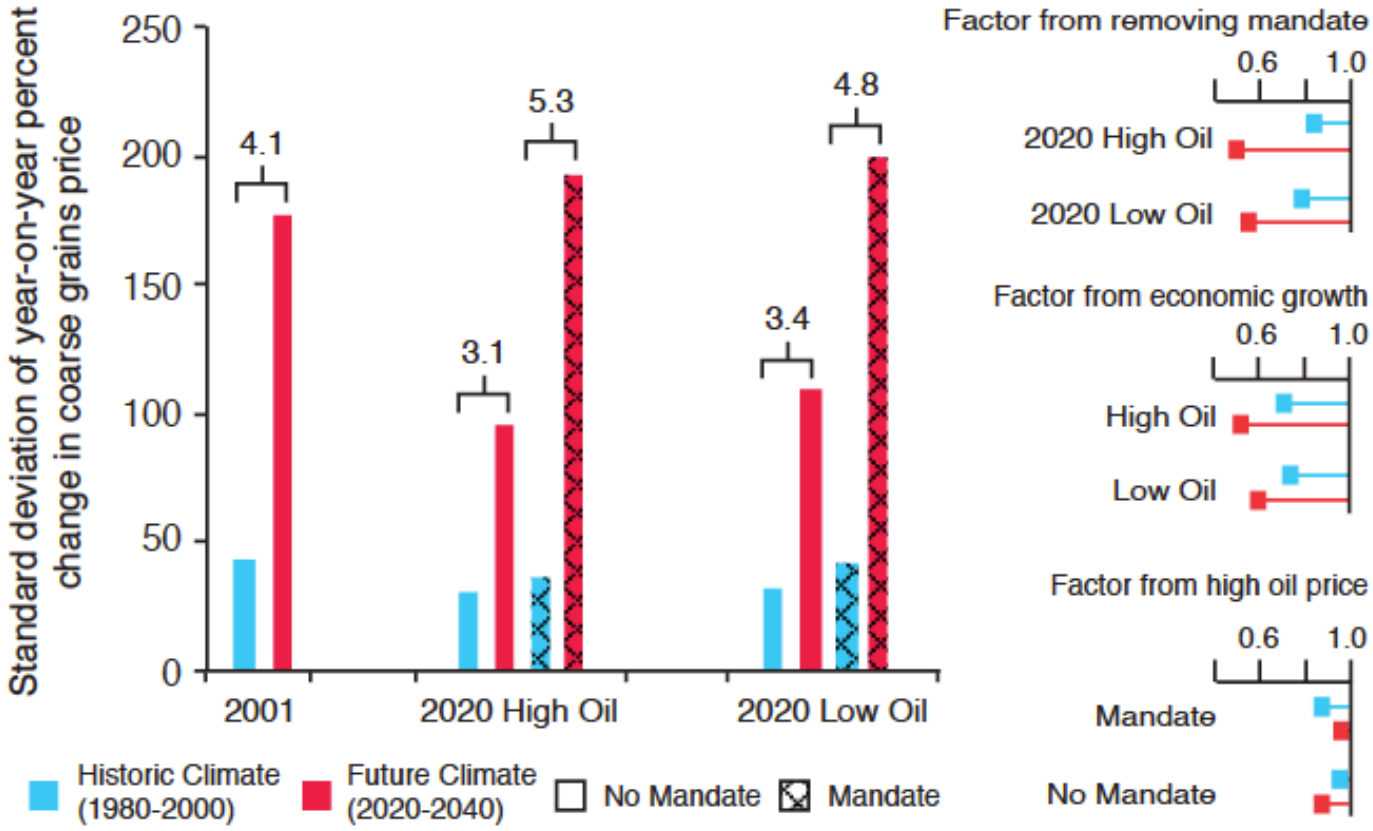
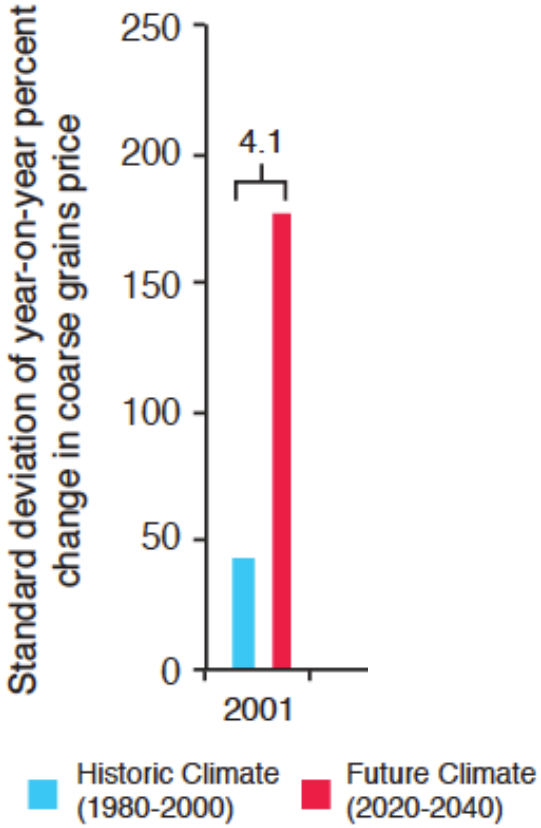
