Climate Change Impacts

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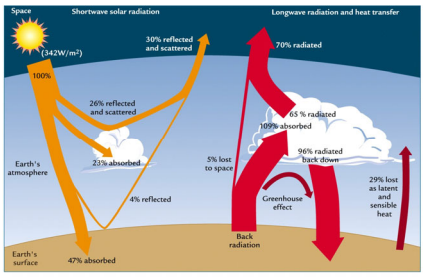
The Earth's greenhouse effect

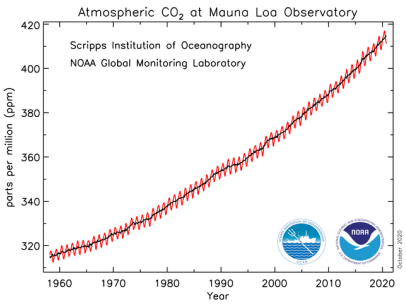
- Certain gases in the atmosphere permit solar radiation to enter the system, but absorb outgoing terrestrial radiation
- The concentration of these gases, namely CO_2, CH_4, H_2O, varies in time due to natural and anthropogenic causes
- Causes initial **radiative forcing**



SOUTHERN ILLINOIS FRUIT & VEGETABLE

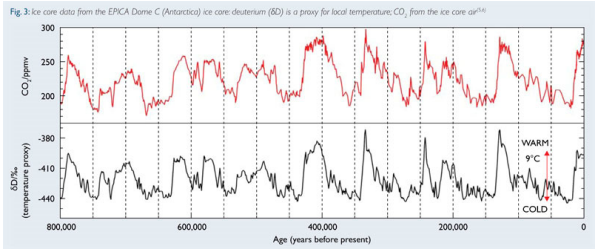
The Earth's greenhouse effect

- We have observed a consistent increase in CO_2 concentrations over the last 60 years (since direct observations)
- December 2020: 414 ppm



SOUTHERN ILLINOIS FRUIT & VEGETABLE

The Earth's greenhouse effect – Historically

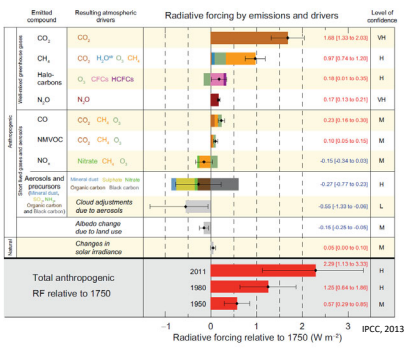


British Antarctic Survey

SOUTHERN ILLINOIS FRUIT & VEGETABLE SCHOOL

The Earth's greenhouse effect

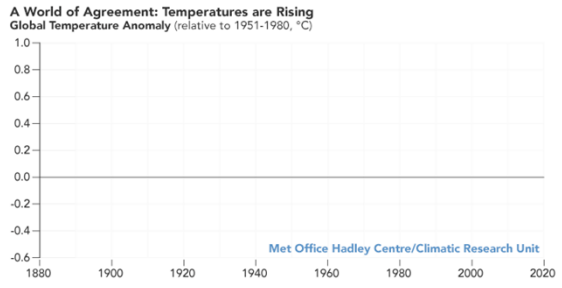
- Increased radiative forcing is primarily due to increased CO_2 & CH_4
- Studies in atmospheric science, chemistry, physics, and engineering have attributed nearly all of the over century-long increase in CO_2 & CH_4 to human activity



SOUTHERN ILLINOIS FRUIT & VEGETABLE SCHOOL

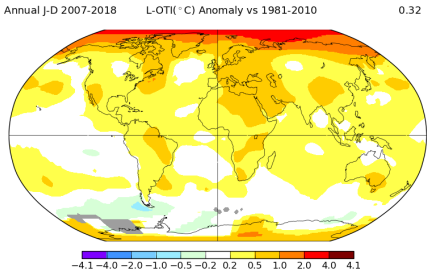
Global Warming

Source: NASA Earth Observatory



SOUTHERN ILLINOIS FRUIT & VEGETABLE SCHOOL

Global Warming



Temperature Changes

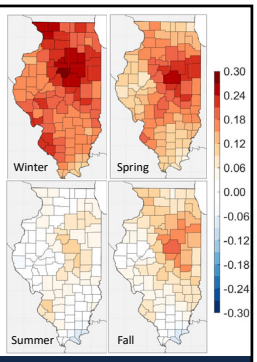
Temperature – Observed Changes

Last 120 Years:

- Statewide annual average temperature has increased by 0.10°F per decade between 1895 and 2019
- Warming trends in winter & spring are much larger than summer & fall
- Largest change in daily minimum temperatures

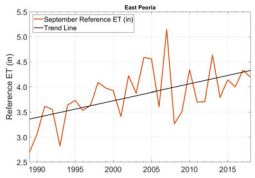
Trends (1895 – 2019)	Winter	Spring	Summer	Fall
Mean (°F dec^{-1})	+0.19	+0.22	+0.06	+0.13
Max (°F dec^{-1})	+0.17	+0.21	-0.10	+0.10
Min (°F dec^{-1})	+0.22	+0.23	+0.20	+0.16

