Impact of Climate Change on the Hydrology of Summer Agriculture in the American Midwest

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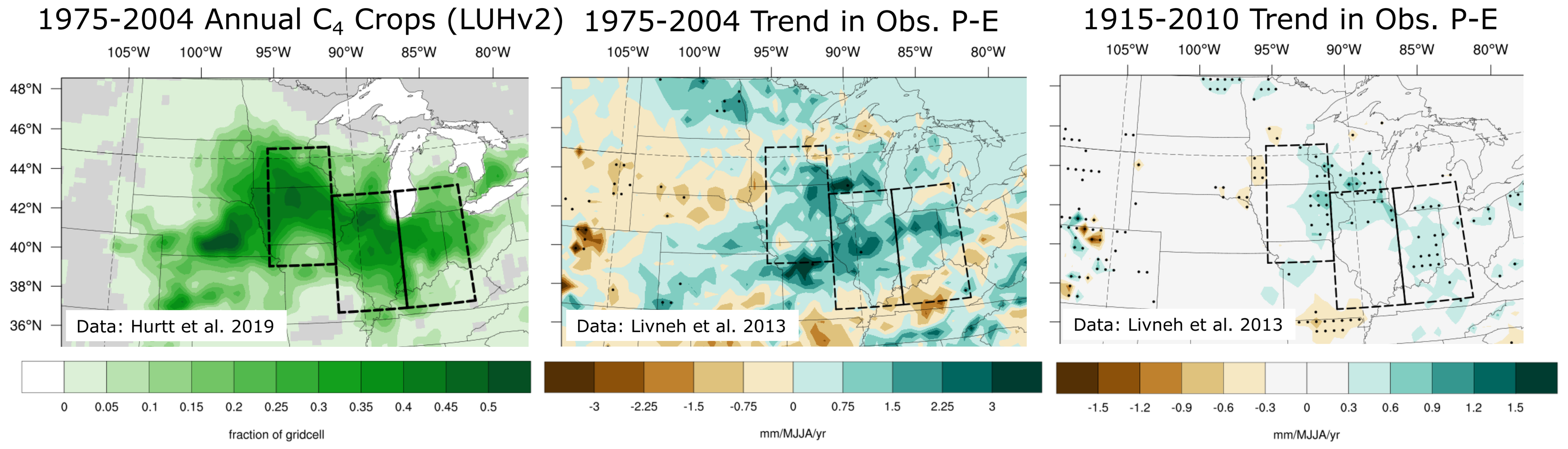
1. BACKGROUND

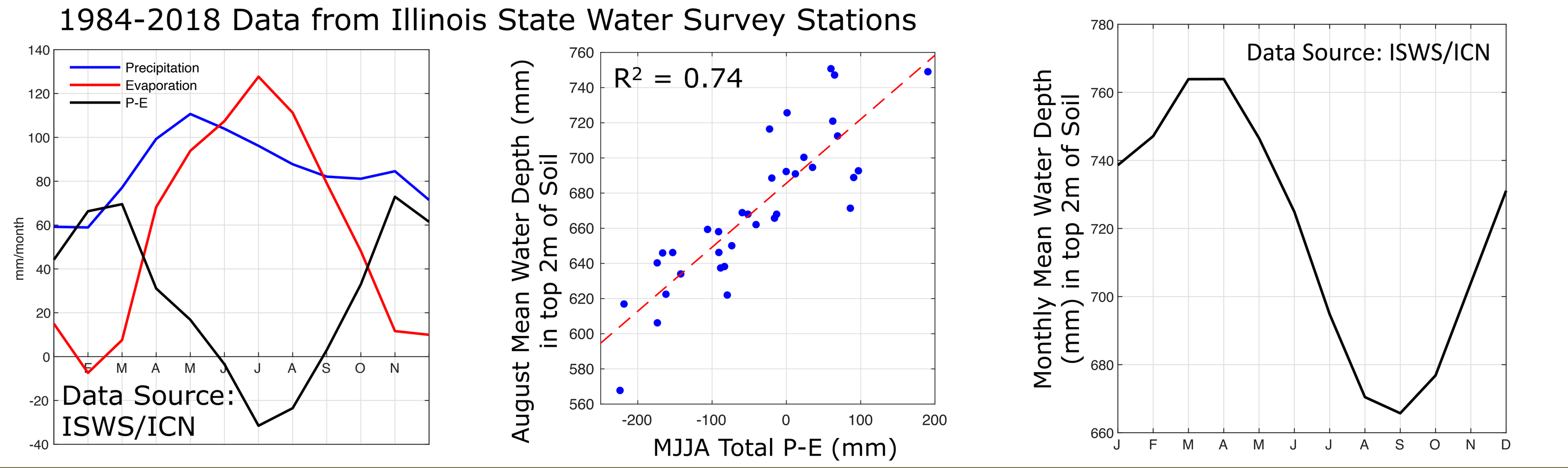
There has been a historical trend towards wetter conditions and increased Precipitation-Evapotranspiration (P-E) in the growing season in the Cornbelt – a high-yield and extensively drained agricultural area with domestic and international importance. **Precipitation increases have largely outpaced increases in evapotranspiration in this region in the 20th century**

