Environmental Linkages

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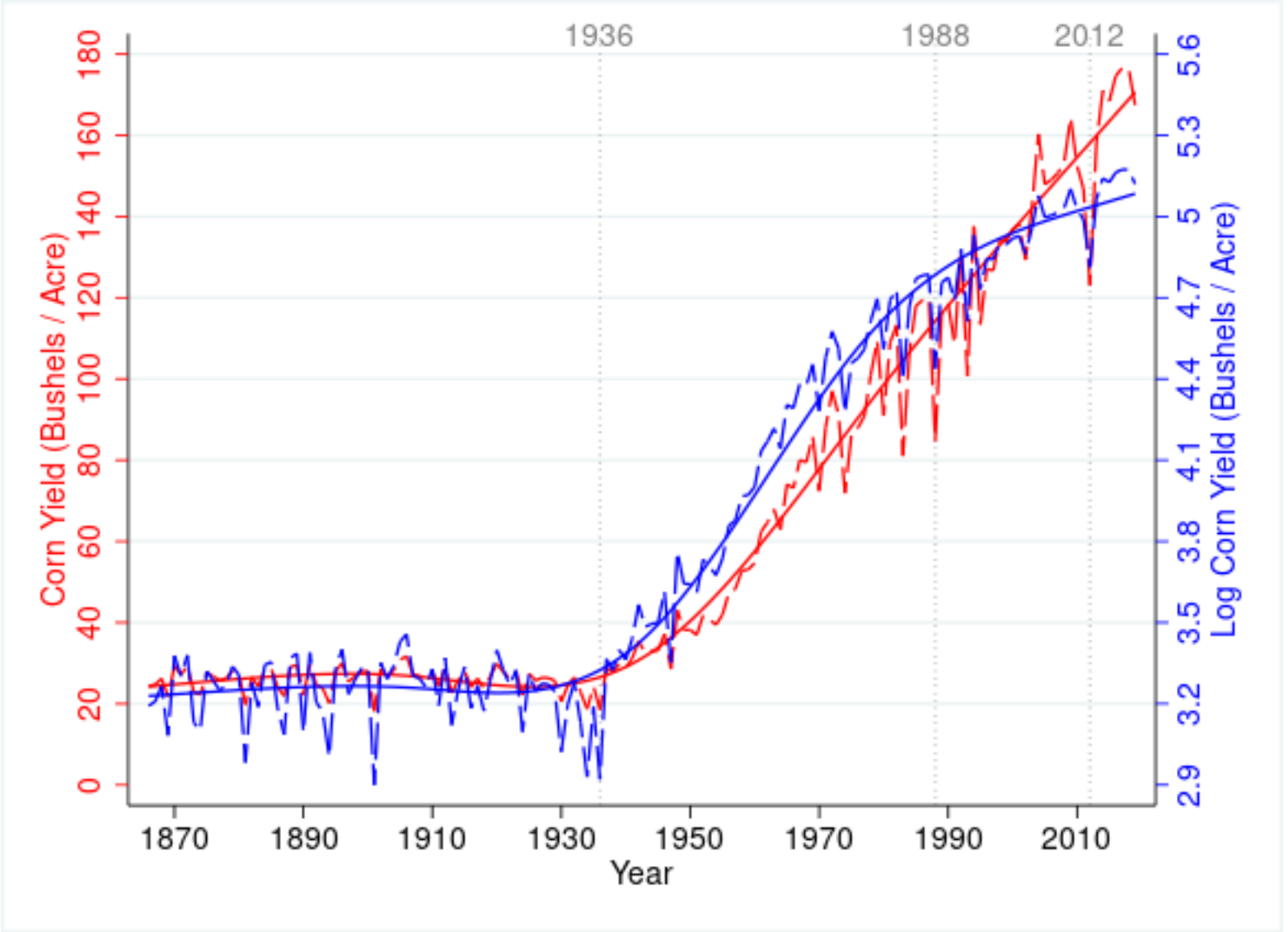
The Roots of Agricultural Productivity Growth