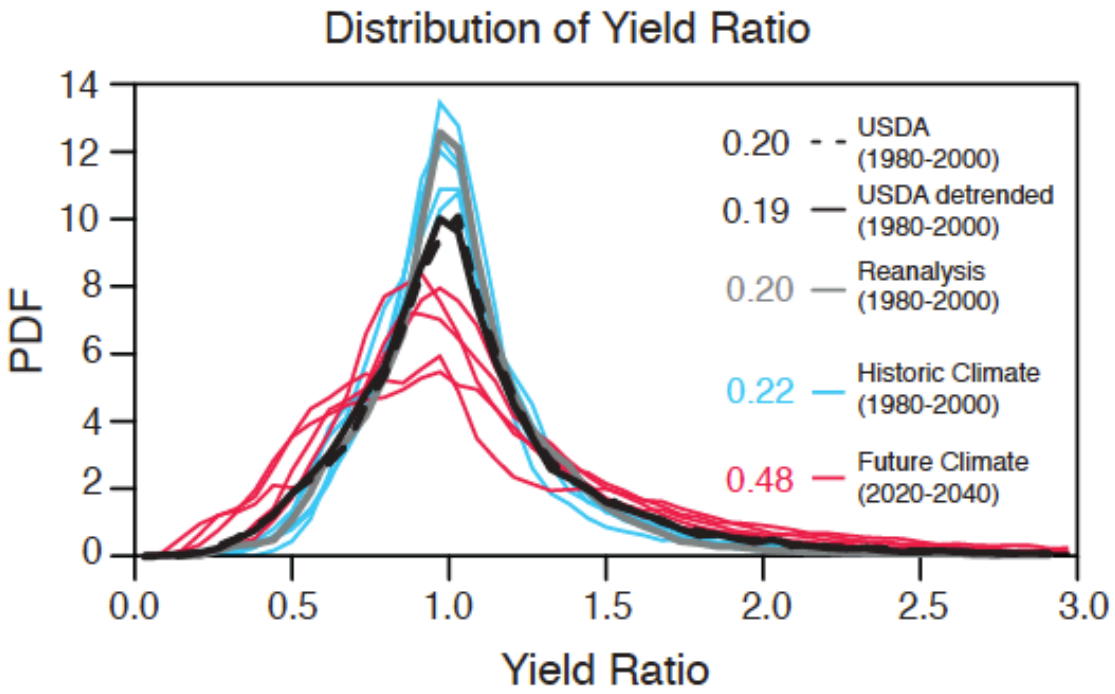
Climate-Energy-Policy Interaction