1975-2004 Annual C_4 Crops (LUHv2) | 1975-2004 Trend in Obs. P-E | 1915-2010 Trend in Obs. P-E



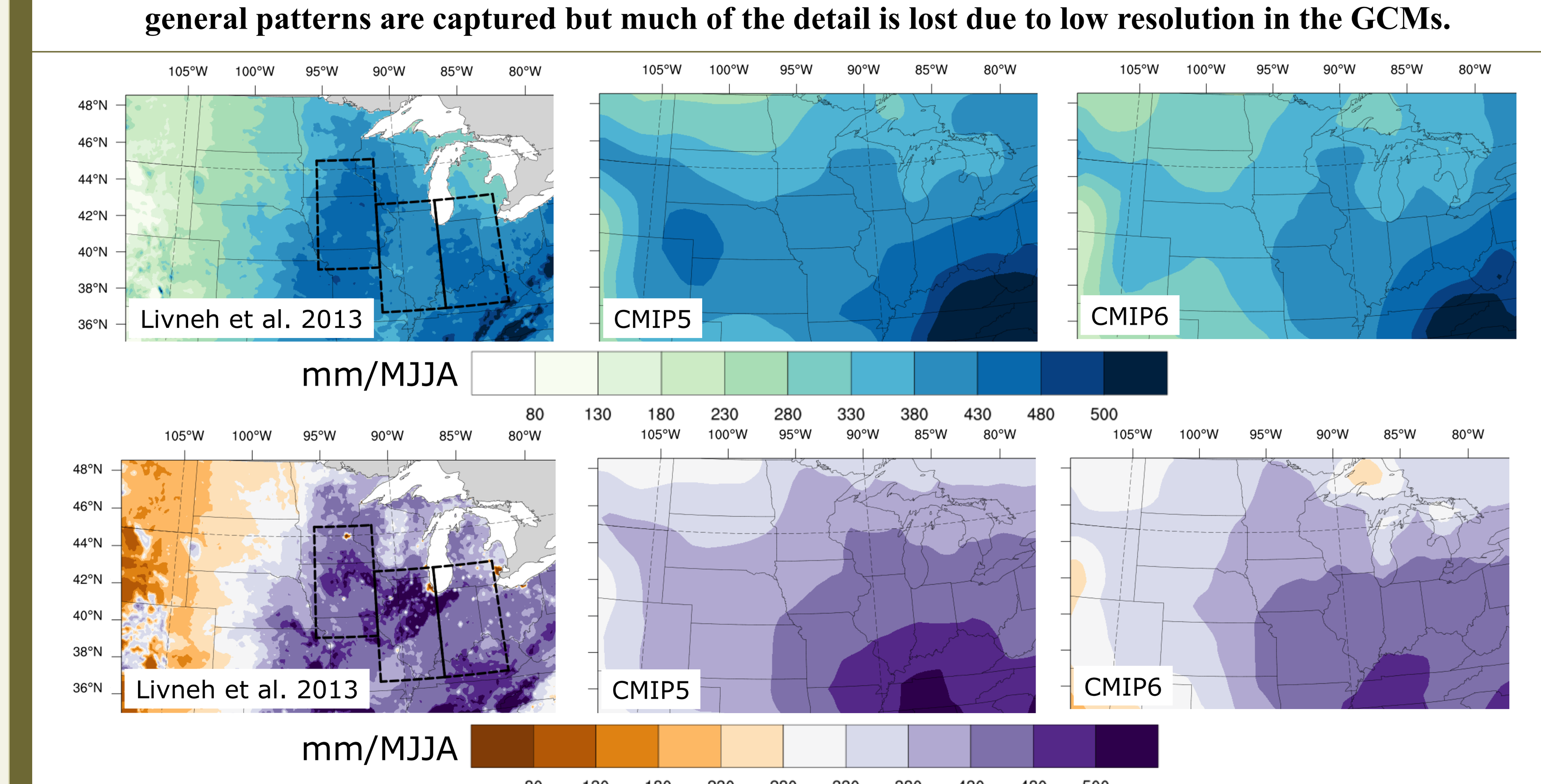
The balance of **P-E in the growing season (May-August) is generally negative** in this region, and soil moisture moves from a peak in March-April to a minimum in August-September. The timing of this minimum is crucial as **water deficits during the maturation of grain can heavily impact yield.**