Productivity: US Corn Yields 1866-2019

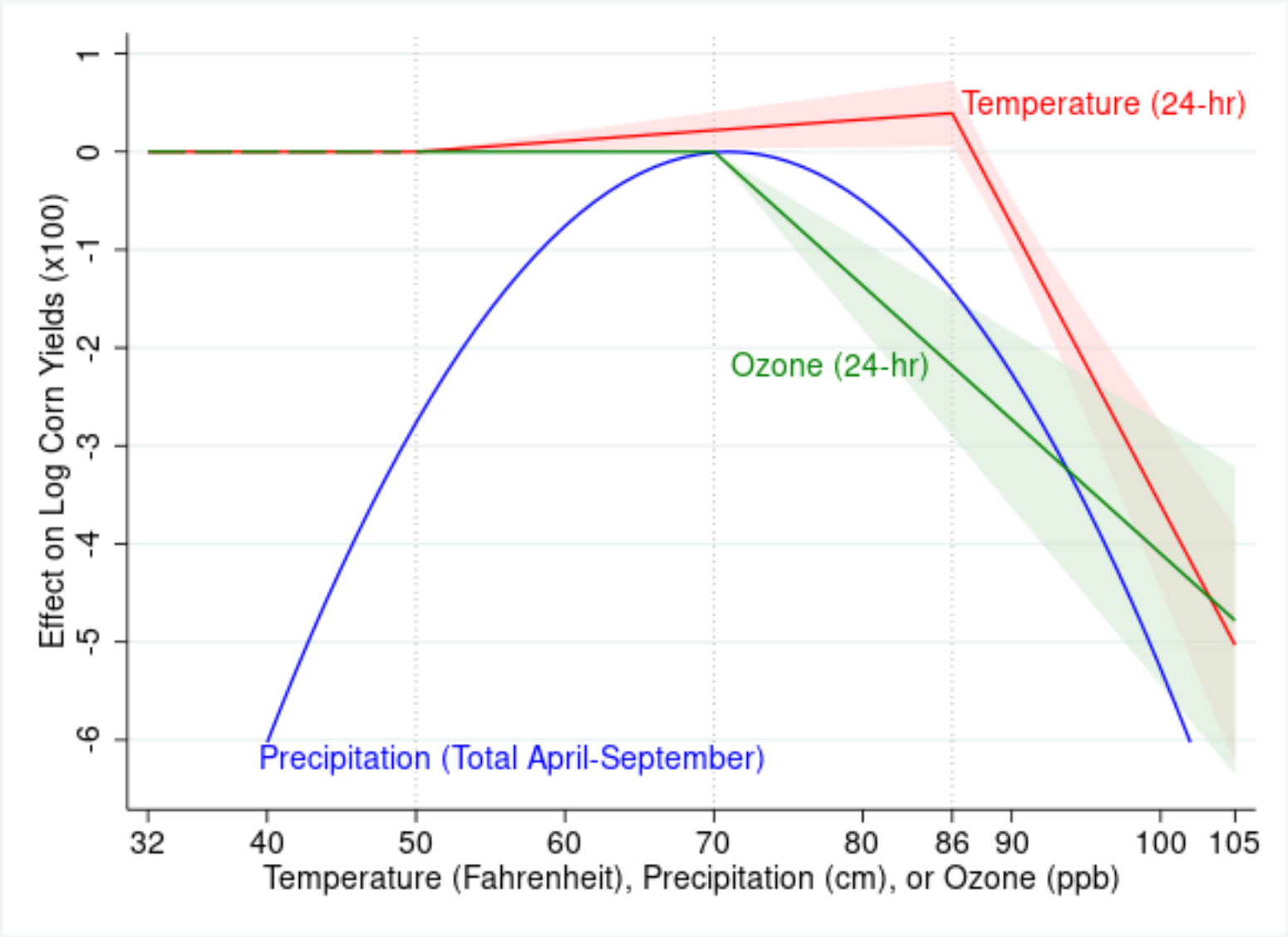
- Phase 1 (1866-1940)
  - Fairly constant average yields
- Phase 2 (1940-1980)
  - Exponential growth in yields
- Phase 3 (since 1980)
  - Linear growth in yields

- Fluctuation around average
  - Constant in percent terms
  - Environmental factors are key