What we missed was Adaptation:

- How can policy on bio-fuels affect it? Trade?



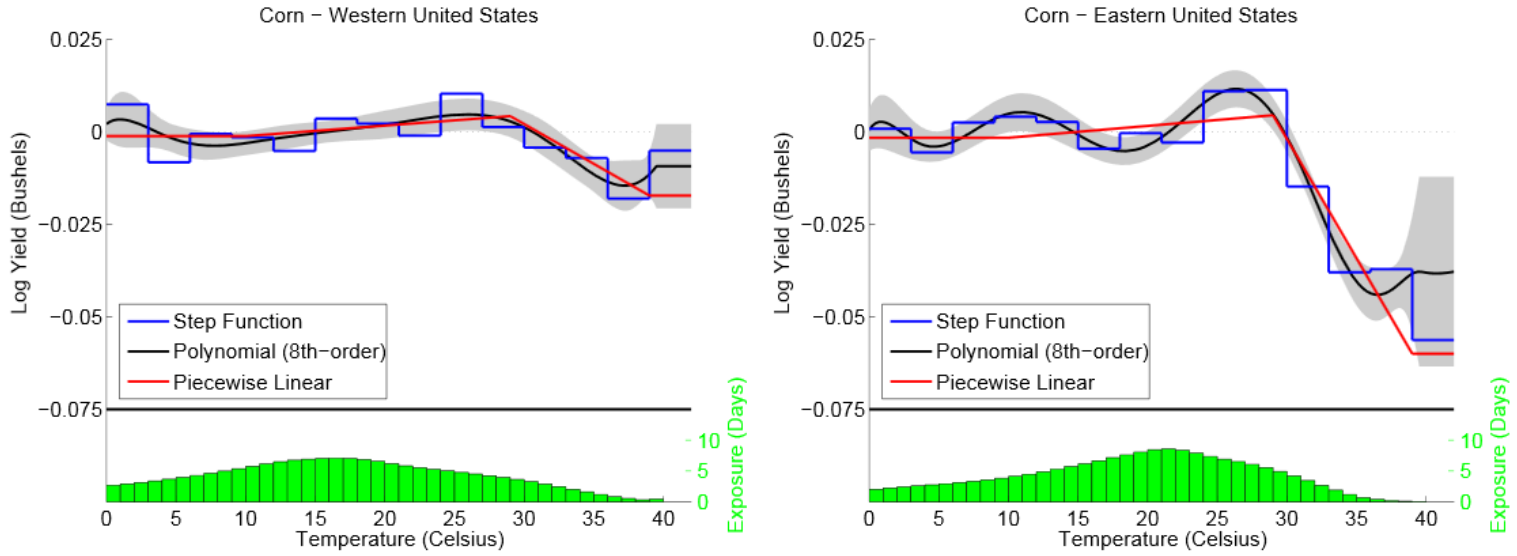


What about irrigation as adaptation?

Corn price Standard Deviation quadruples due to doubled SD of US corn yields, driven by Climate change

Irrigation's Potential Impact

- How irrigation affects yield (model input, US yield SD) $YR_{US,t} = \sum_c w_c YR_{ct}$
- S&R: effect of temperature much different in East and West, major difference - irrigation



Source: Schlenker and Roberts, PNAS 2009, Fig A10

Yield Variability as input

Start with the modified S&R regression (NCC study)

$$\frac{y_{ct}}{y_{ct-1}} = YR_c = e^{\alpha\Delta\phi_{ct}^{-}+\beta\Delta\phi_{ct}^{+}} . \; e^{\delta_1\Delta P_{ct}+\delta_2\Delta P_{ct}^2}$$

$$YR_{cn} = e^{\phi_{cn}^{\cdots}} . \; e^{P_{cn}^{\cdots}}$$
$$YR_{ci} = e^{\phi_{ci}^{\cdots}} . \; e^{P_{ci}^{\cdots}}$$

Same functional form

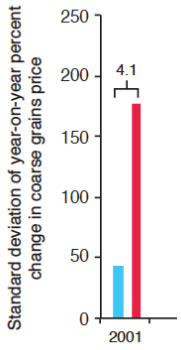
$$YR_c = (w_{ci}YR_{ci} + w_{cn}YR_{cn}); w_{ci} + w_{cn} = 1$$

Irrigated and non-irrigated corn production shares in county's corn production

- USDA-NASS data for Nebraska– irrigated and non-irrigated corn yield/production county data (1990-2012)

- Construct the same metric for Nebraska
  - Yield SD for irrigated corn: 0.12
  - Yield SD for non-irrigated corn: 0.34 (~ 3 times)
  - Yield SD: 0.15

- Question, what our previous graphs would look like with irrigation.
  - Focus on simple case, leave out policy and oil price scenarios, concentrating on just climate change



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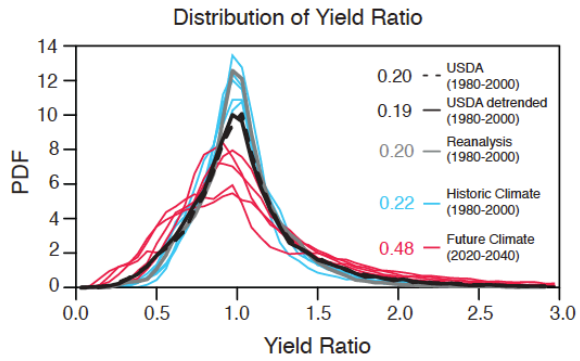


+ irrigation

  - How do we bring in irrigation into our standard model framework, for comparison with earlier results?