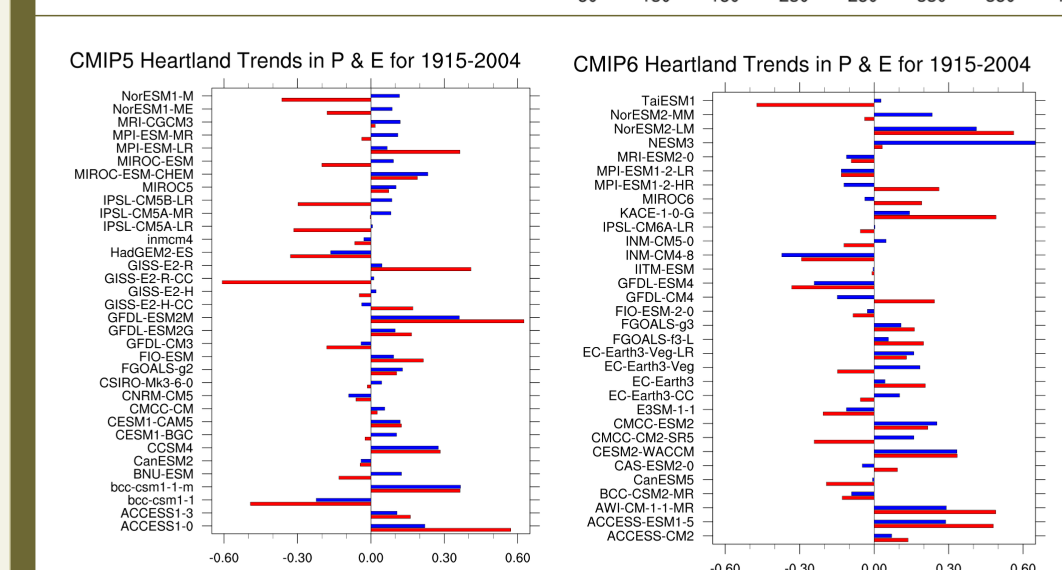
1984-2018 Data from Illinois State Water Survey Stations



2. DATA AND METHODS

This study uses **all available CMIP5 and CMIP6 global climate models (GCMs)** with P and E output for the **RCP8.5/SSP585 emissions scenario** to examine P, E, and P-E in the **historical period (1975-2004) and in the future (2070-2099)**. 1975-2004 May-August average patterns of P (top) and E (bottom) show that **general patterns are captured but much of the detail is lost due to low resolution in the GCMs.**





We are sacrificing the higher resolution of a regional climate model (RCM) simulation to capture the full range of risk projected in the global climate models. This is important because the GCMs show a wide range of precipitation and evapotranspiration trajectories even in the historical period over this region. This is in part due to incomplete representation of vegetation processes on water and energy balance components.