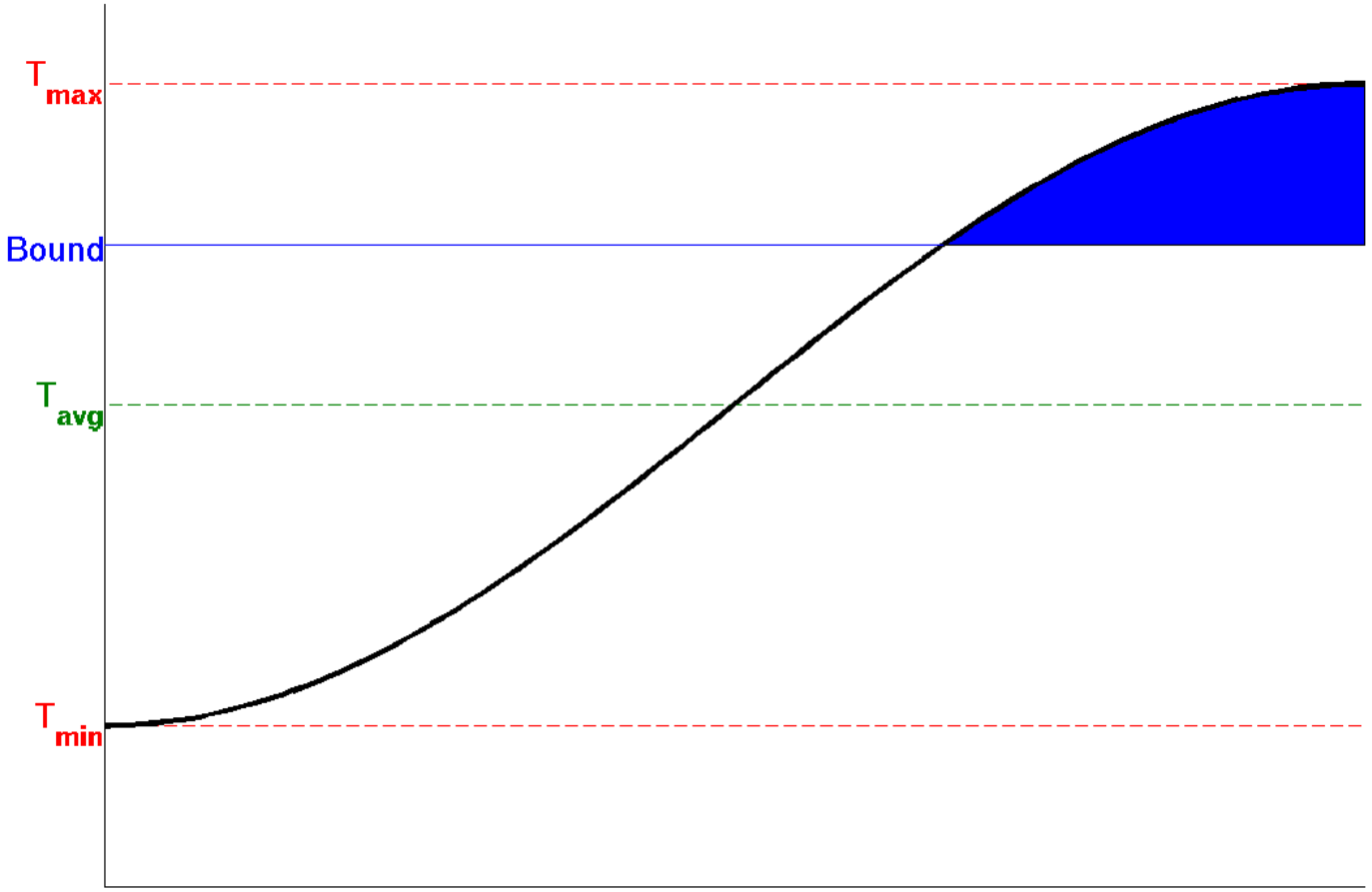
Environmental Drivers of Corn Yields

- Growing Season
  - April - September
- Peak exposure crucial
  - Temperatures
  - Ozone
- Temperature
  - Degree days above 86F
- Ozone
  - Exposure above 70ppb
- Precipitation
  - Season-total

