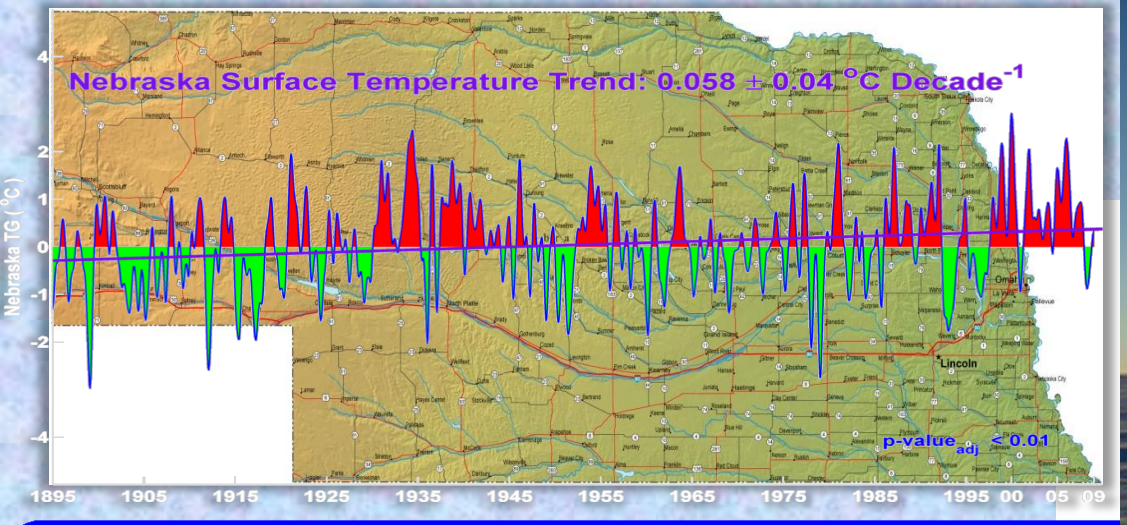

Impact of change in climate variables on agricultural productivity and water resources: Quantitative analyses

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University of Nebraska-Lincoln
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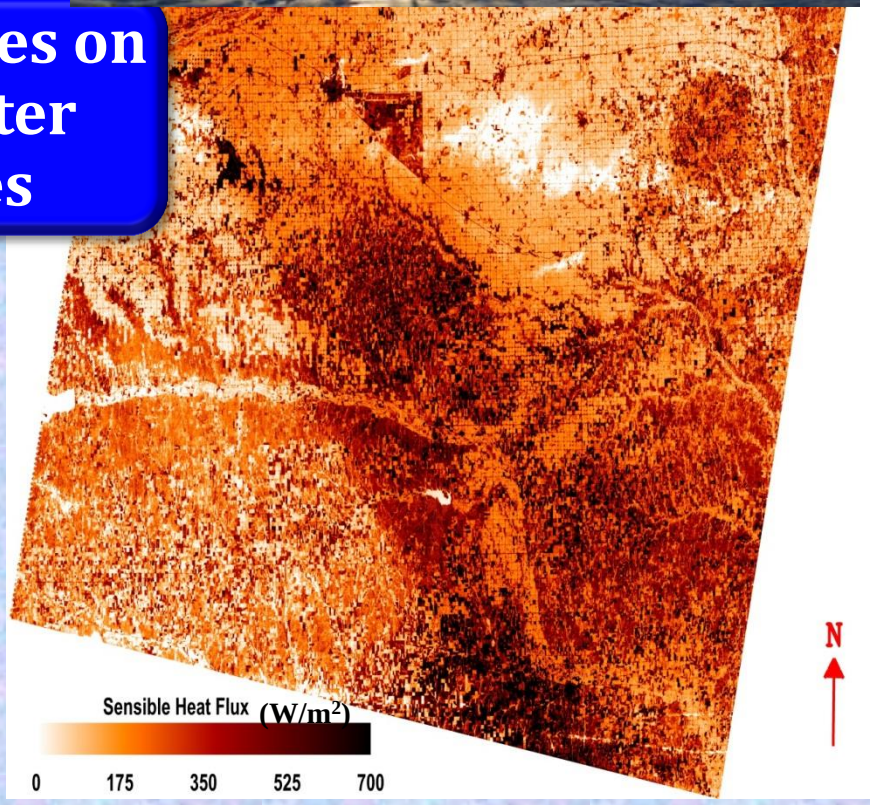
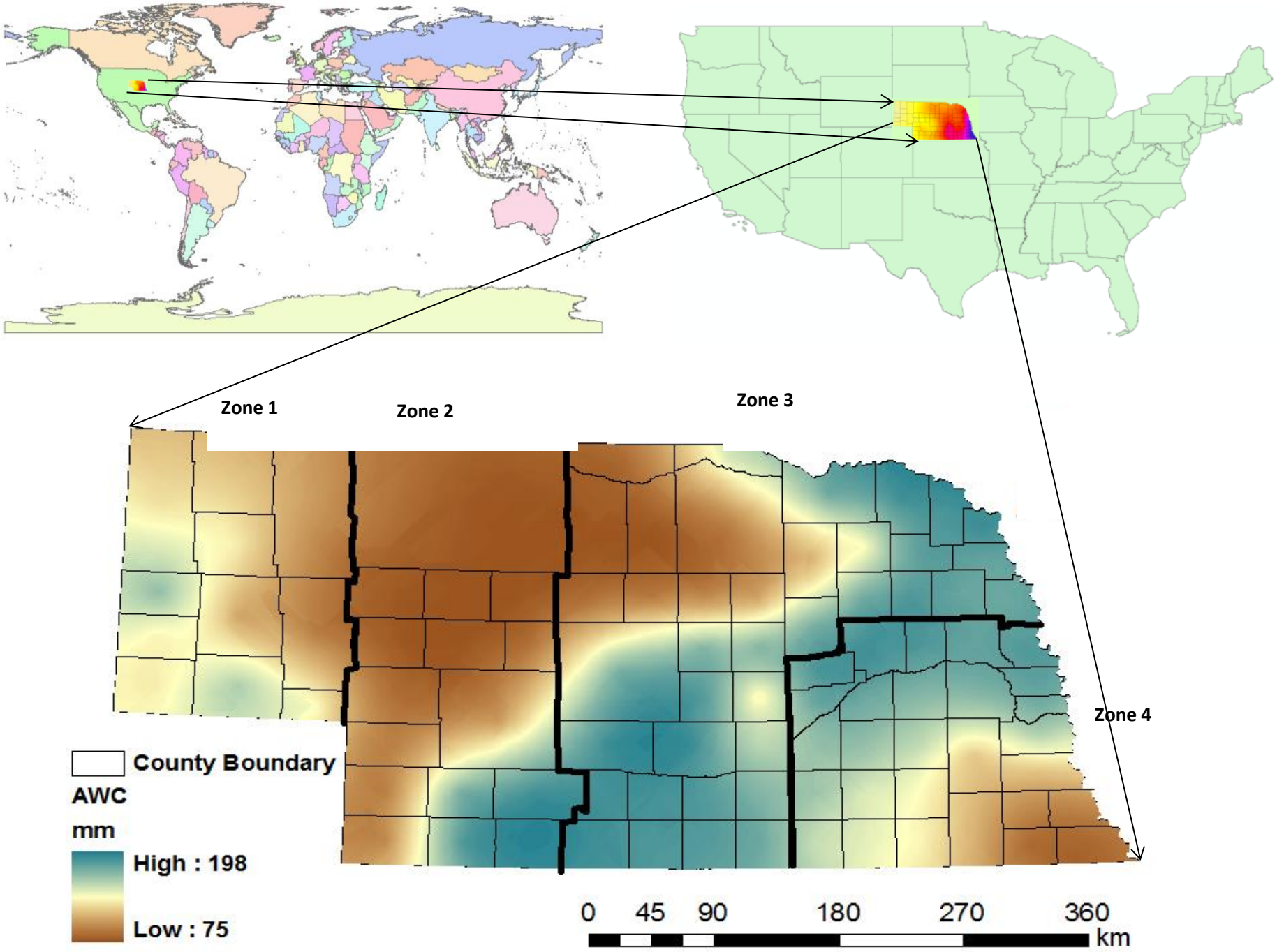
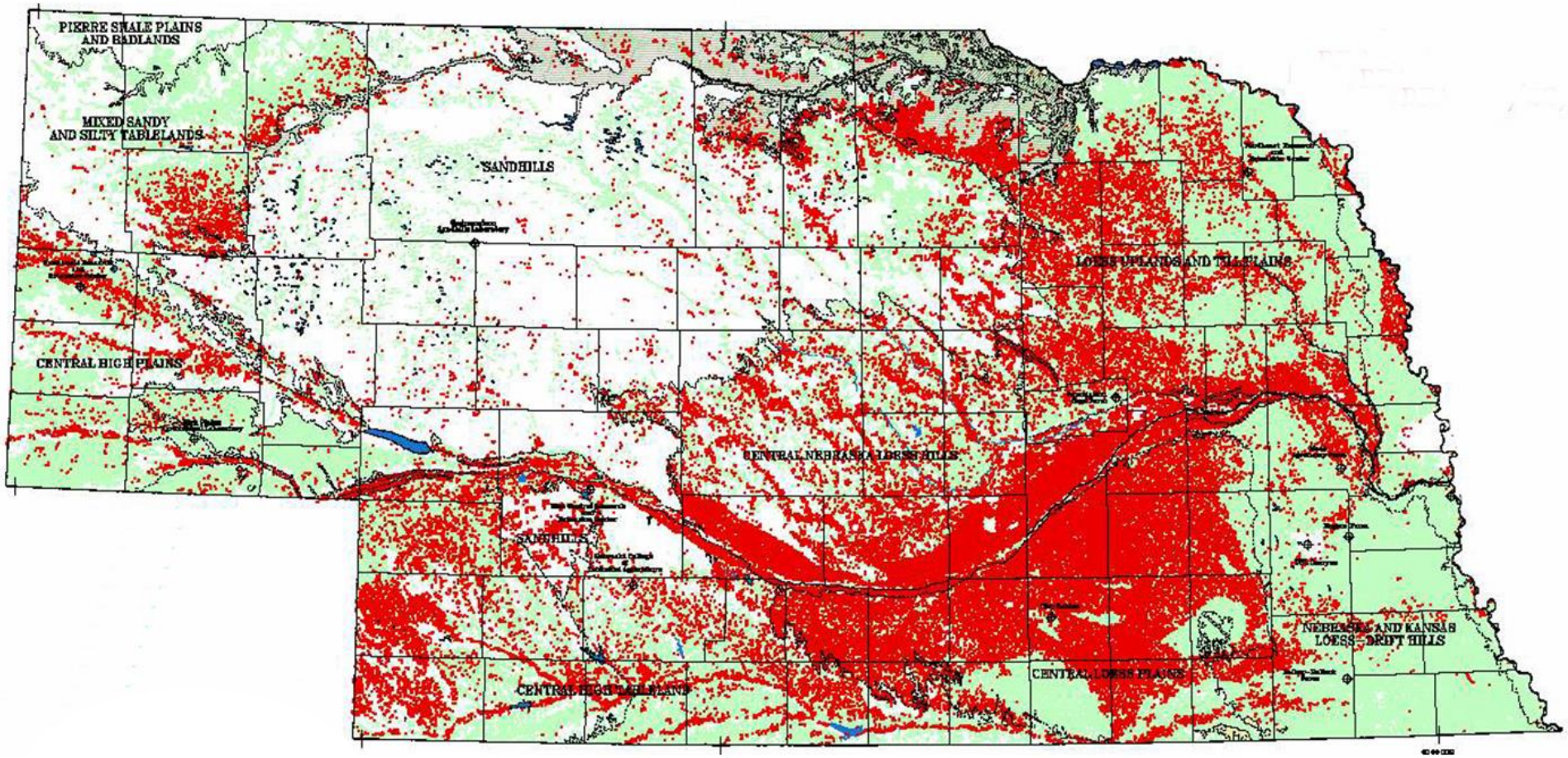
Lincoln, NE U.S.A.