- $$YR_{US} = \sum_{c} w_c (w_{ci} YR_{ci} + w_{cn} YR_{cn})$$
$$= \underbrace{\sum_{c} (w_c YR_{cn})} \left(w_{ci} \frac{YR_{ci}}{YR_{cn}} + w_{cn} \right)$$

  - what we had with our no-irrigation story
  - Know its present climate SD
  - Know that it doubles with climate change

A more generic version, including irrigation

Implications

- Case 1: No Irrigation ($w_i = 0, w_n = 1$)

$$YR_{US} = \sum_{c} (w_c YR_{cn})$$

  – Same as NCC work form, with no irrigation

- Case 2: Full Irrigation ($w_i = 1, w_n = 0$)

$$YR_{US} = \sum_{c} (w_c YR_{cn}) \frac{YR_{ci}}{YR_{cn}}$$

Simplifying assumptions in absence of data –

- NE data applies to all counties/states
- UNL study to approximate $\frac{e^{\Phi ci^{\cdots}} . e^{P ci^{\cdots}}}{e^{\Phi cn^{\cdots}} . e^{P cn^{\cdots}}} = \frac{YR_{ci}}{YR_{cn}}$ (Grassini, Yang, Casssman 2009)

$\left(\frac{e^{\Phi ci^{\cdots}}}{e^{\Phi cn^{\cdots}}} = \frac{-0.32}{-0.34} \text{ and } \frac{e^{P ci^{\cdots}}}{e^{P cn^{\cdots}}} = \frac{0.30}{0.67} \right)$

- $\frac{YR_{ci}}{YR_{cn}} = 0.42 < 1$ implies

"year on year yield ratios for fully irrigated crop are less than those for non-irrigated crop, hence pointing to potential of irrigation as adaptation"

- SD with irrigation = 0.42*SD without irrigation

- Case 3: Partial irrigation ($w_i = a, w_n = 1 - a$)

$$YR_{US} = \sum_c (w_c YR_{cn}) \left[1 - w_{ci} \left(1 - \frac{YR_{ci}}{YR_{cn}} \right) \right]$$

0<(.)<1

0<(.)<1

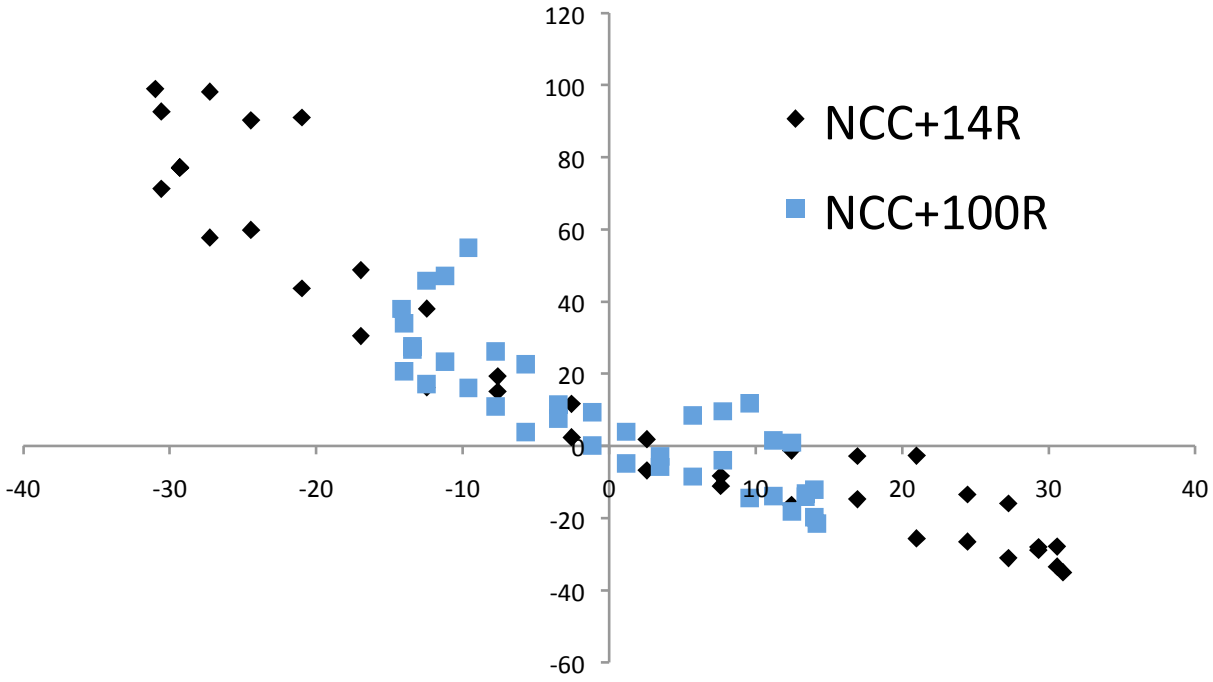
  - SD is decreasing in share of production under irrigation

a	$a\frac{YR_{ci}}{YR_{cn}} + (1-a)$	Rebased	SD (US yield)
Case1: no irrig	1	1.09	23.89
Case3(Base for 2001): 0.14	0.92	1	**21.92**
Case2: full irrig	0.42	0.46	10.03