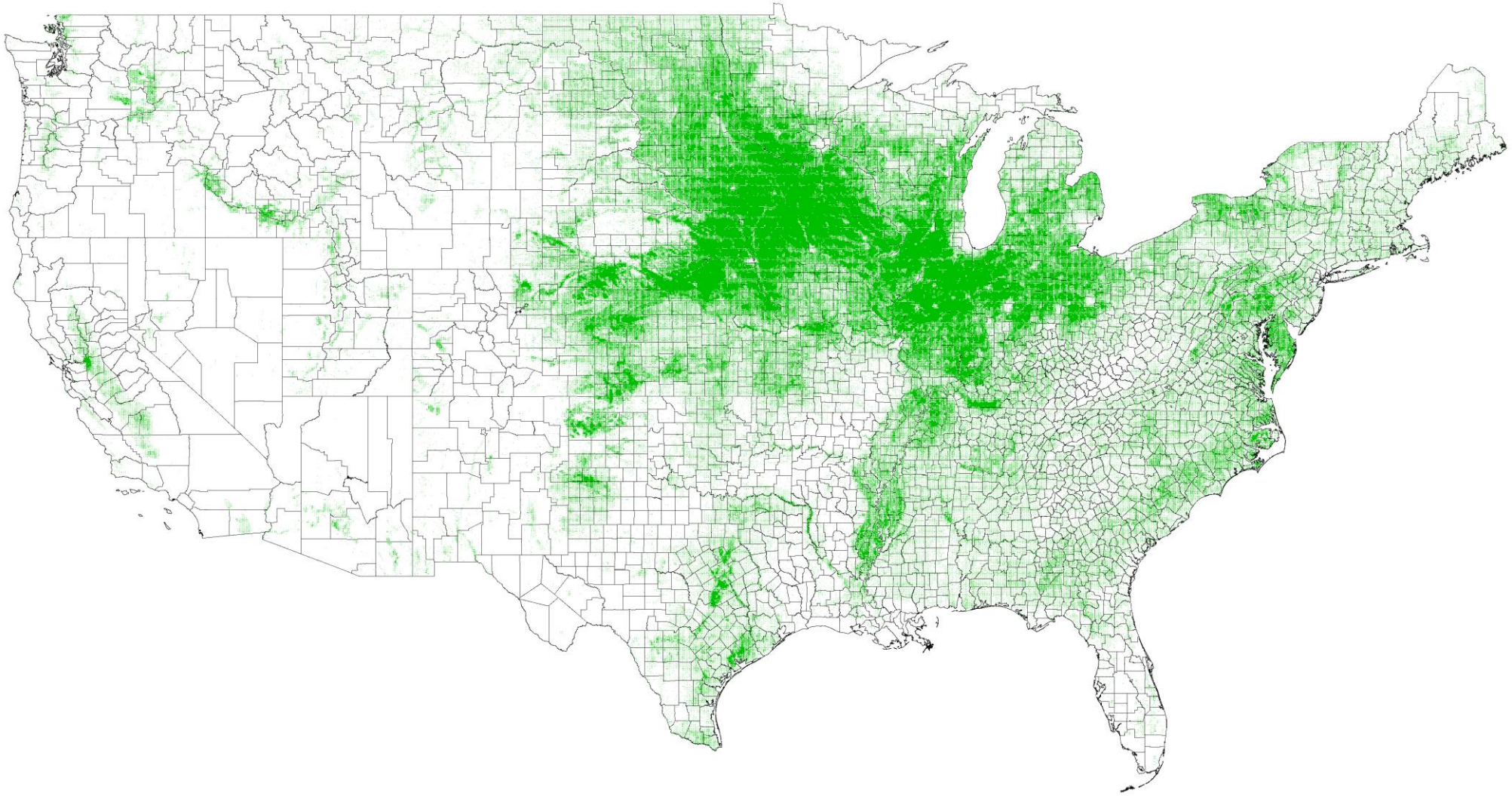


Key Concept: Measures of Peak Exposure

- Degree days above bound
  - measures how much above
  - measures how long above
- Degree days above 86F
  - Explains more than half of year-to-year variability in corn yields
- Peak ozone
  - Hourly ozone readings
  - Exceedance above 70ppb
  - Summed over all hours