Zone 1
Zone 2
Zone 3
Zone 4
County Boundary
AWC
mm
High : 198
Low : 75
0 45 90 180 270 360
km

More than 115,000 active irrigation wells create challenges for agricultural water management

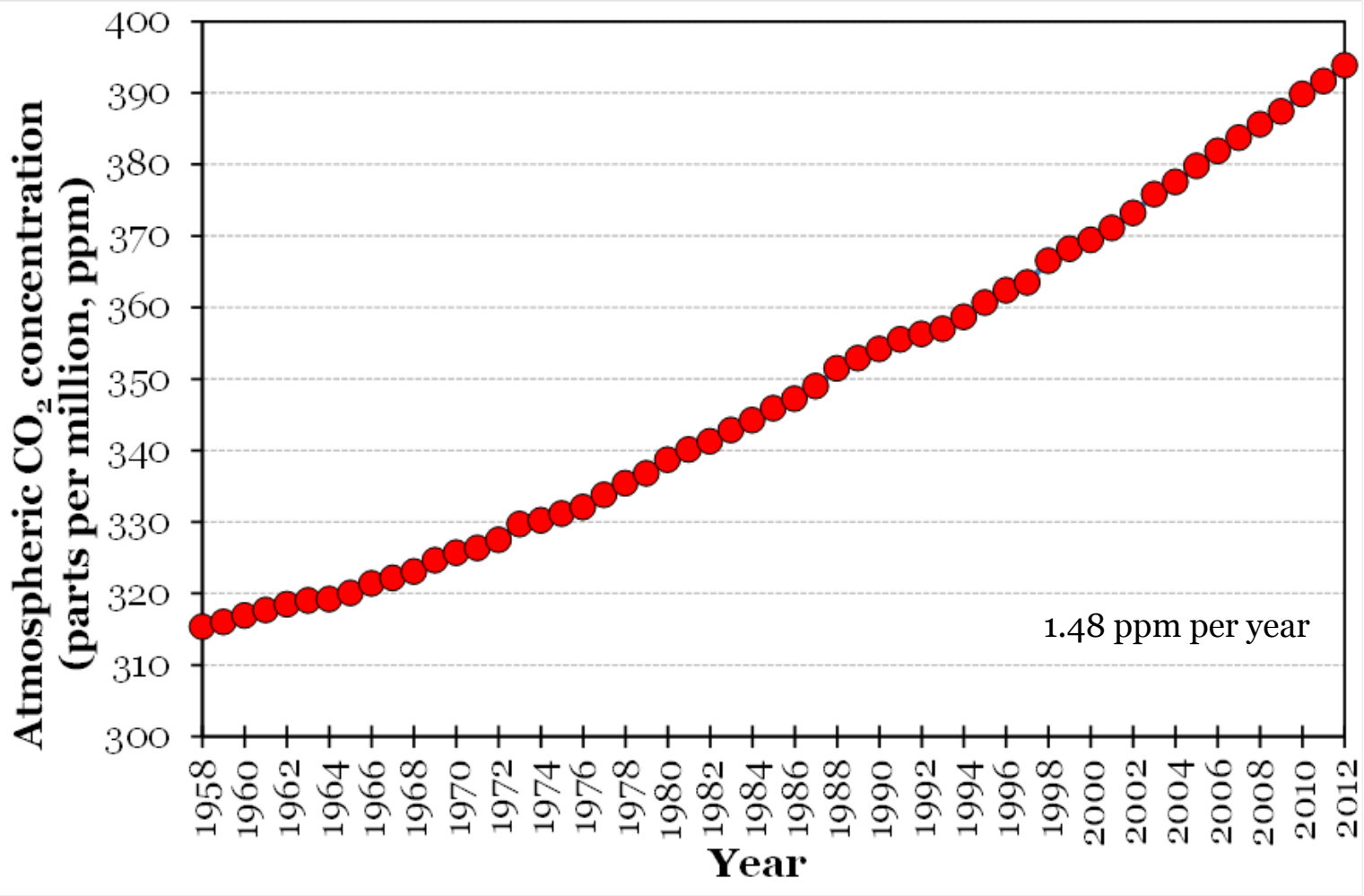


Irrigation wells

Global temperature trends

- ***Whether it is man-made or due to natural cycles, the climate is changing…!***
- **Global average surface temperature increased by 0.74 ± 0.18° C from 1906 to 2005, a large portion of which occurred at a rate of 0.13 ± 0.03° C per decade during the latter half of the century (IPCC, 2012).**
- **Global surface temperature is expected to continue to increase by 0.4° C by 2025.**
- **Irmak et al. (2012) observed increases of 3.8° C and 1.9° C in daily minimum and average air temperature, respectively, from 1893 to 2012 at Central City in central Nebraska.**
- **Skaggs and Irmak (2013) observed that growing season length is getting up to 17 days! Longer and early spring and late fall frost-free days are exhibiting significant changes.**

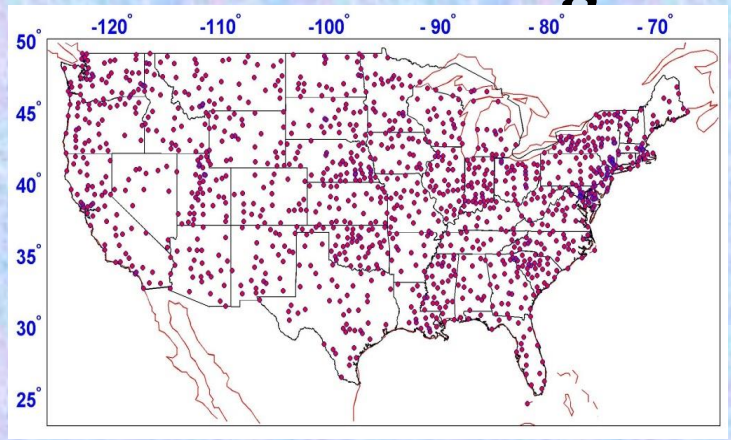
Global CO_2 concentration trends



The atmospheric CO_2 concentration (CO_2 mole fractions) measured at Mauna Loa, Hawaii (a location where atmospheric contamination from greenhouse gas emissions is minimal) has increased from 315.71 parts per million (ppm) in March 1958 to 394.28 ppm in December 2012 (20% increase)!

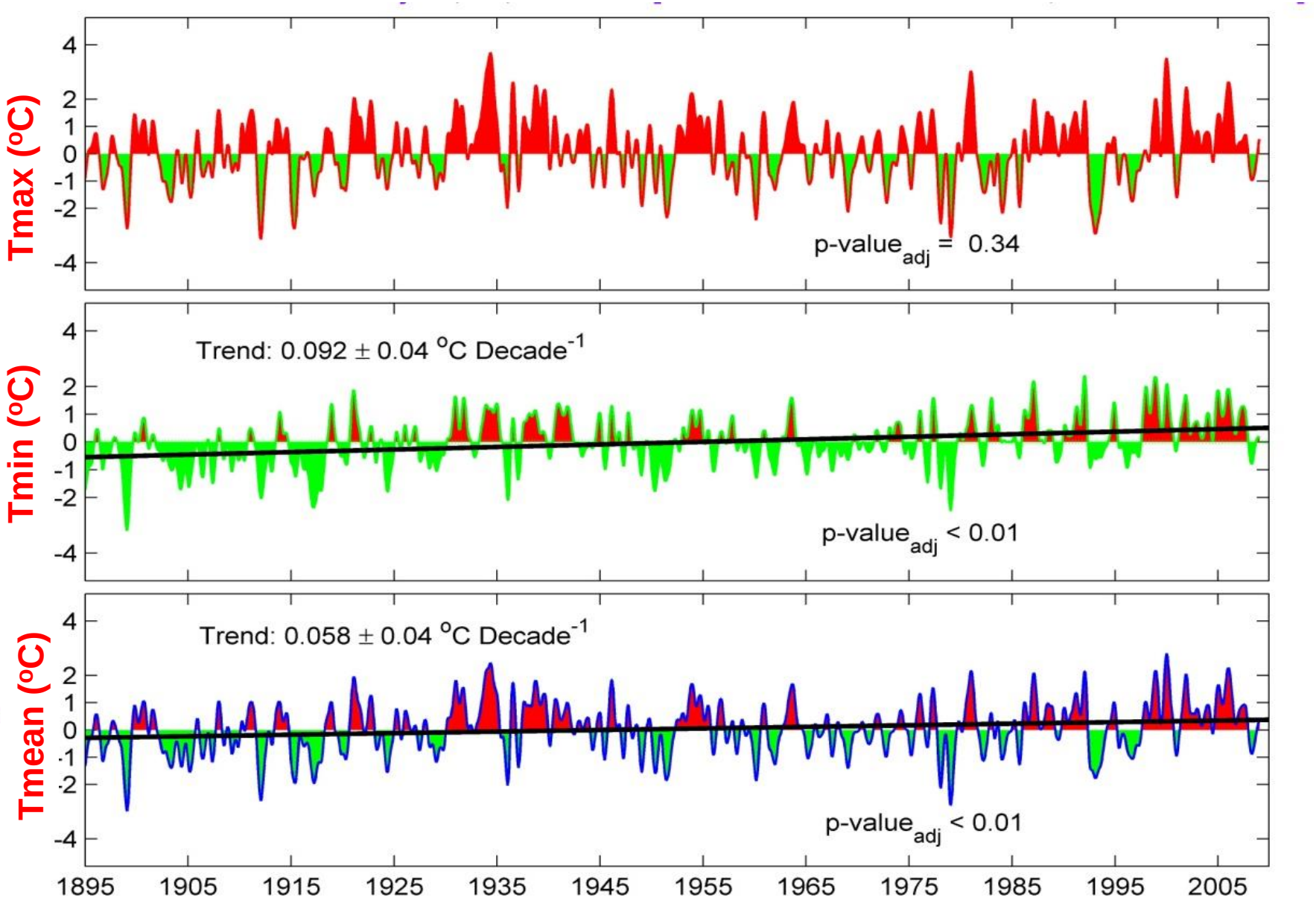
Climate change challenges in terms of agricultural productivity

- One of the biggest challenges is the ***spatial and temporal variability*** in changes in climate variables!
- Increase in temperature, CO_2, and changes in other variables are having direct impact on agricultural productivity, ***especially in terms of increasing pressure on freshwater resources for irrigation.***
- Keeping up with the population growth in terms of agricultural productivity adds more complications.
- Lack of good quality historical datasets and scientific research to quantify the impact of climate change on agricultural productivity!

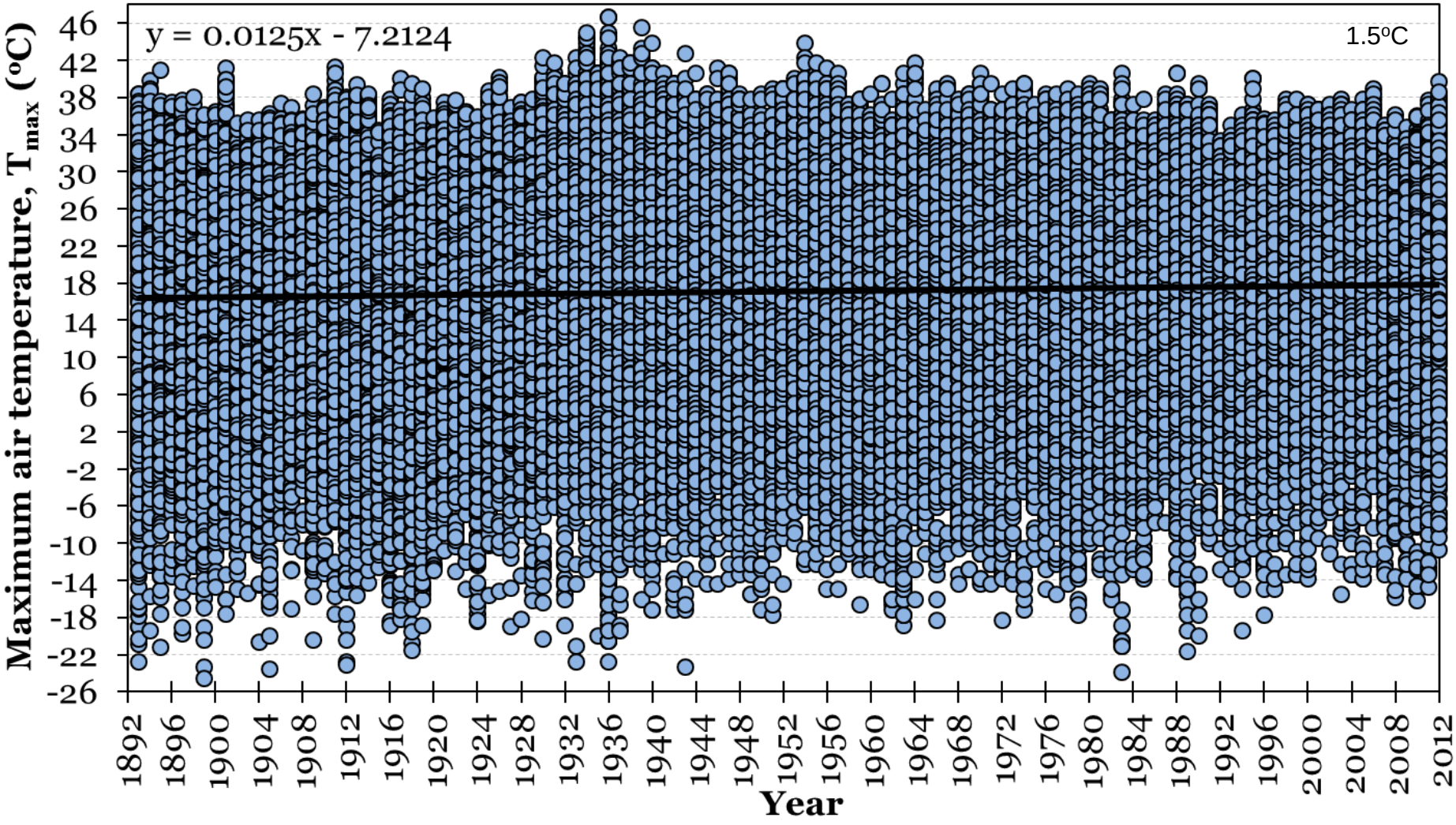


Extreme events are increasing: wet is getting wetter and dry is getting drier!