Implementation

- Use the factor to scale the yield distribution
- Scenarios
  - NCC + 14R (yield SD ~ 22)
  - NCC + 100R (yield SD ~ 10.03)
  - CC + 14R (yield SD ~ 44/20)
  - CC + 100R (yield SD ~ 39/4)
- What happens with climate change? ($\frac{YR_{ci}}{YR_{cn}}$)

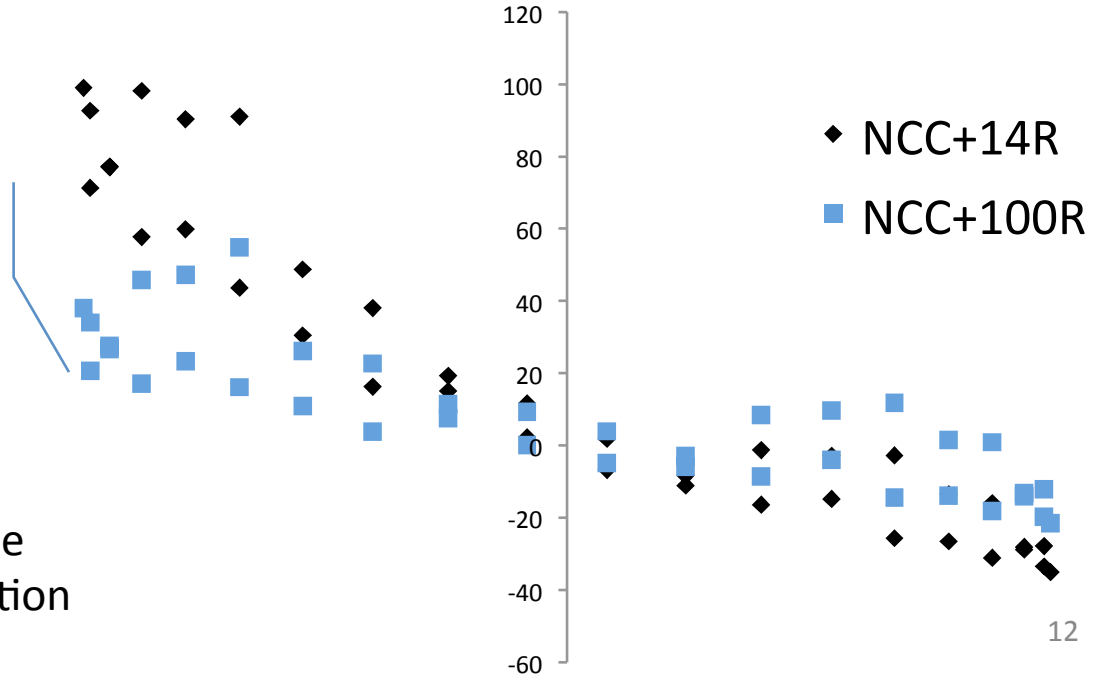
  $\frac{YR_{ci}}{YR_{cn}}$ remains same in future climate or is halved, 2 extremes [0.42,0.21]

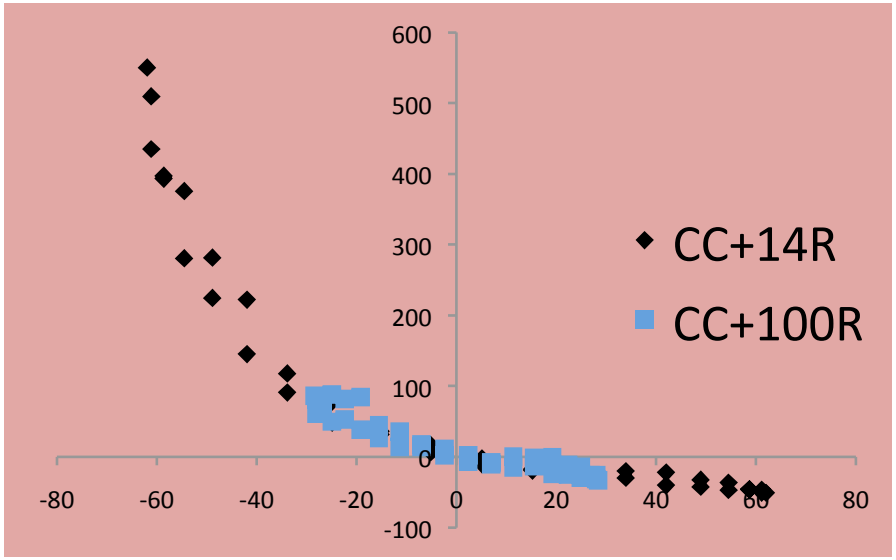


X: corn yield SD
Y: corn price SD

Vertical distance: difference in price SD coming from irrigation

Y: corn price SD
Two points on same vertical line represent same climate realization