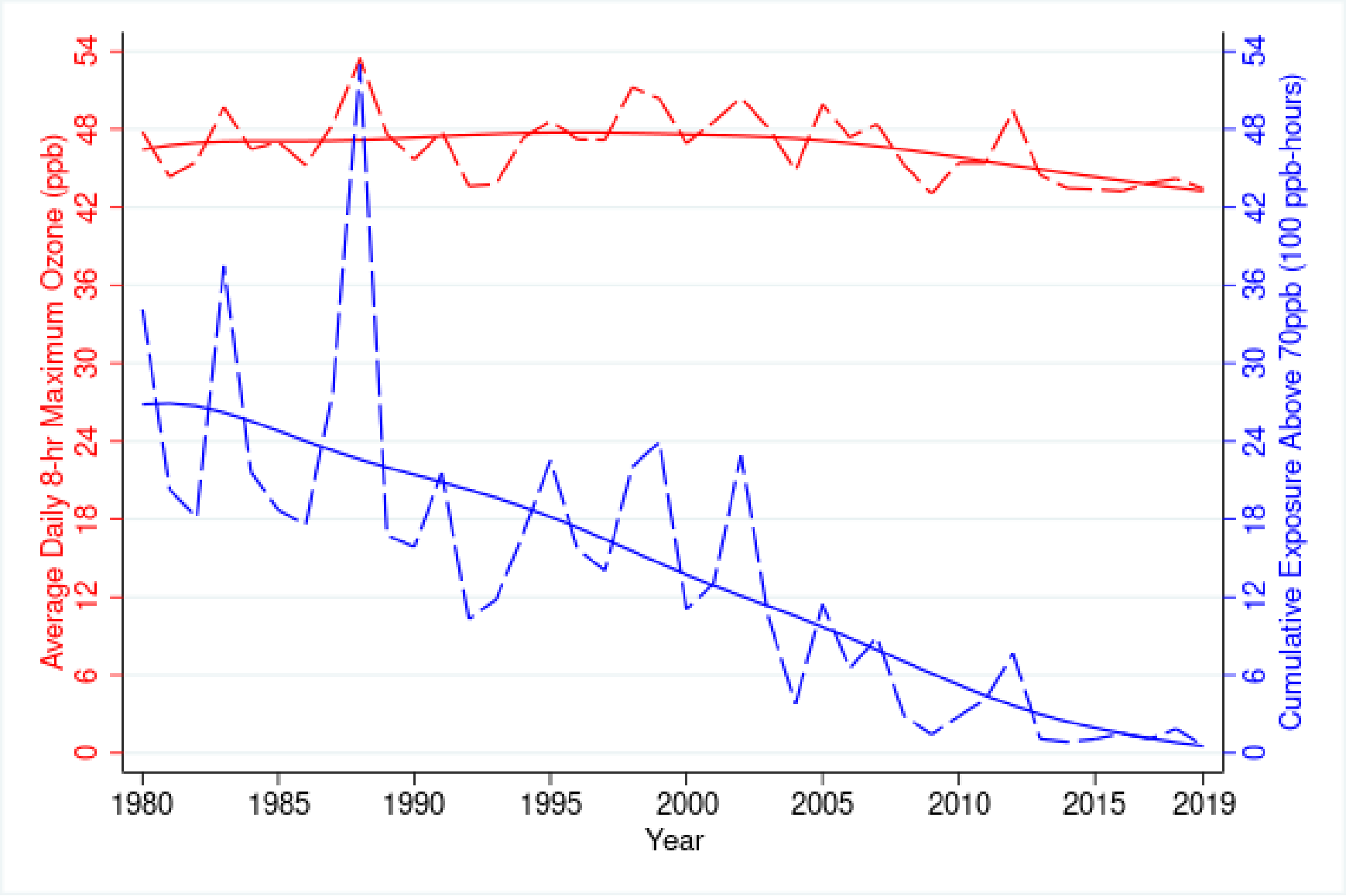
Average for US over Corn Growing Area



- Cropland Data Layer (30x30m satellite data 2010-2018)
  - Average of grid that grows corn

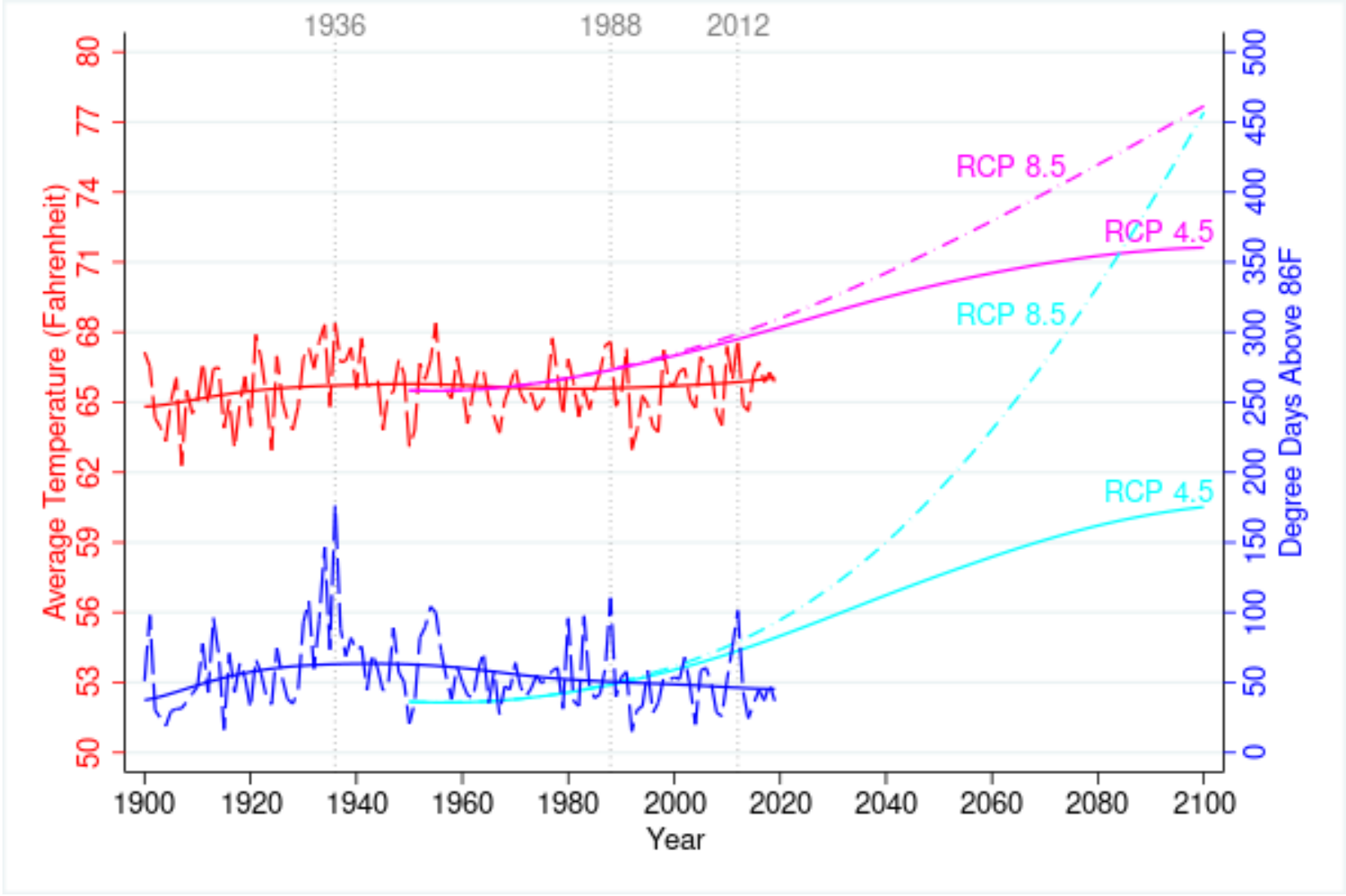
Ozone over Corn Area over Time

- Average ozone
  - Red line (left y-axis)
  - Minor decrease
- Peak ozone
  - Blue line (right y-axis)
  - Phased out
    - Clean Air Act
  - No further reduction going forward