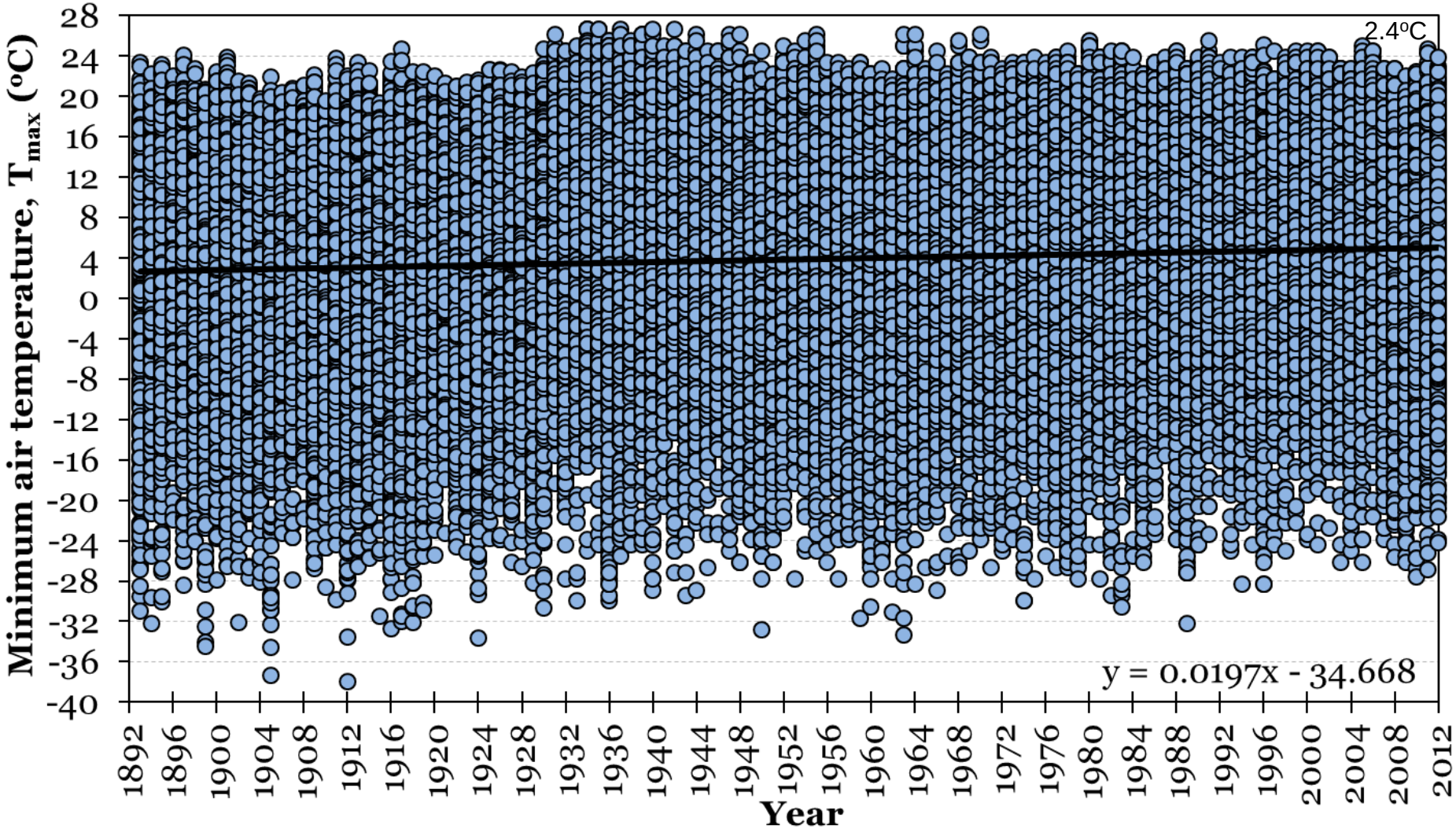
Climate Trends in Nebraska [1892 to 2012]



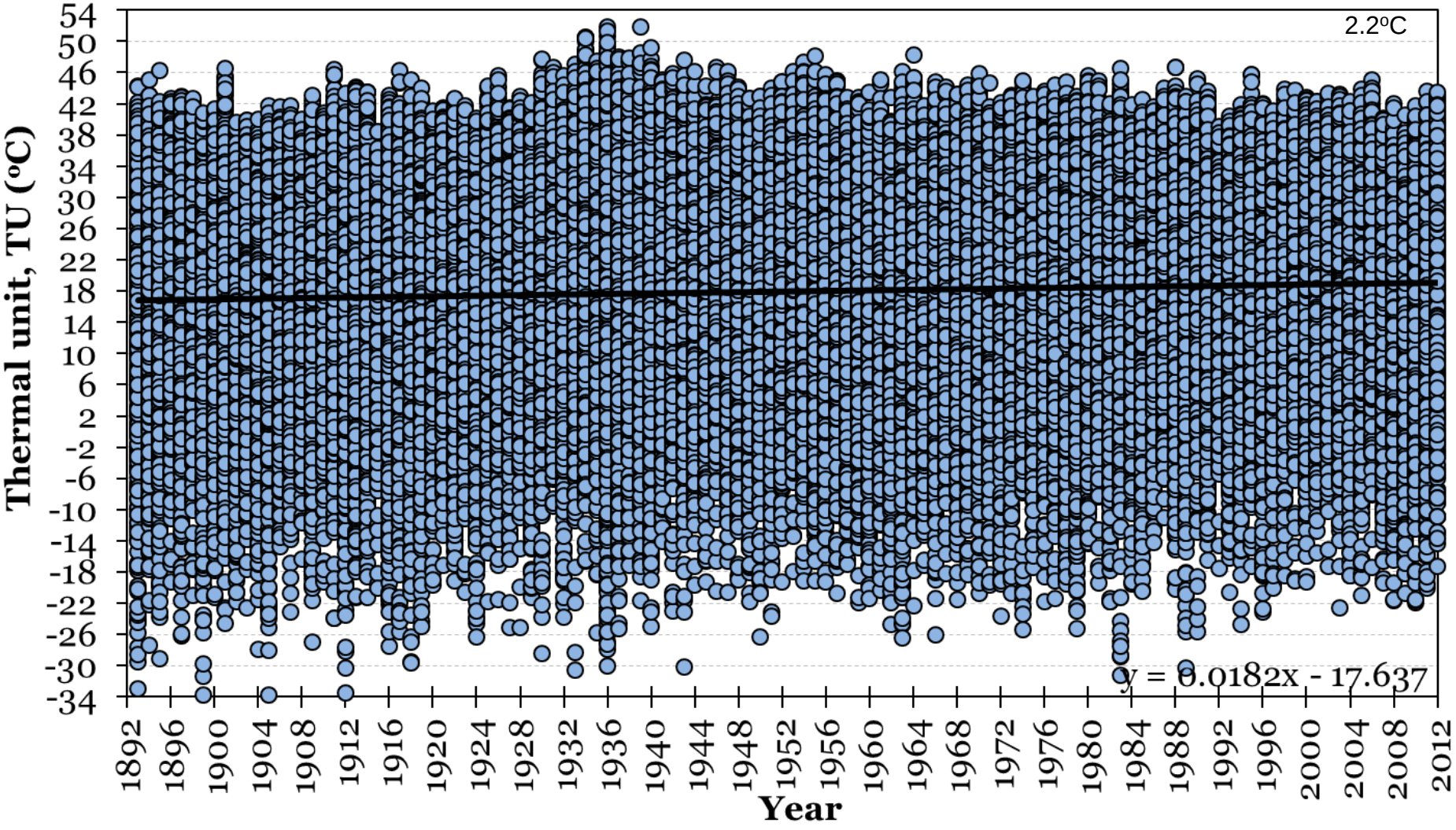
Climate Trends in Nebraska [1892 to 2012]



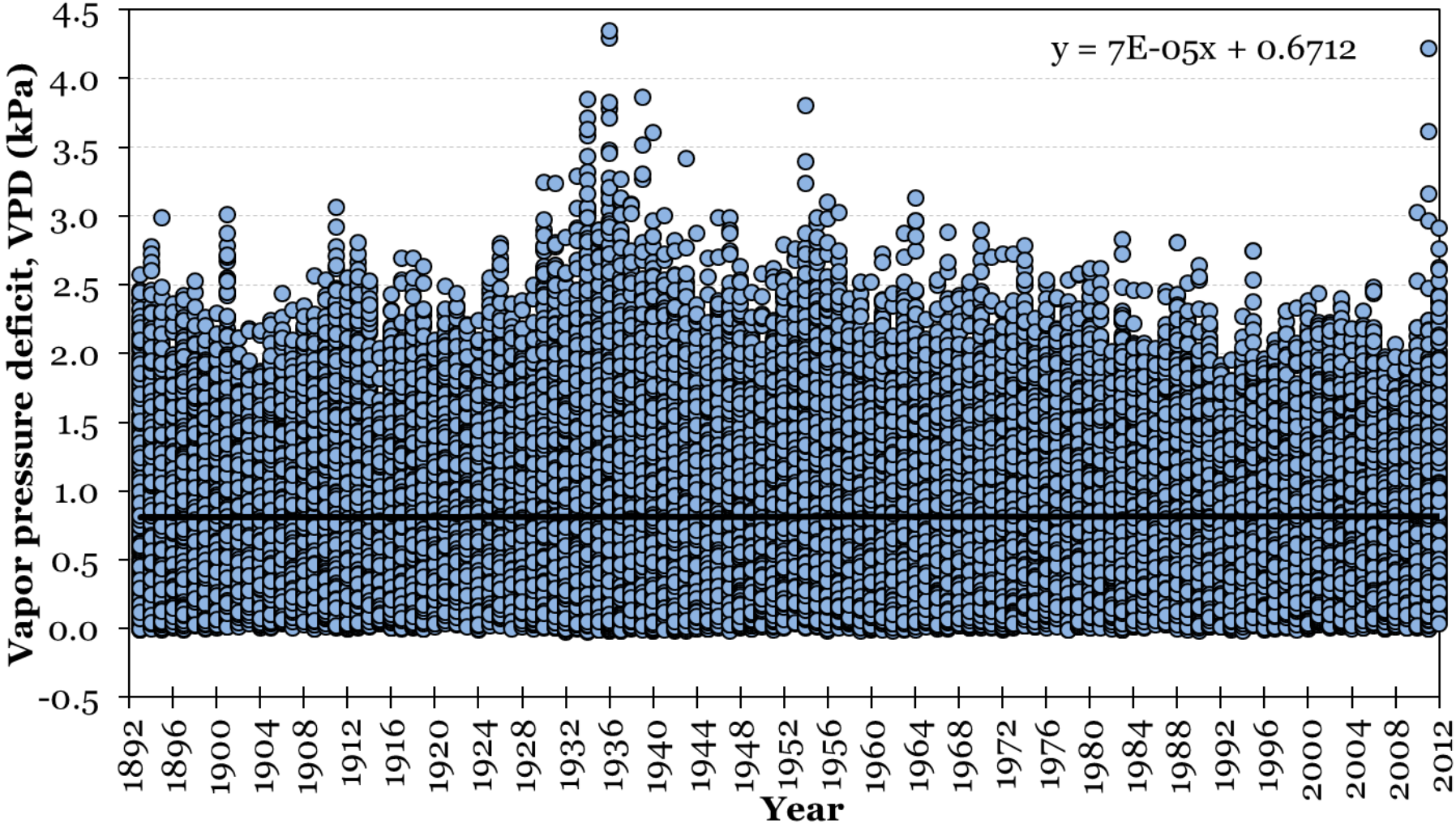
Climate Trends in Nebraska [1892 to 2012]