600
500
400
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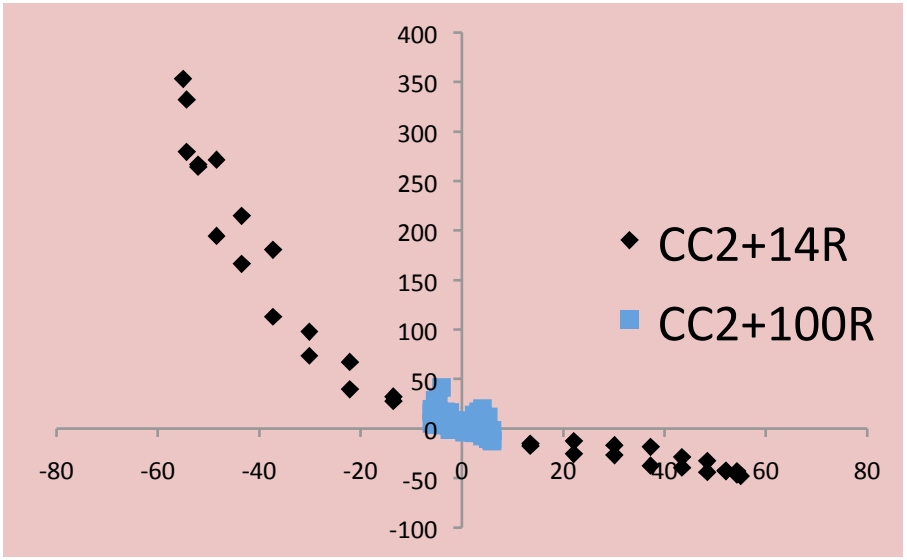
0
20
40
60
80
CC+14R
CC+100R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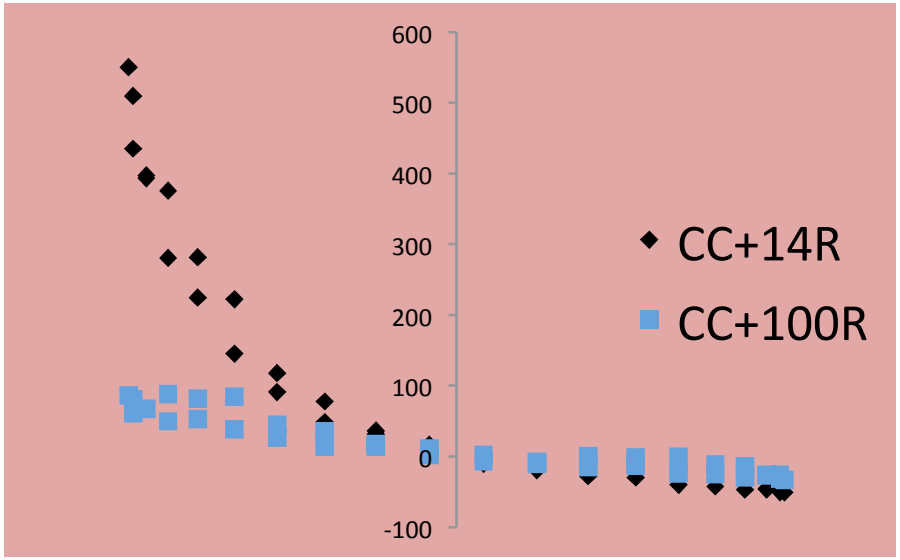
CC2+14R
CC2+100R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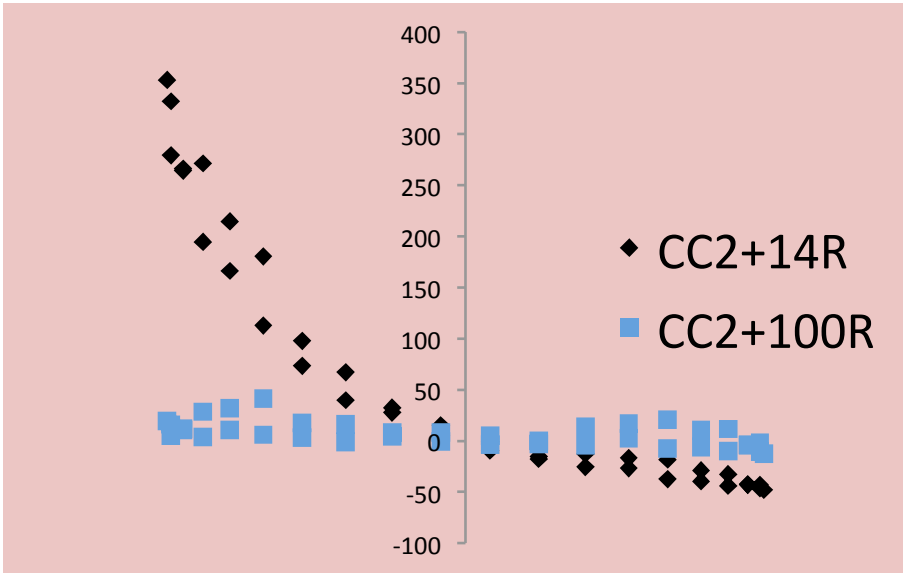
CC+14R
CC+100R