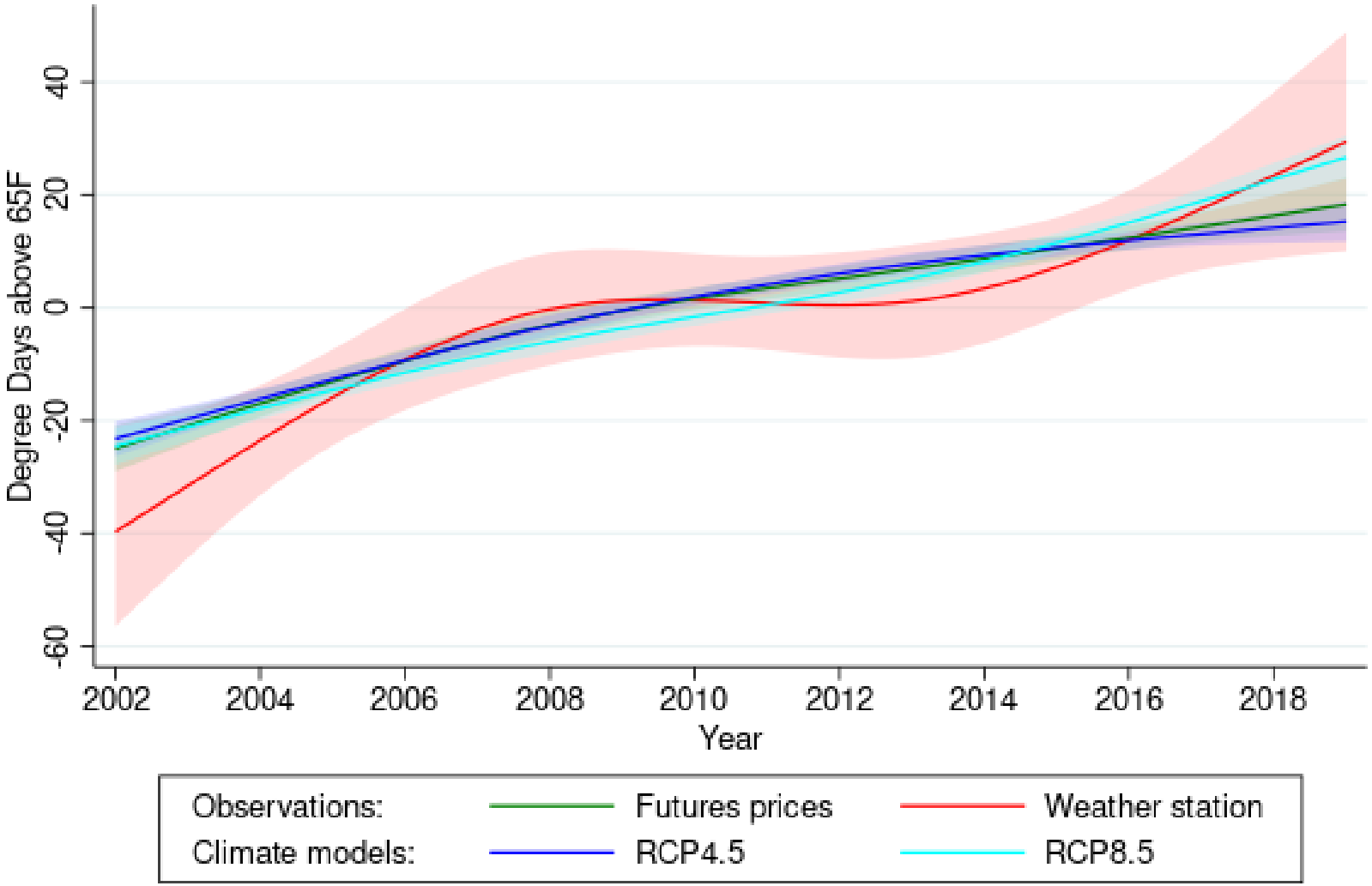
Temperature over Corn Area over Time

- Average temperature
  - Red line (left y-axis)
  - Small increase since 1980
  - Not as much as predicted
- Degree days above 86F
  - Blue line (right y-axis)
  - Decrease 1980-2020
    - Cooling effect of irrigation
    - Intensification of agriculture
  - Predicted to increase
    - Especially under RCP 8.5