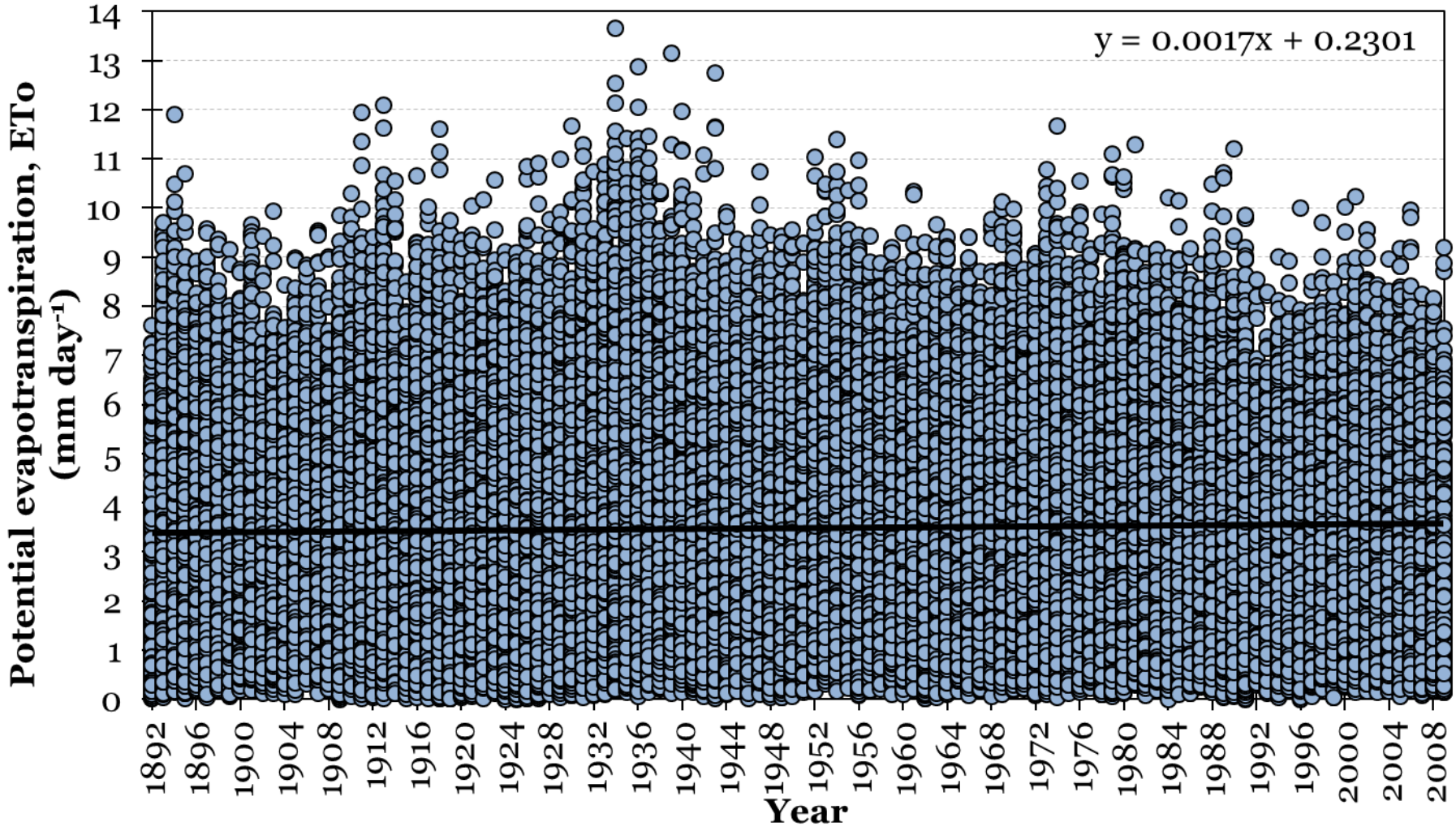
Climate Trends in Nebraska [1892 to 2012]



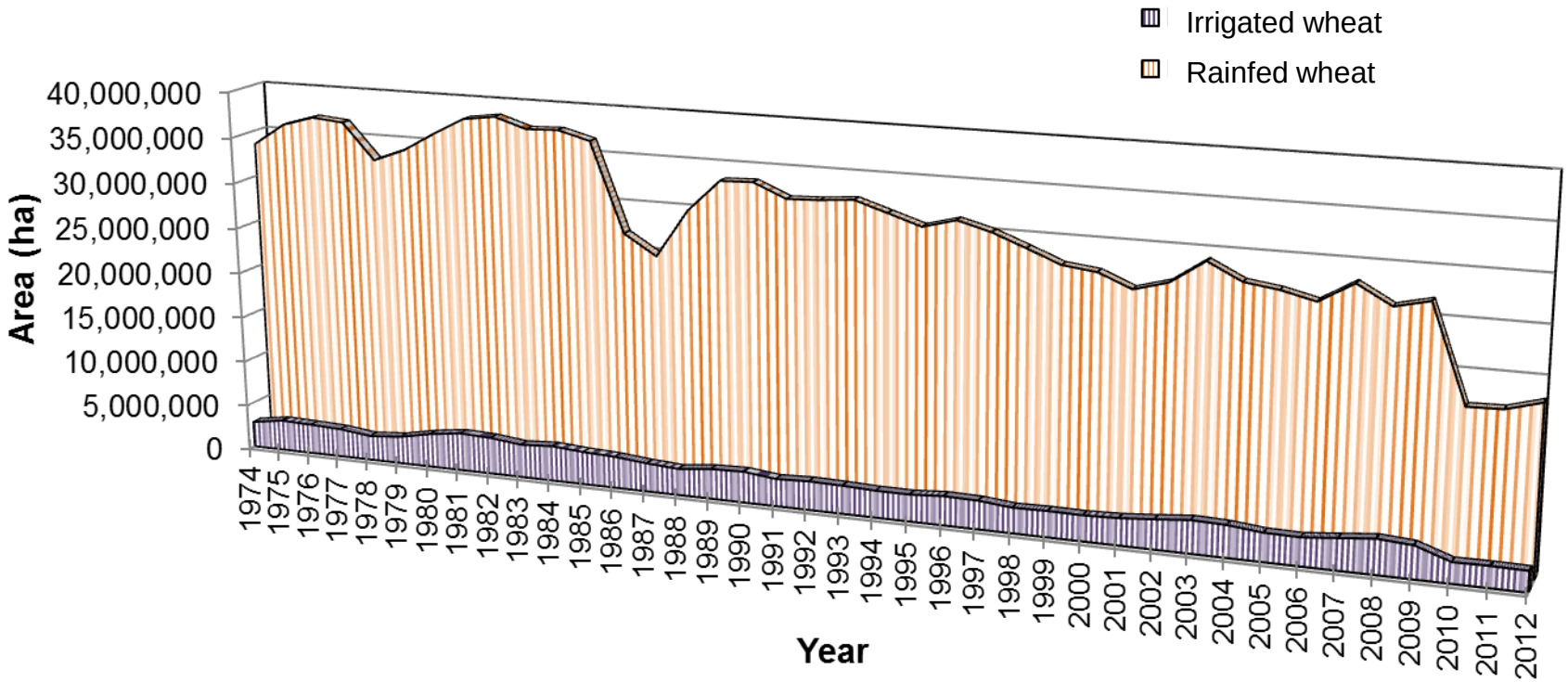
Climate Trends in Nebraska [1892 to 2012]



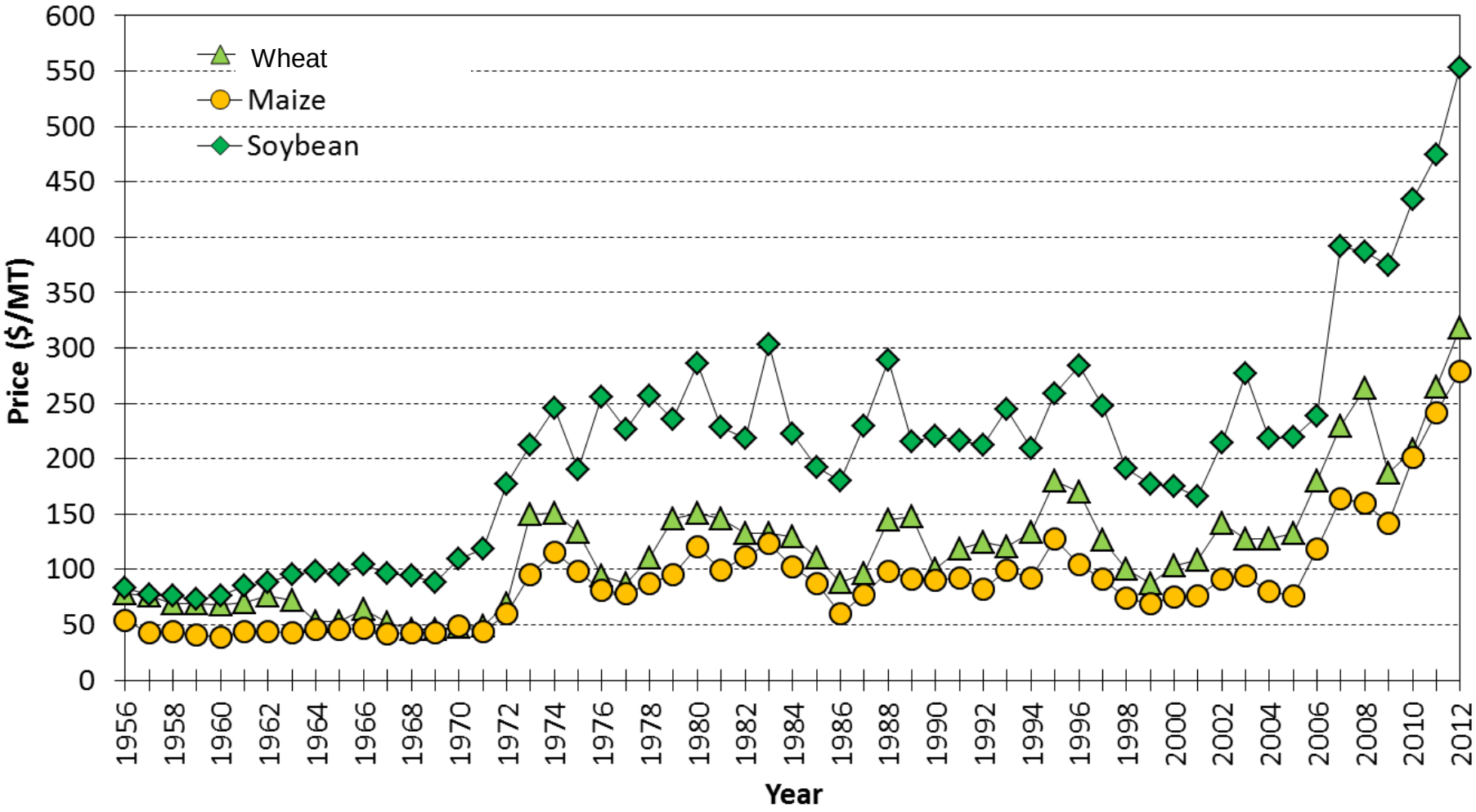
Climate Trends in Nebraska [1892 to 2012]



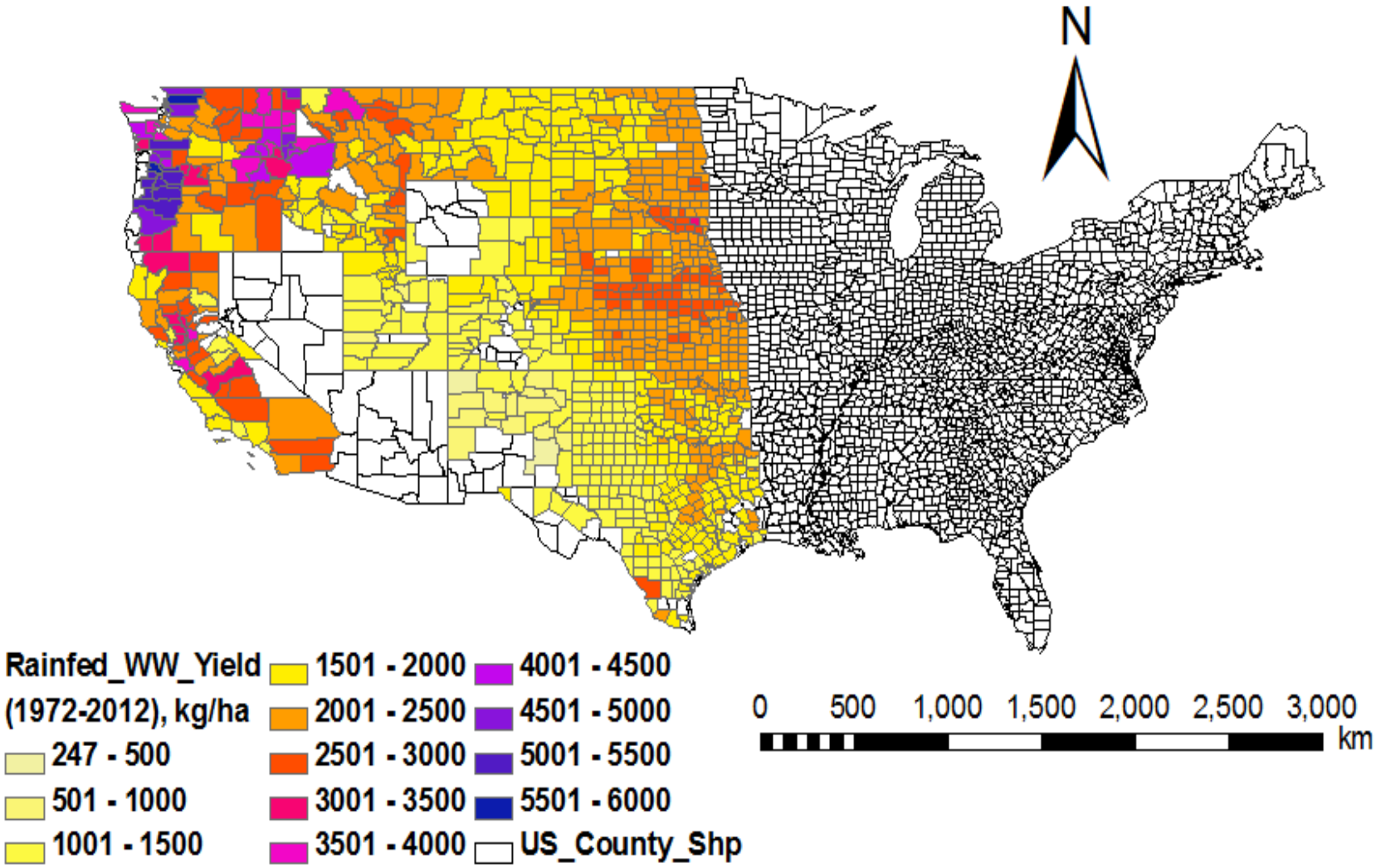
So, how is climate change impacting agricultural productivity?: Example for wheat



Planted area for irrigated and rainfed wheat from 1974 to 2012 across the U.S.A.