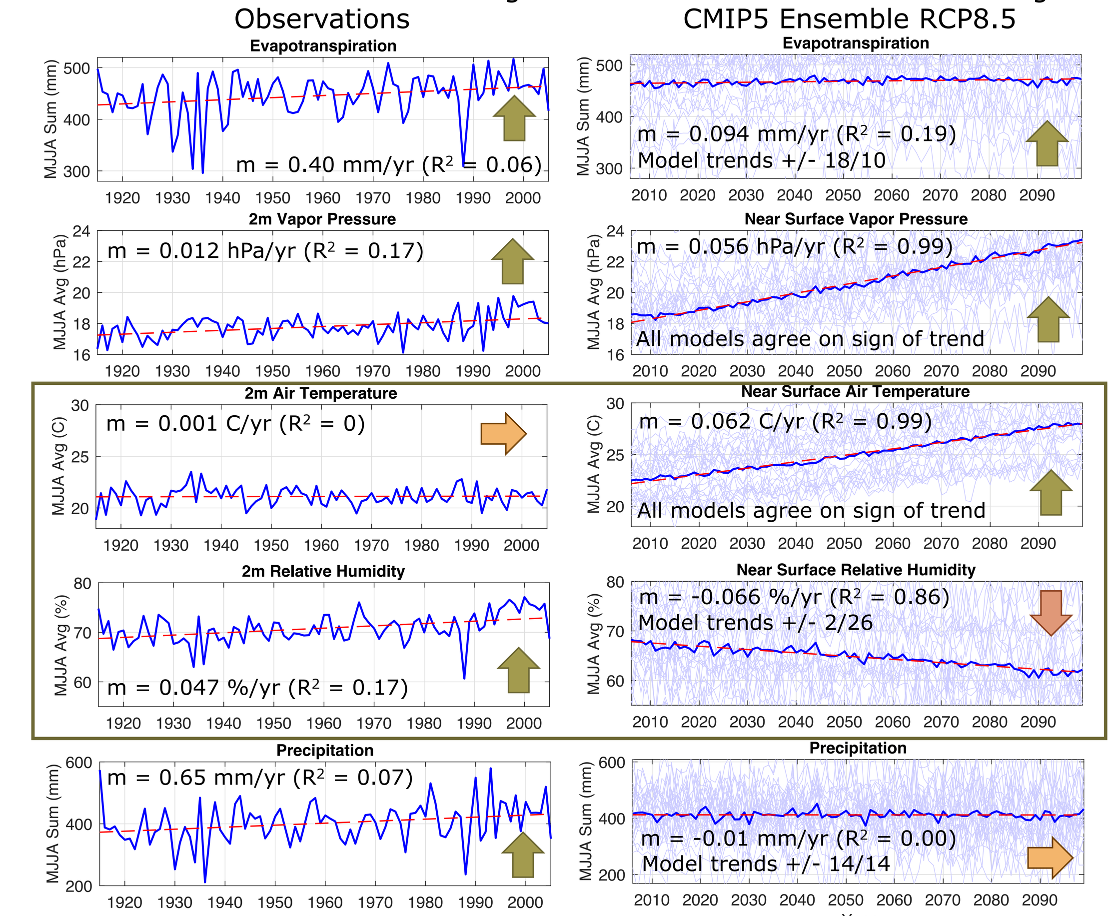
KEY RESEARCH QUESTION

How has the balance of summer **Precipitation-Evapotranspiration (P-E)** changed in the "Cornbelt" region in the past and how will it be impacted by future **climate change**?

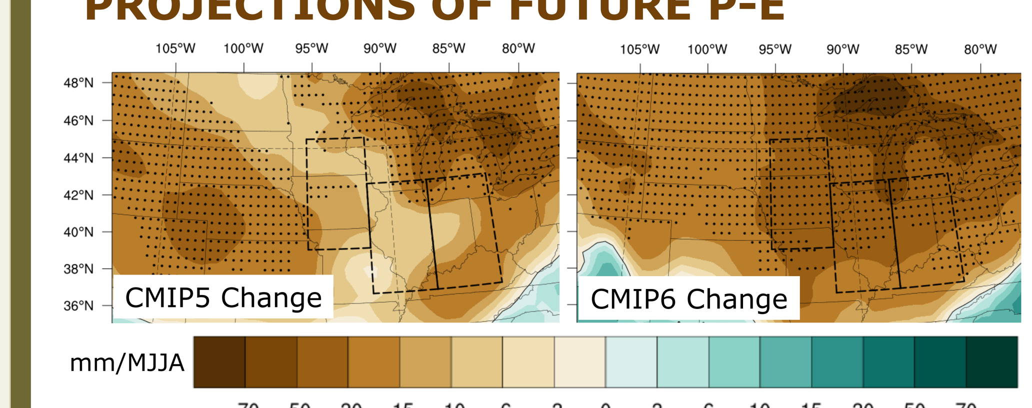
3. RESULTS

HISTORICAL VS. FUTURE TRENDS

- Trends driven by **agricultural changes** in the historical period (Nikiel and Eltahir, 2019) and by **climate change** in the future period.
- **Historically (1915-2005)**:
  - ET and vapor pressure increased, and temperature was stable
  - Relative humidity and precipitation increased.
- **In the Future (2006-2099 RCP8.5)**:
  - ET, vapor pressure, and temperature all increasing
  - Relative humidity decreasing and stable precipitation trend.