400
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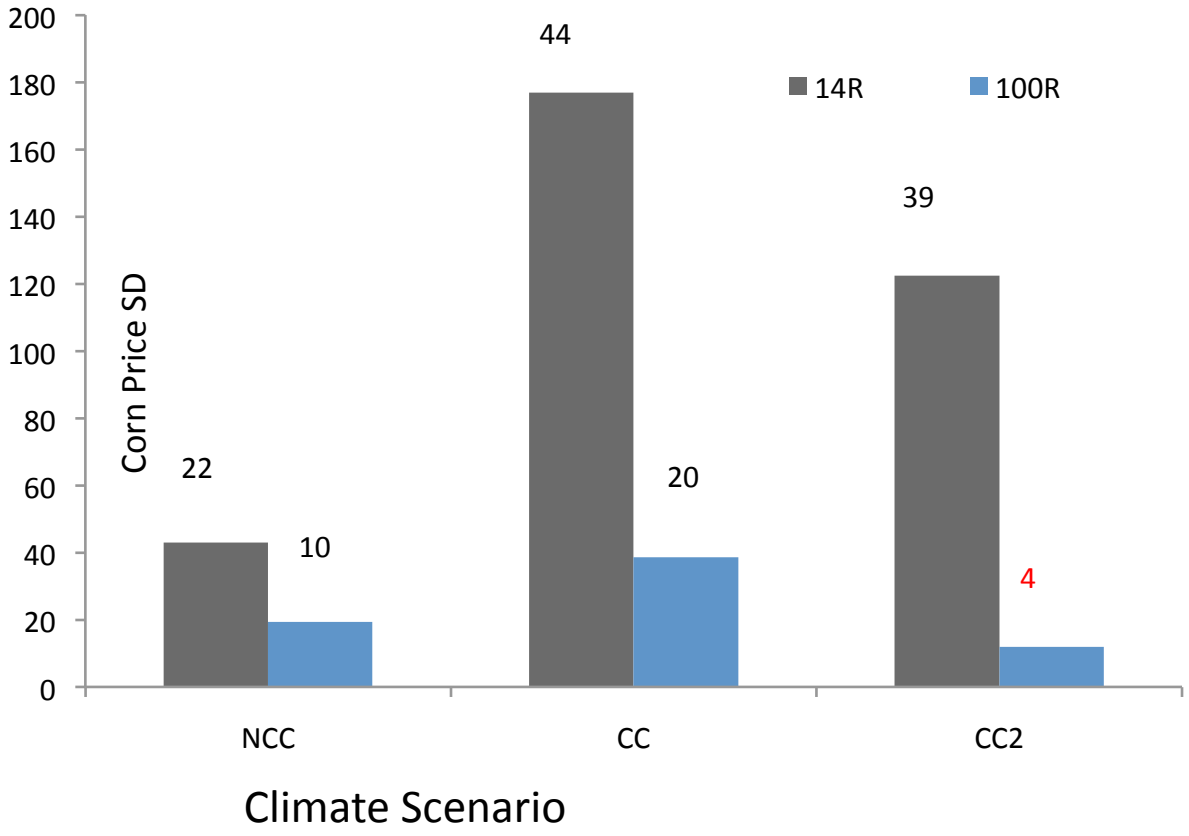
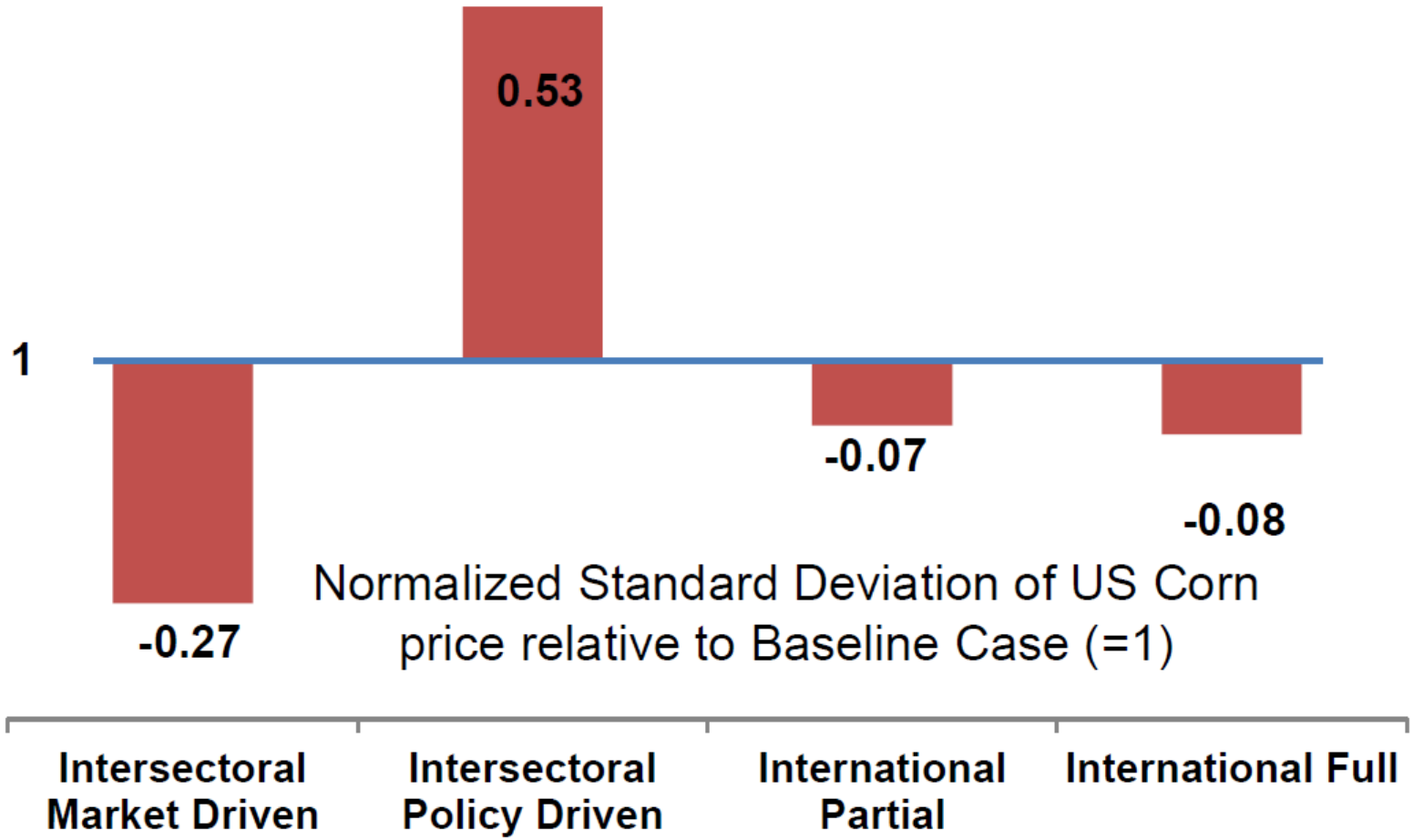
CC2+14R
CC2+100R

Price and Yield SD under different climate and irrigation combinations



Height of Bar indicates Price SD and number next to bar is the yield SD

- Strange result (with irrigation even after climate change we get less variability than under same irrigation % and no climate change)
  - Other study: one from Swiss corn (Finger et al 2011, ClimChng)
- Bring in more economics: even if irrigation is effective, under what conditions would it be feasible/viable to use
  - One approach would be to take multiple corn price realizations for future and see if its profitable for farmers to use surface, ground water to irrigate
  - Cost of irrigation, infrastructure.
- Collaborate with actual working water model and see if these insights hold, magnitude of impact would likely change


0.53
1
-0.07
-0.08
-0.27
Normalized Standard Deviation of US Corn price relative to Baseline Case (=1)
Intersectoral Market Driven
Intersectoral Policy Driven
International Partial
International Full