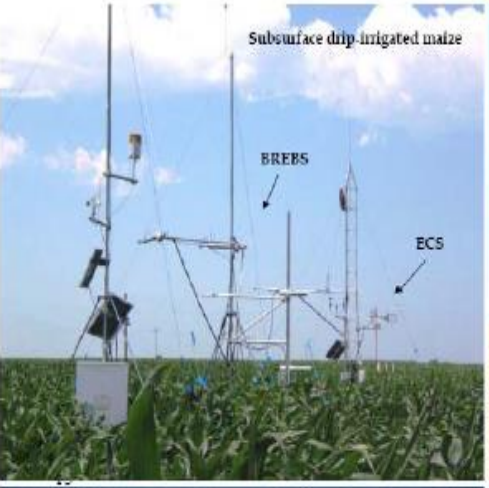


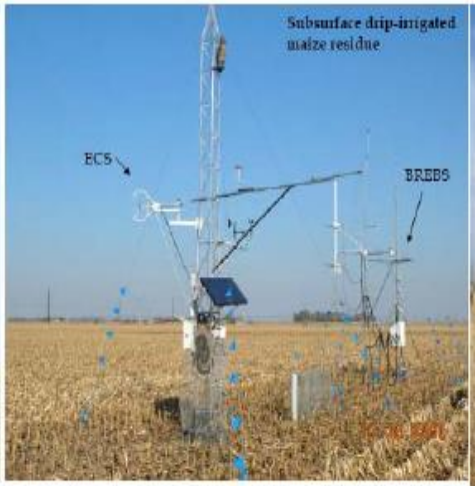
Long-term changes in price ($) of soybean, maize and wheat per metric ton.



Spatial Distribution of Rainfed wheat yields in kg/ha from 1972-2012 across United States.

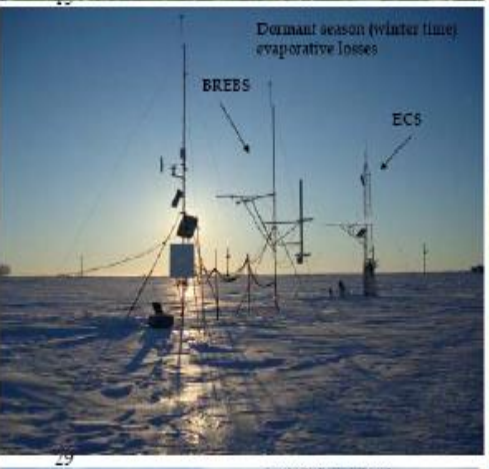

• 1.5 cm
• 20 cm
• 90 kg/ha


Subsurface drip-irrigated maize
BREBS
ECS


Subsurface drip-irrigated maize residue
ECS
BREBS


Phragmites-dominated cottonwood and willow plant community in the Platte River channel