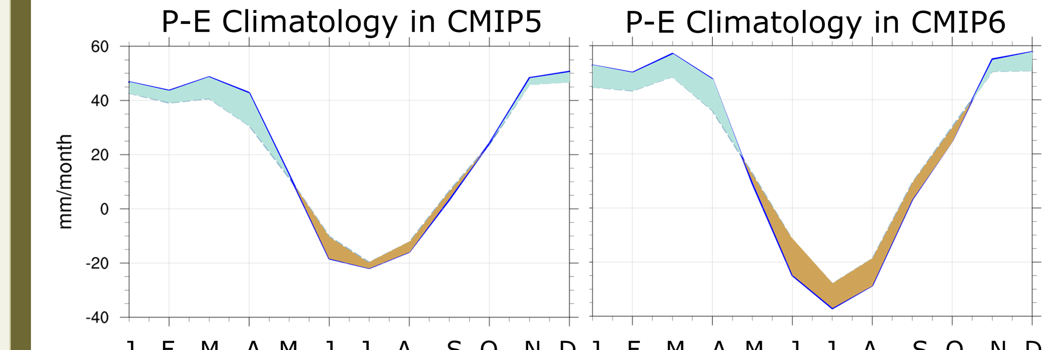


PROJECTIONS OF FUTURE P-E

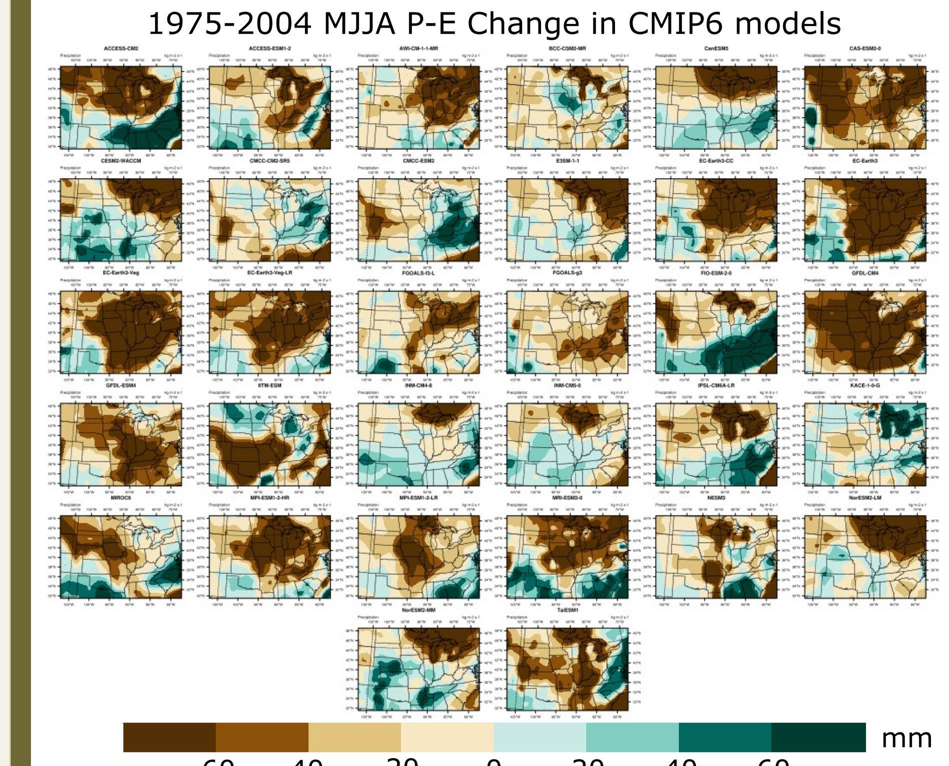


Stippling indicated 75% of models agree on the direction of change

P-E Climatology in CMIP5 | P-E Climatology in CMIP6

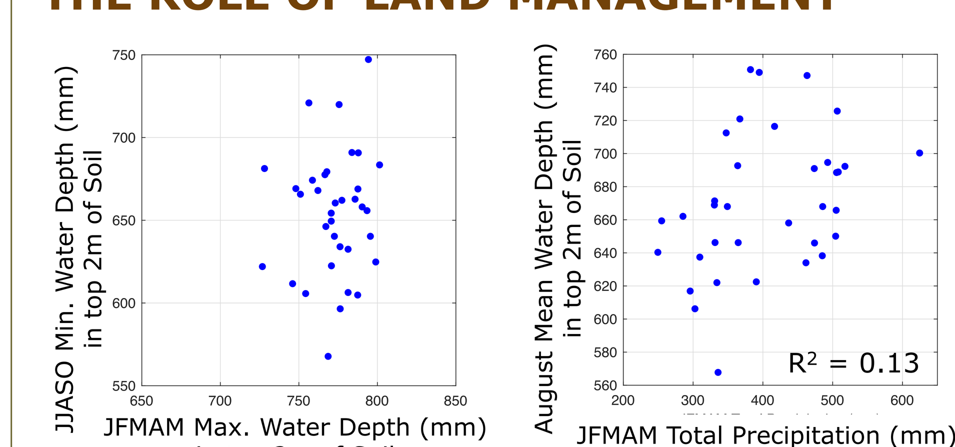


1975-2004 MJJA P-E Change in CMIP6 models



- Models project **widespread drying of P-E** in the future (change from 1975-2004 to 2070-2099) under RCP8.5, driven largely by **increases in ET**, especially in the north of the domain around the Great Lakes Region.
- There is **broad spread in individual models**, with some projecting **P-E wetting in some areas**.
- Area average drying of **12-36 mm depending on the model** is comparable to the wetting trend in the 20th century of 17 mm.
- Climate change will **intensify** the hydrologic cycle:
  - Increase in P-E in spring/winter
  - Decrease in P-E in summer/autumn.

THE ROLE OF LAND MANAGEMENT

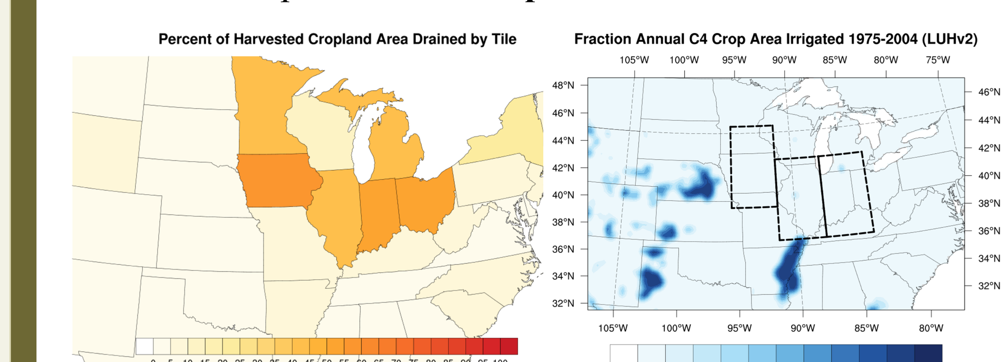


Tile drainage has strong influence on spring soil moisture

- Soil moisture data shows there is low correlation between spring precipitation and minimum summer soil moisture.
- The variability of peak spring soil moisture is about half of the summer soil minimum

4. CONCLUSIONS

- **Main Finding #1:** Historical wetting driven in part by agricultural development will yield to future drying driven by climate change.
- **Main Finding #2**: There is wide-spread in the model projected changes in precipitation and evapotranspiration, with **some models projecting P-E increases** in the region of interest.
- **Main Finding #3:** The historical wetting of the region means that future **drying will not necessarily bring the region to an unprecedented climate state**, however, drying will be **unprecedented in the context of the agricultural production** that has developed over the course of the 20th century.
- **Main Finding #4:** Drying in the context of **current drainage networks and supplementary irrigation** leaves ample room for **adaptation**.



5. FUTURE WORK

- Investigate the **influence of varying coupled model LSMs** on the results and use this comparison to choose a **more targeted subset of models**, for instance only those that **capture historical trends accurately**.
- Investigate **the spatial heterogeneity of soil moisture** responses to P-E trends.
- Investigate the **influence of the Great Lakes on evapotranspiration** in the historical and future period.

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7. ACKNOWLEDGEMENTS

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