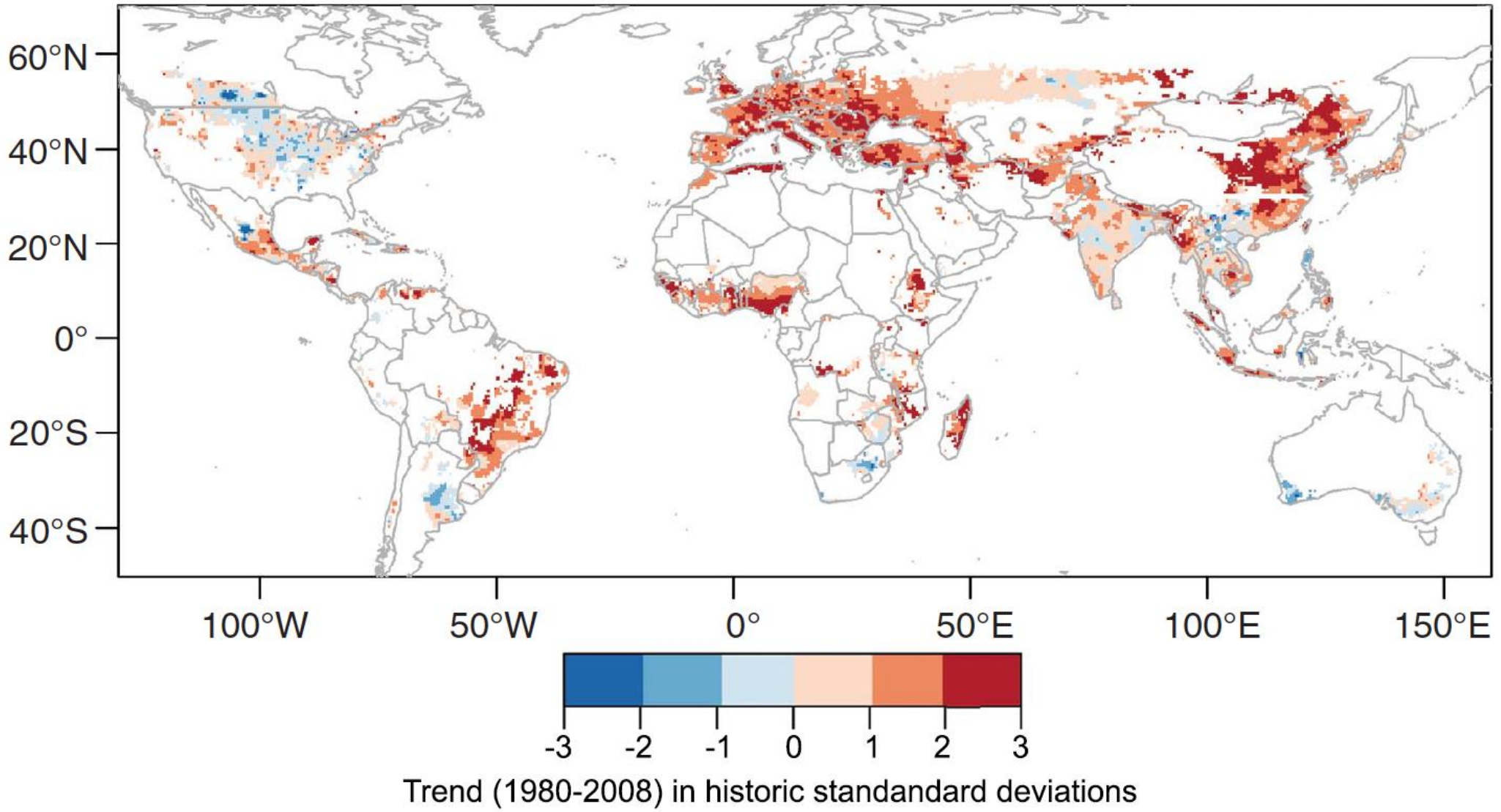


Weather Derivatives at US Airports

- Weather futures
  - Payout based on weather
  - 8 airports in the US
    - ATL, CVG, DFW, LAS, LGA, MSP, ORD, SAC
- Prices have been rising
  - Comparable trends
  - Price of derivative (green)
  - Actual weather (red)
  - Climate models (blue)
- Schlenker & Taylor (JFE, 2021)