Subsurface drip-irrigated soybeans


Dormant season (winter time) evaporative losses
BREBS
ECS


Center pivot-irrigated grassland


Subsurface drip-irrigated soybean residue


Irrigated winter wheat


Rainfed grassland


Rainfed winter wheat
BREBS


Irrigated alfalfa


Center pivot-irrigated no-till soybean
BREBS

Rainfed Switchgrass

Irrigated seed corn/cover crop rotation

Dormant season evaporative losses and water and energy balance

Irmak, 01/28/2008

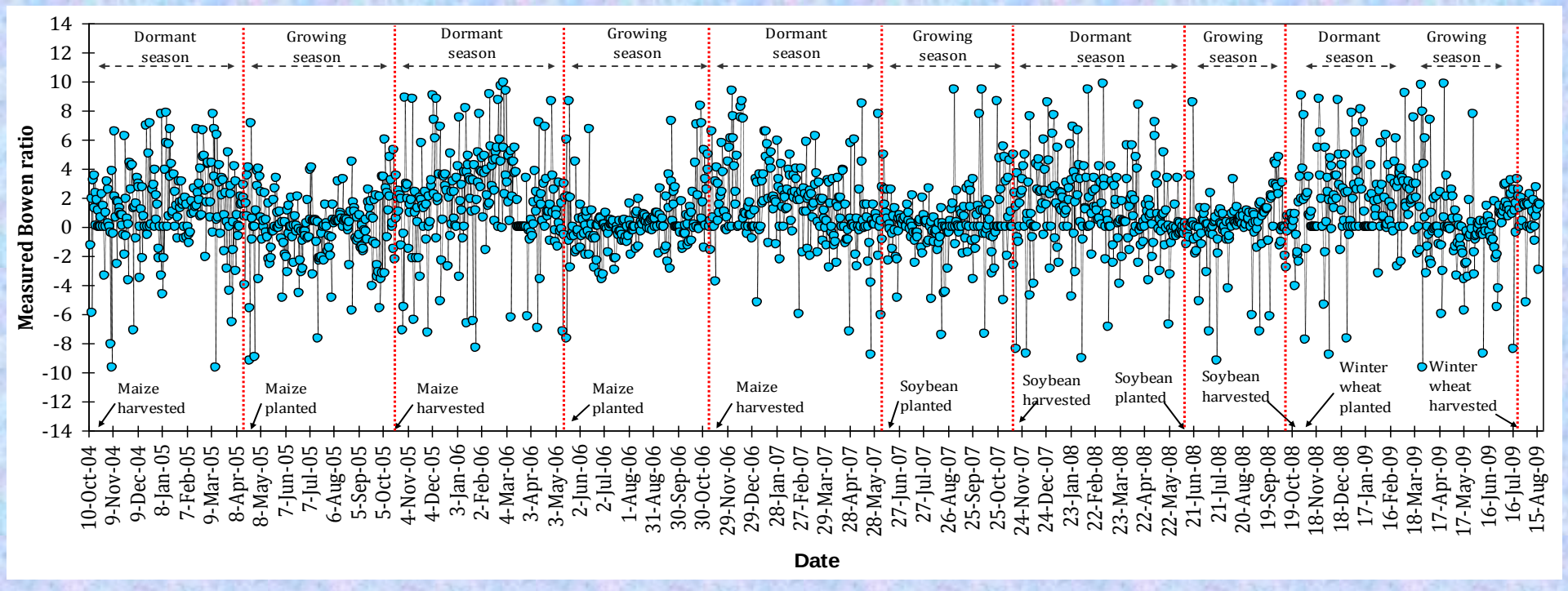
Disk-tilled field - Holdrege

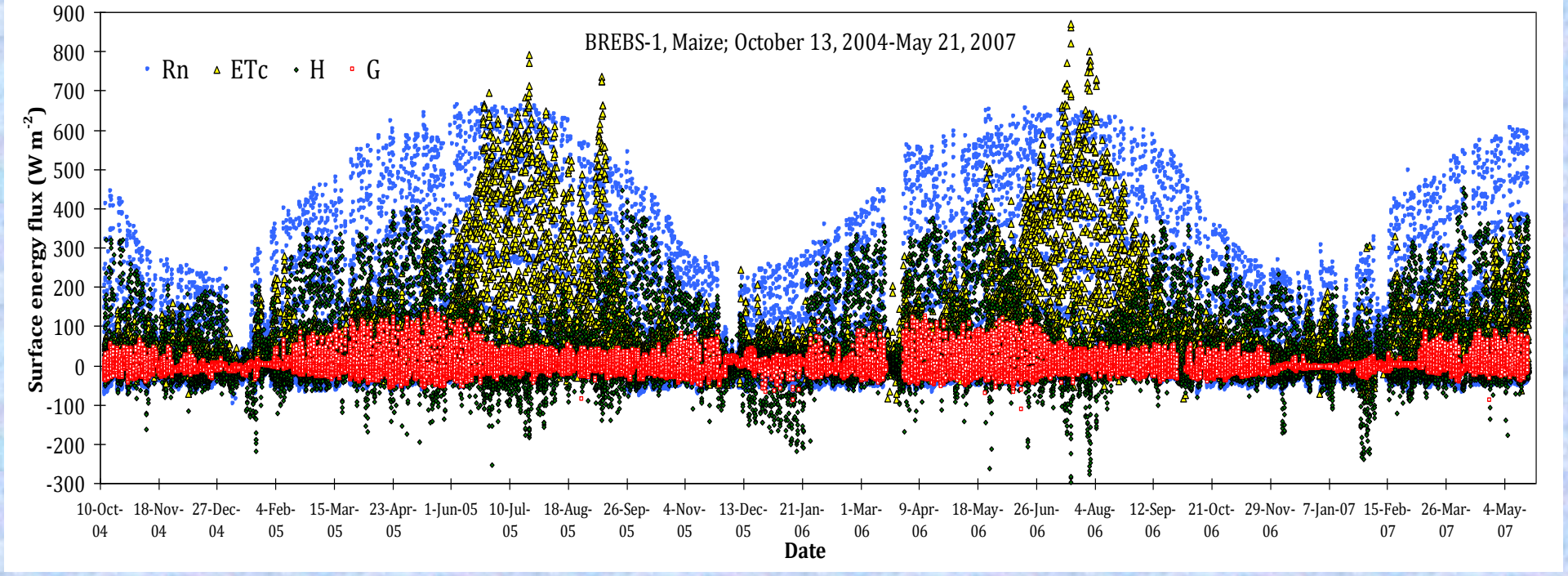
No-till field - Holdrege

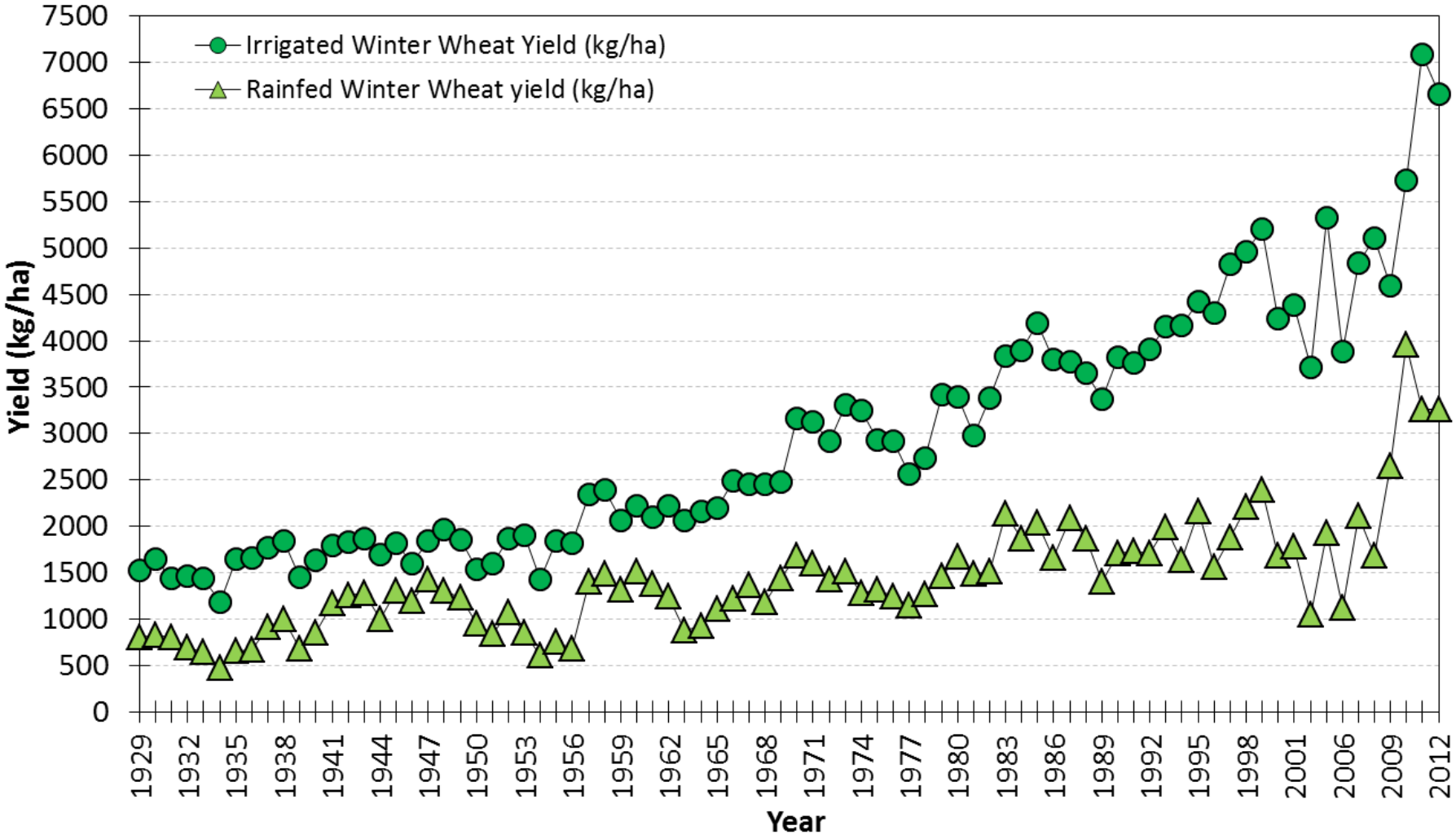
No-till field - Holdrege


No-till field - Holdrege

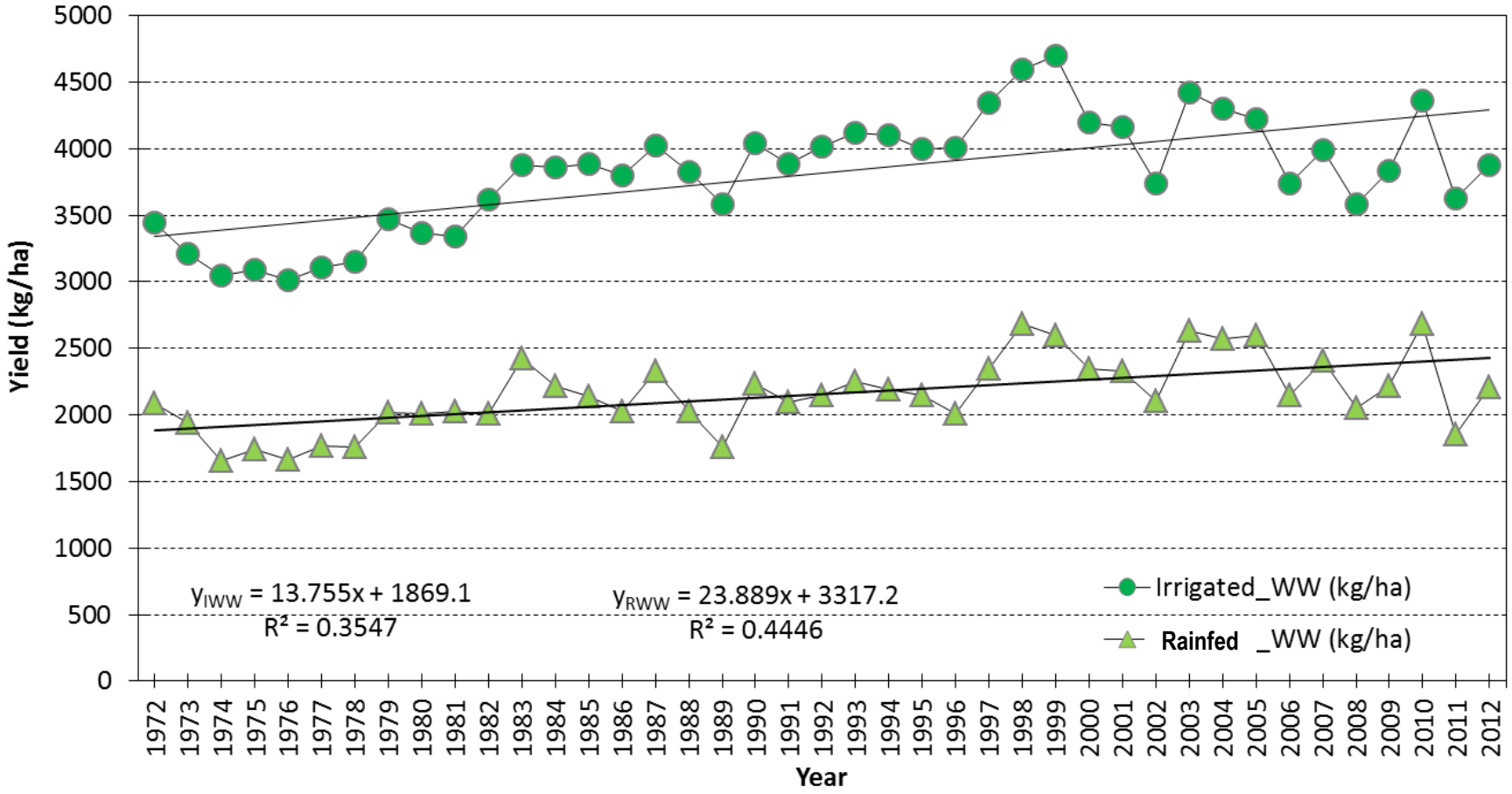

No-till


Measured Bowen ratio
Dormant season
Growing season
Maize harvested
Maize planted
Soybean planted
Soybean harvested
Winter wheat planted
Winter wheat harvested
Date

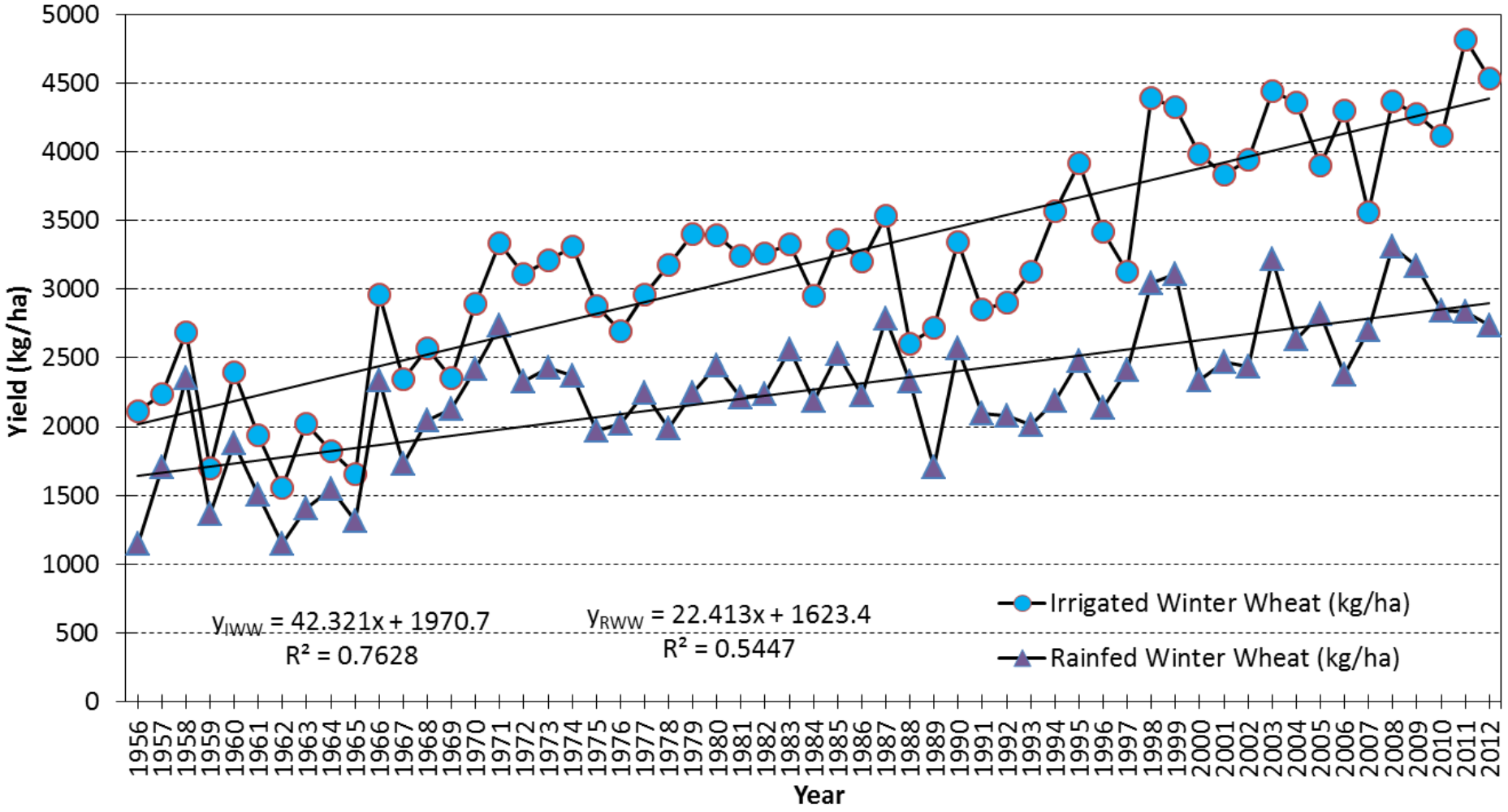

BREBS-1, Maize; October 13, 2004-May 21, 2007
Rn
ETc
H
G
Surface energy flux (W m-2)
Date



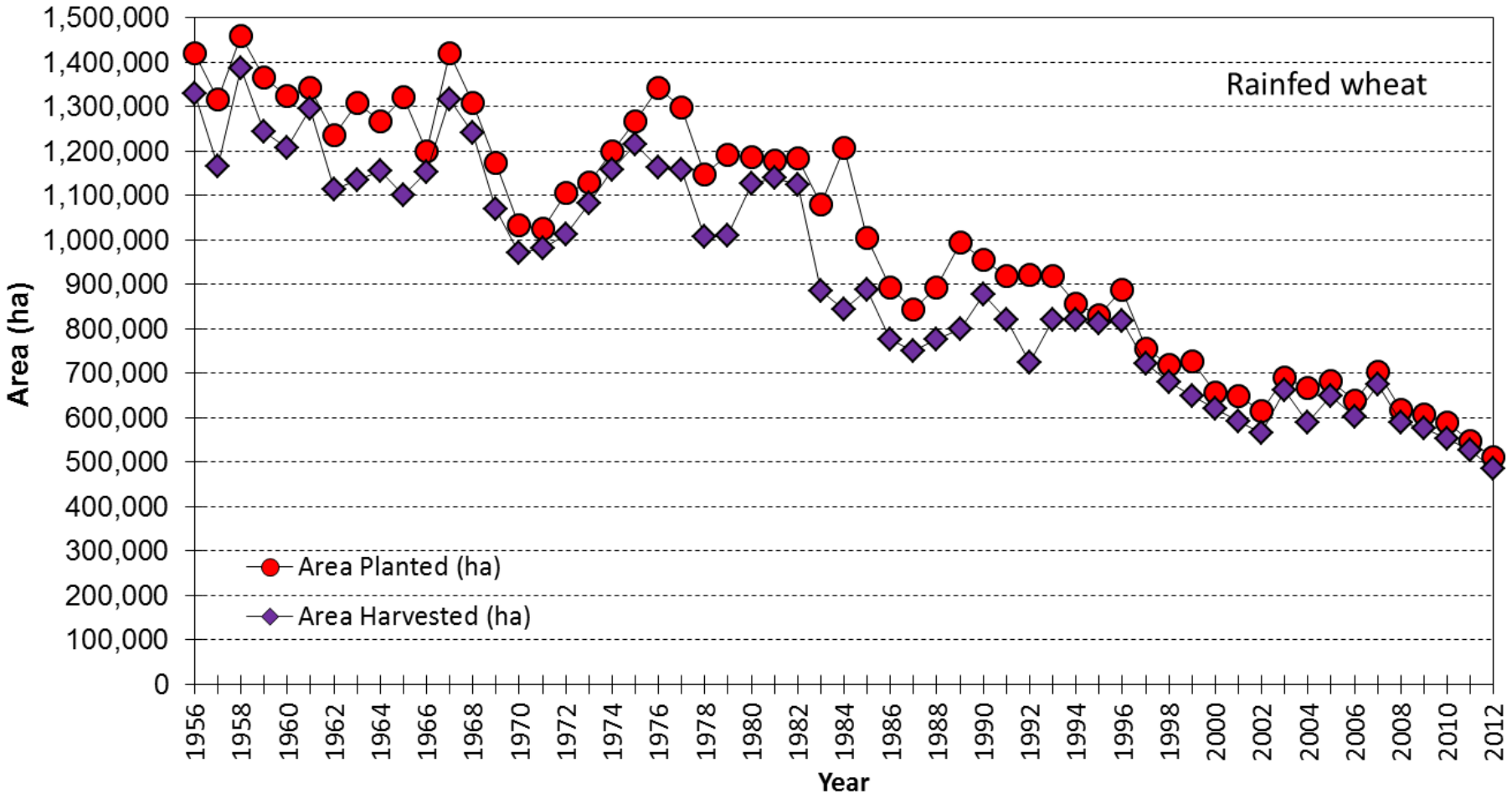
Inter-annual variation in long-term (1929-2012) average irrigated and rainfed wheat yield (kg/ha) in Colorado.



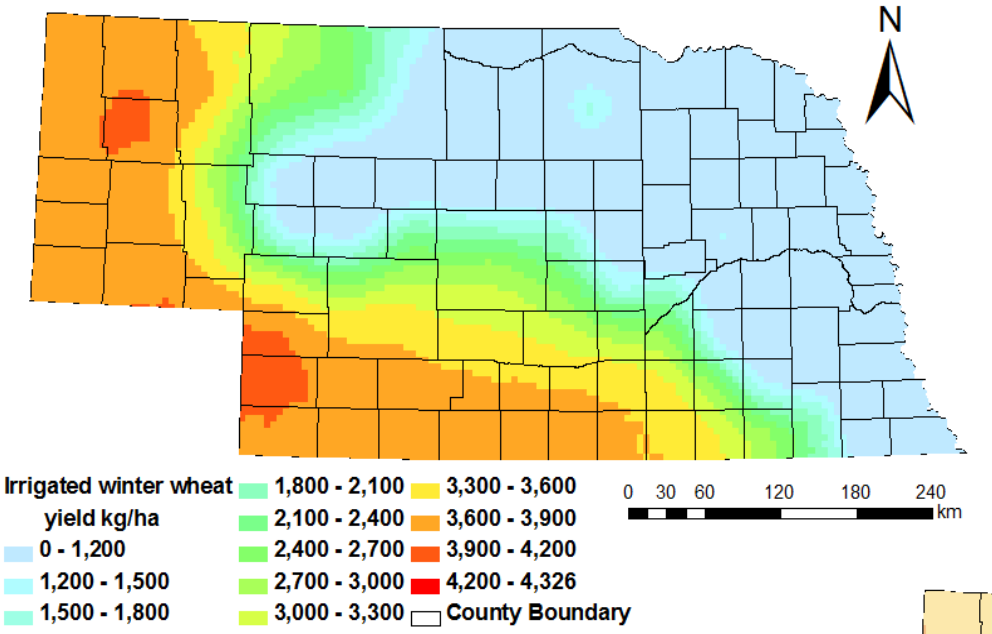
Inter-annual (1972-2012) variation in irrigated and rainfed wheat yield (kg/ha) across United States.

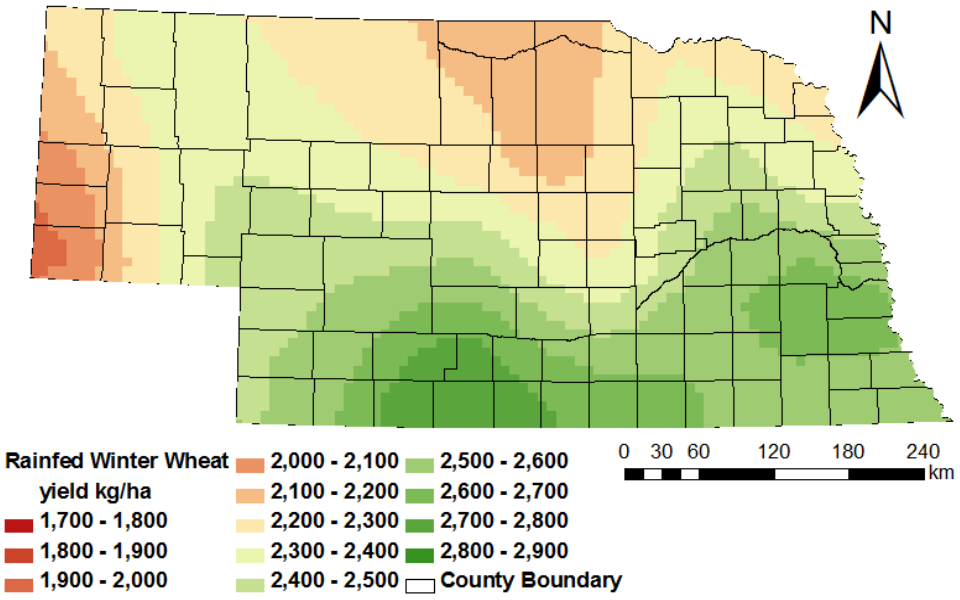


Inter-annual (1956-2012) variation in irrigated and rainfed wheat yield (kg/ha) across Nebraska.