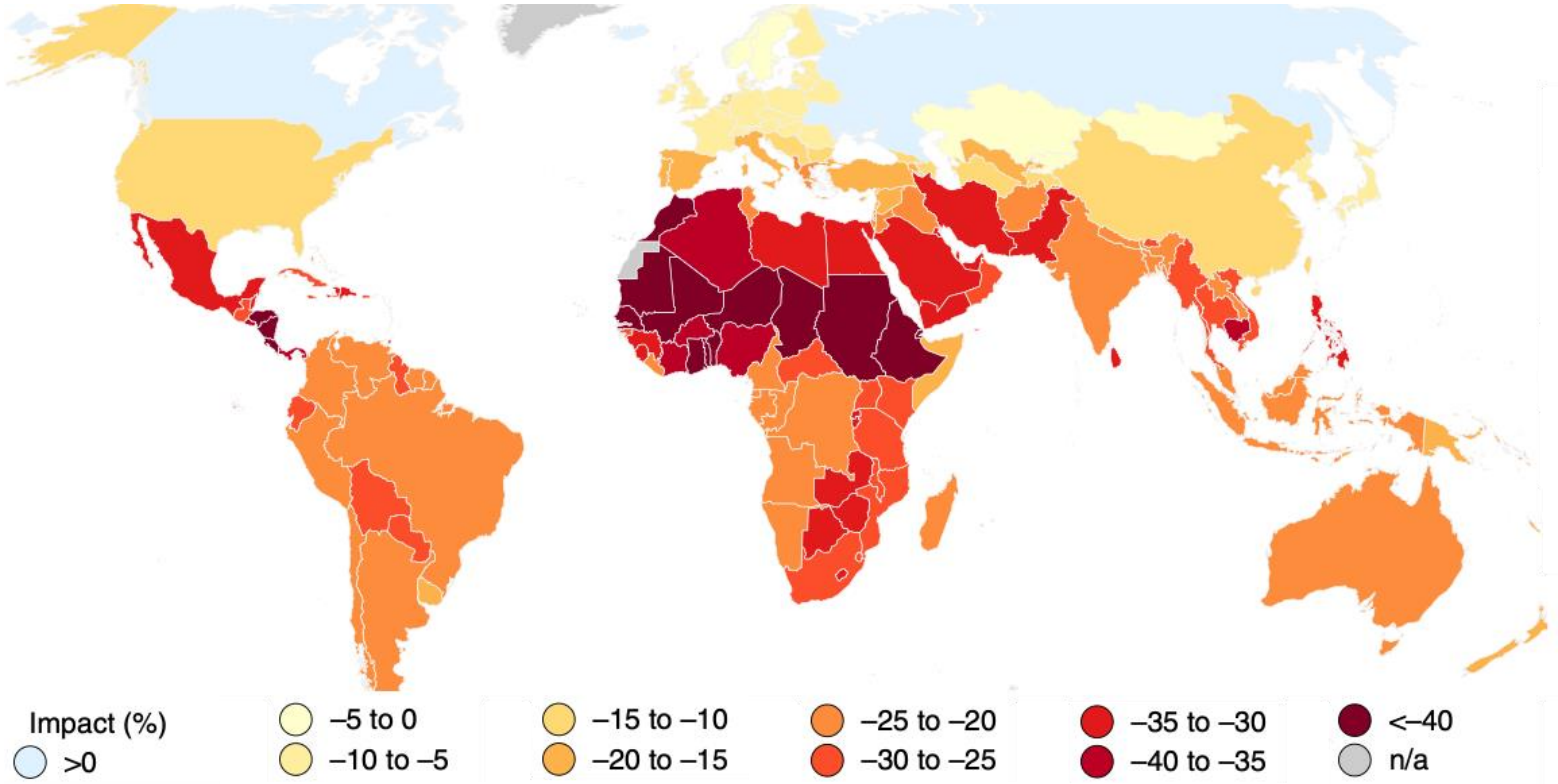
Observed Trend over Agricultural Area



- Ortiz-Bobea et al. (Nature Climate Change, 2021)

Climate Effect on Total Factor Productivity

- So far: focus on output
  - Yields
  - Climate change might impact required input use as well
- Total factor productivity
  - Output minus input
  - TFP growth since 1961 linked to weather
  - Ortiz-Bobea et al. (NCC, 2021)
- Observed climate change lowered TFP
  - Effect varies spatially
  - Hotter areas more impacted



Going Forward

- Climate change
  - Four basic staple commodities (corn, wheat, rice and soybeans)
    - 75% of calories that humans consume, US market share 25%
  - Extreme heat will rise and lead to slowing of productivity growth
    - So far increase in extreme temperature has been limited
    - But local feedback loops can only counterbalance warming trends to a limited amount
  - Peak ozone has been eliminated – further reduction not possible
  - CO2 fertilization increases productivity growth

- Lower global agricultural productivity growth
  - Increase in prices of basic food commodities
  - Good for farmers, bad for consumers, especially in developing countries
    - US: commodity cost small share of price in store
  - Regional shifts are likely (e.g., growing area expansion in Russia)

Conclusion: Socioeconomic Spillovers

- In the past, agricultural productivity declines had large ripple effects
  - Dust Bowl: large outmigration, especially of younger population
    - 1936 still year with highest number of degree days above 86F
    - Climate projections predict this to be an average year by mid century (RCP 8.5)
  - Migration in Africa
    - Linking bi-national flows to price shocks caused by world markets
    - If prices of cash crops decrease, outmigration increased
    - If prices on non-cash crops decreased, no effect on outmigration

- Conclusion
  - Agriculture still very much dependent on environmental inputs
  - Relationship often highly nonlinear (temperature, droughts, ozone)
  - Climate change lowers productivity growth in current growing areas