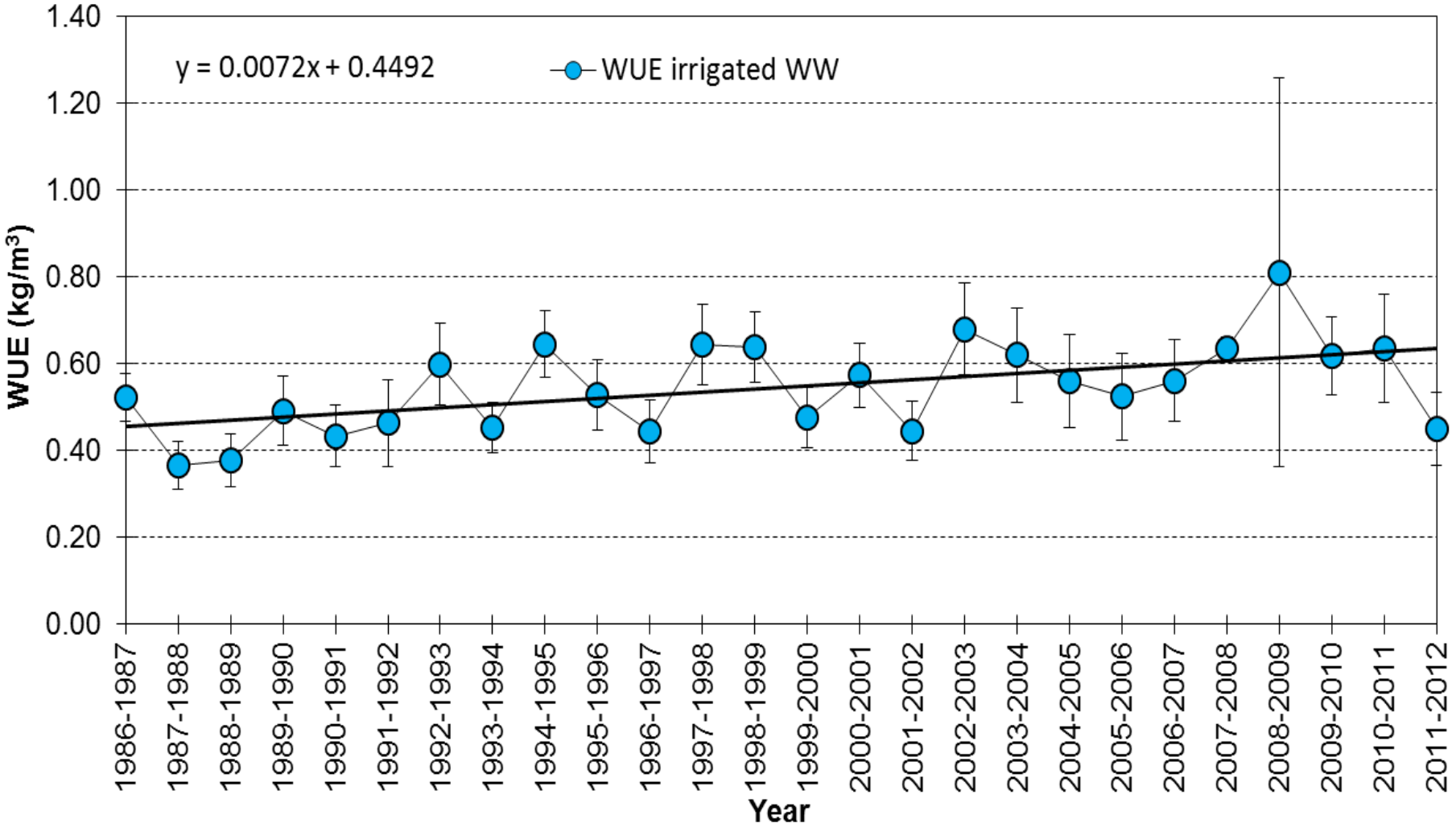


Planted and harvested rainfed wheat area in Nebraska from 1956 to 2012

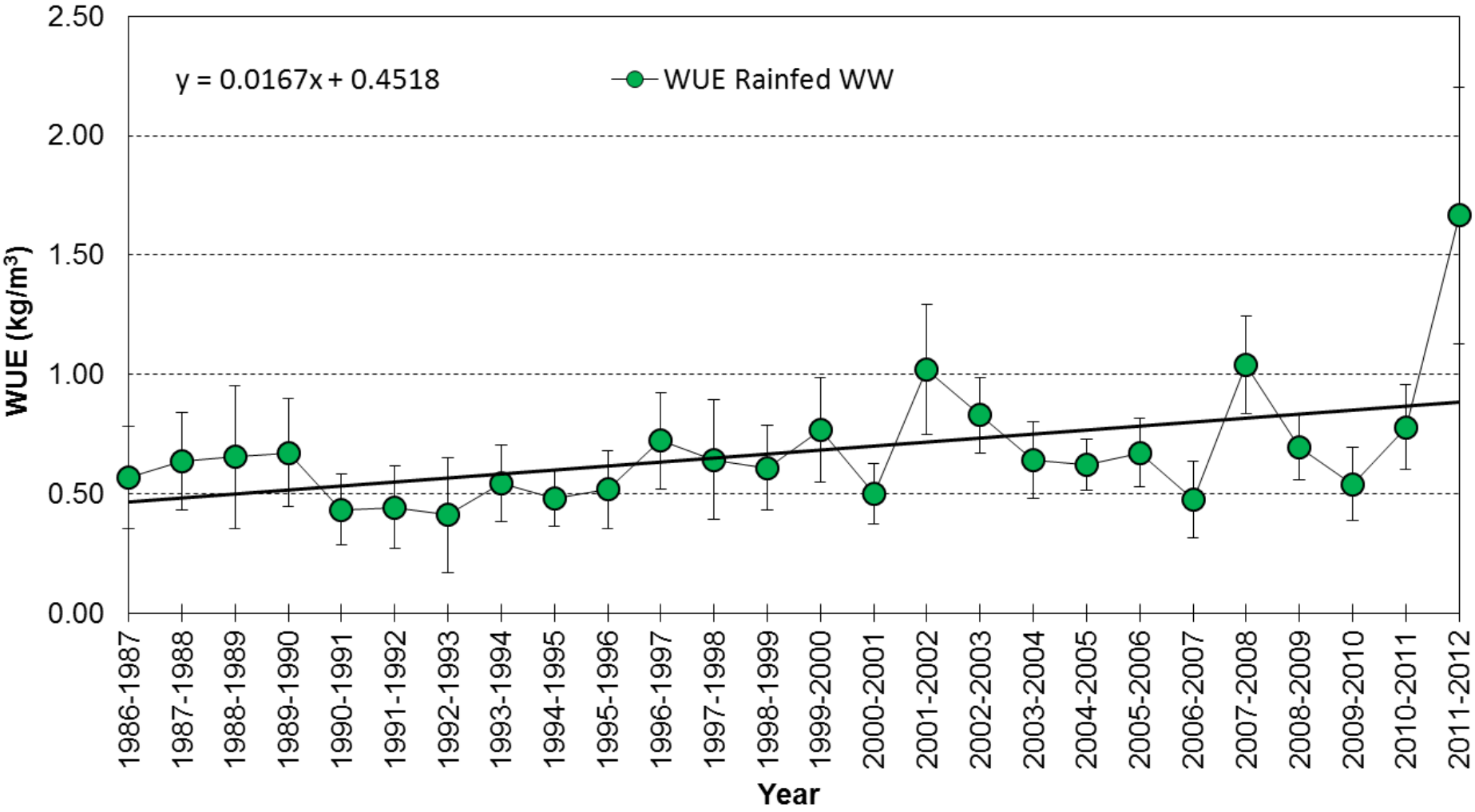




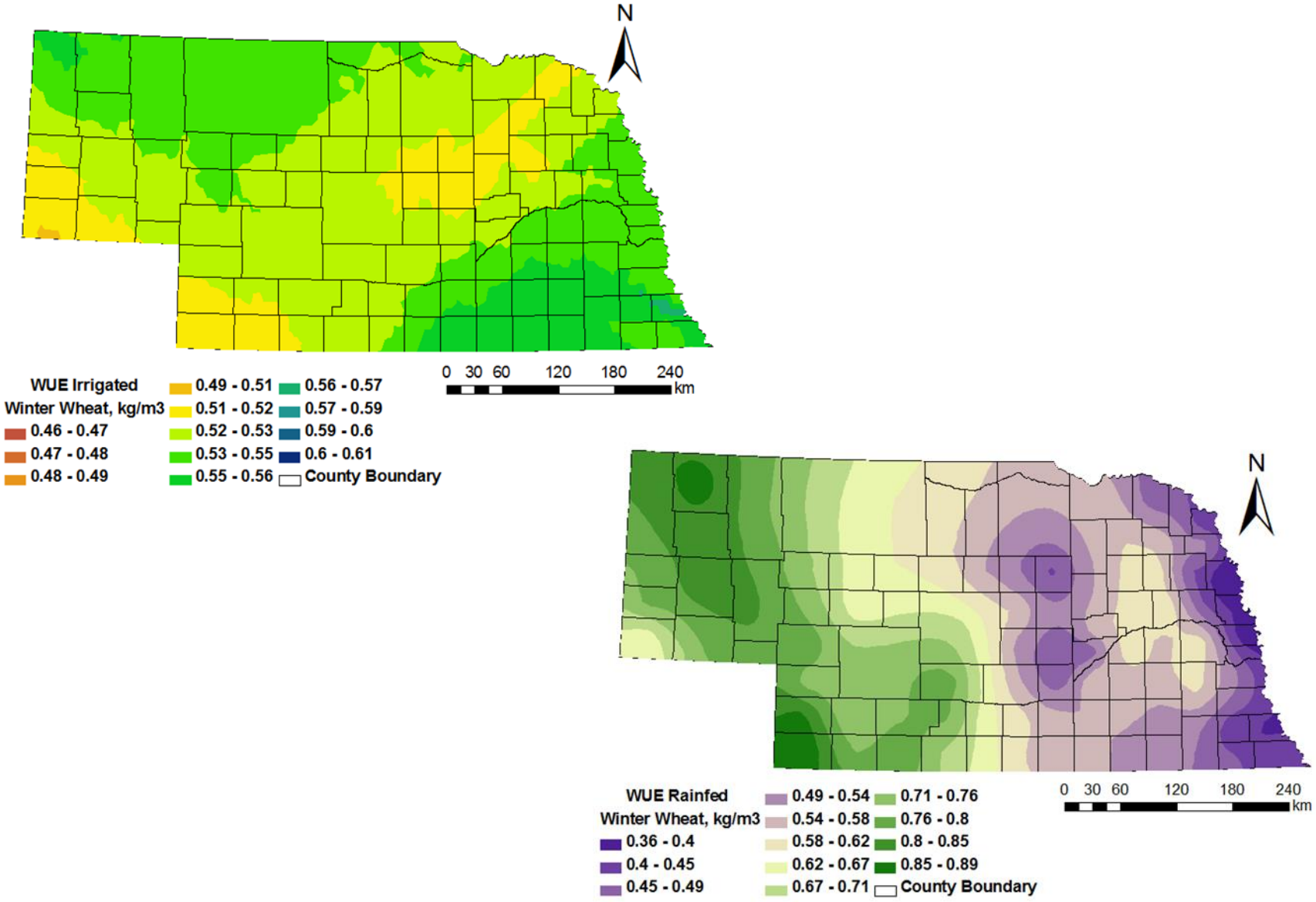
Spatial distribution of long-term (1986-2012) average irrigated and rainfed wheat yield (kg/ha) across Nebraska.



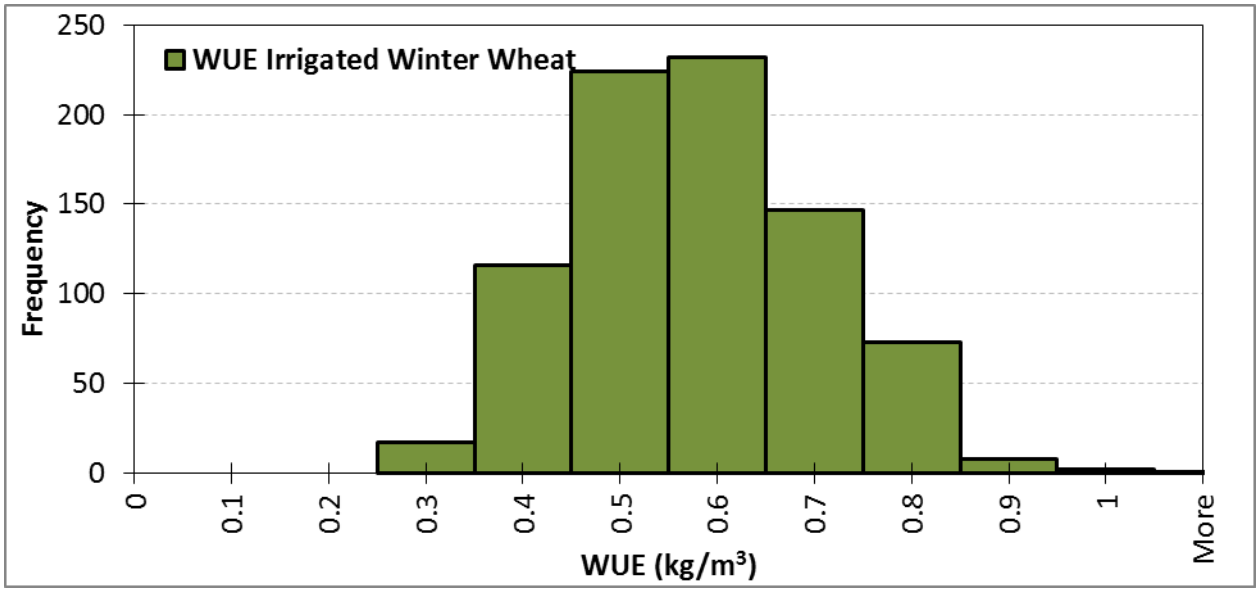
Inter-annual (1986-2012) variation in irrigated winter wheat water use efficiency in Nebraska.

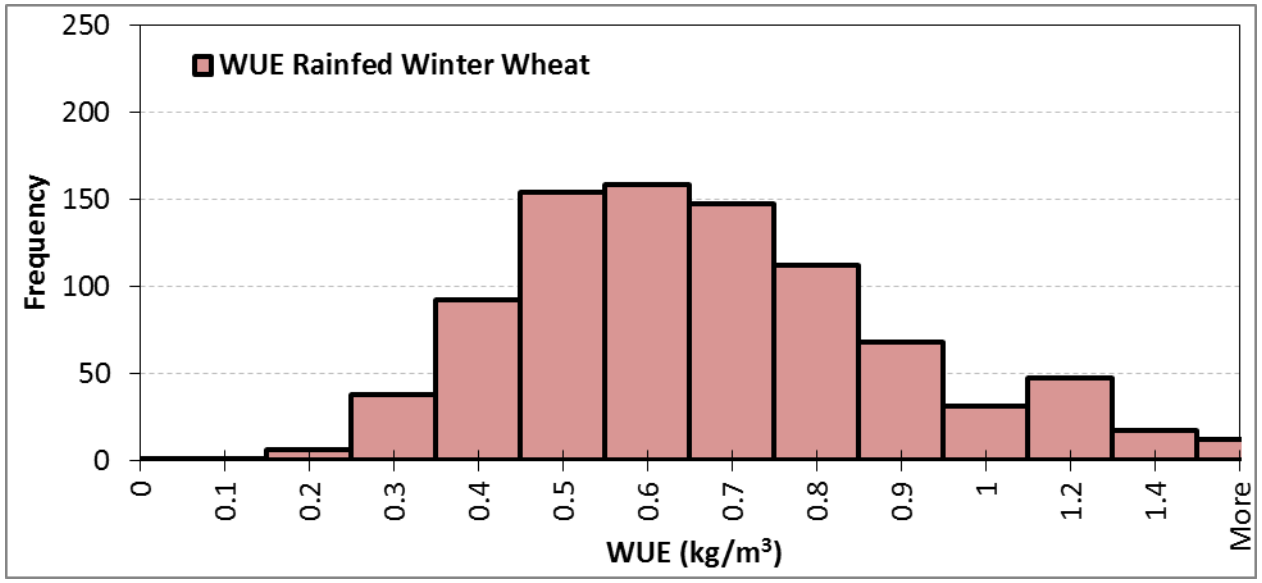


Inter-annual (1986-2012) variation in rainfed wheat water use efficiency (WUE) across Nebraska.



Spatial variation in irrigated (a) and rainfed (b) wheat water use efficiency (WUE, kg/m^3) across Nebraska.



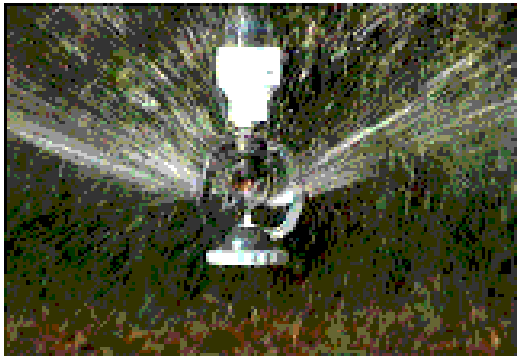


Frequency distribution of irrigated and rainfed wheat water use efficiency (WUE, kg/m³) in Nebraska.

- **Transferring research and scientifically-based data and information to the growers, crop consultants, state and federal agency personnel policy and decision-makers and other professionals is crucial to adopt/implement best management practices and technologies in agriculture to mitigate impact of climate change and continue to enhance agricultural productivity…**


06 . 13 . 2006

Research needs to be done for various cropping systems to reach all producers who utilize a diverse crop production/irrigation systems!



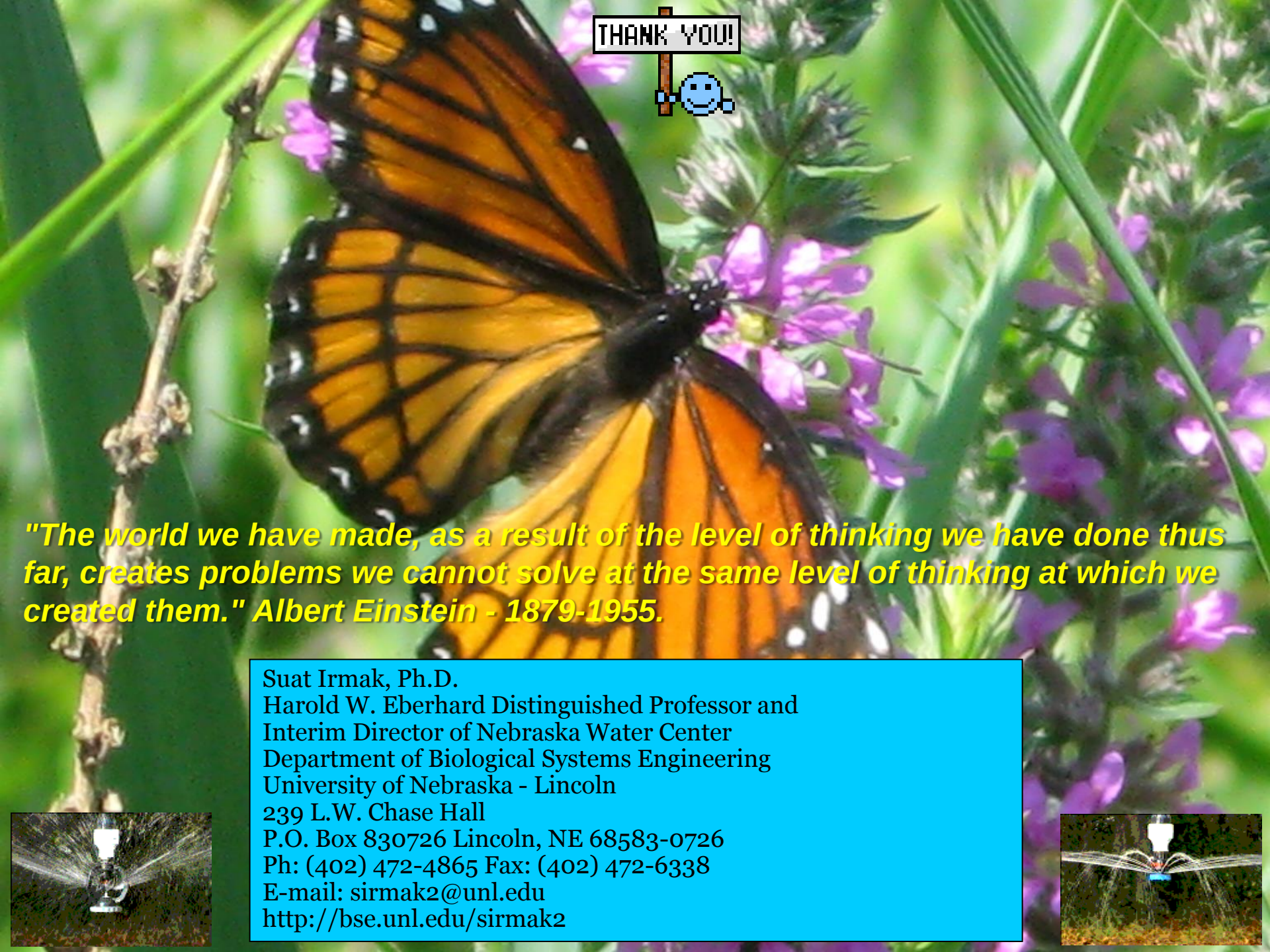
CLOSING REMARKS

- **Despite of significant increases in Tair and atmospheric CO_2 concentration, the CWUE of wheat has been increasing and t**
- **The impact of change in climate variables on wheat yields has been more visible in the last decade or so.**
- ***Increase in Tair and CO_2 impact on evapotranspiration should receive very close attention because water is the most important driver of agricultural productivity.***
- **More *research research research* is needed to better understand the climate change vs. agriculture interactions so that more robust methodologies can be developed for projecting future scenarios.**

CLOSING REMARKS

- **Research, scientific innovation and technological implementation will always find ways to encounter negative implications of climate change on agriculture. *Research to understand and interpret the local implications of climate change is crucial!***

- **New generation scientists should be involved in the research and technology development and education so that the agricultural productivity can keep pace with rapidly growing world's population and can provide enough food and fiber for over 9 billion people by 2050, and beyond.**



"The world we have made, as a result of the level of thinking we have done thus far, creates problems we cannot solve at the same level of thinking at which we created them." Albert Einstein - 1879-1955.

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