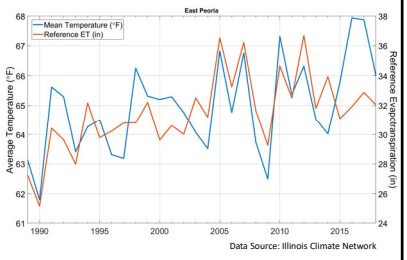
Source: NOAA NCEI



Observed Changes in Evaporative Demand

- Increased temperatures lead to increased evaporative demand, evaporation: 0.18" per year since 1989
- Largest trends (% of normal monthly ET) are in September (0.8% per year)

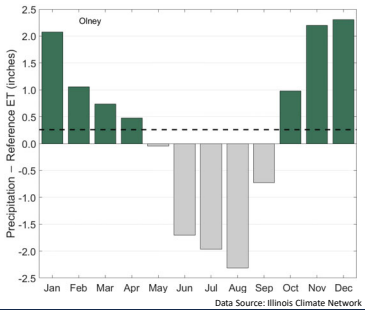




Monthly Soil Water Balance

$$\Delta S = P - ET - Runoff$$

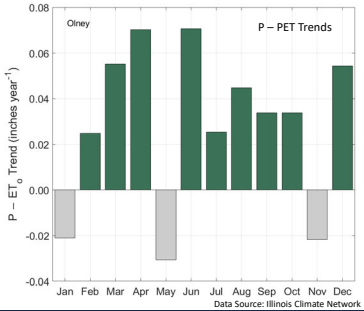
- Precipitation (P) outweighs evapotranspiration (ET) most months
- Over 12 months the state has a water surplus



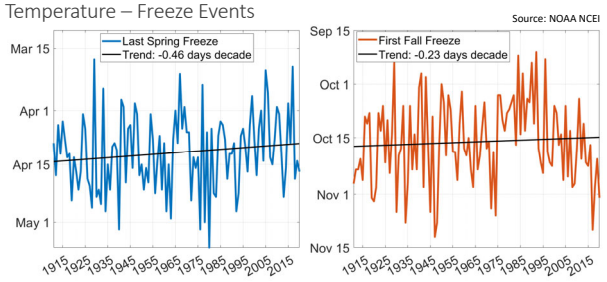
Monthly Soil Water Balance

$$\Delta S = P - ET - Runoff$$

- Precipitation (P) outweighs evapotranspiration (ET) most months
- Over 12 months the state has a water surplus
- Overwhelmingly positive trends in surface water balance
- Precipitation surplus increasing in all but 3 months
- 5 of the last 8 Septembers in Olney had a positive water balance



Temperature – Freeze Events

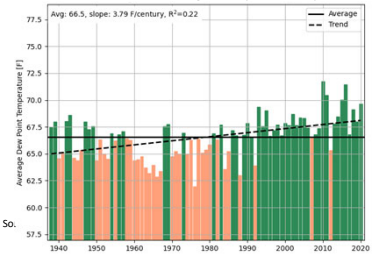


- Last spring freeze date is trending earlier
- First fall freeze date has weak trend (caused by 70s and 80s), but has been trending later in recent decades

Temperature – Humidity & Warm Nights

- Humidity has increased in all seasons except Fall, most in summer
- More very warm nights, fewer cool nights in spring and summer

Belleville Summer Average Dewpoint Temperature



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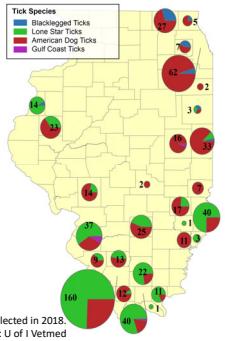
Climate Change Impacts – Health

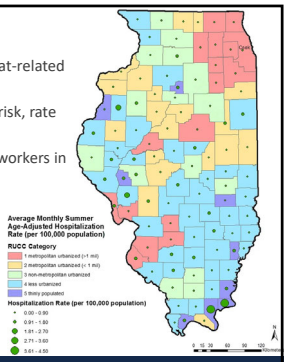
- Increased temperatures have helped expand range of ticks and mosquitoes, leading to vector-borne disease
- Heartland disease – spread by Lone Start tick – was confirmed in Williamson Counties for the first-time 2019
- Higher prevalence of Lyme Disease and West Nile in Metro East (related to short dry spells)
- Gulf Coast tick expanding northward into southern Illinois



Tick species collected in 2018.
Source: U of I Vetmed

Climate Change Impacts – Health

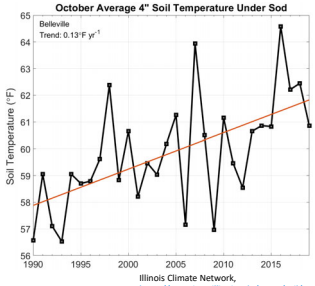
- Increasing temperatures results in higher risk of heat-related illness
- Research shows several rural counties have higher risk, rate of hospitalization, than urban counties in Illinois
- Increased extreme heat health issues among farm workers in Illinois



Source: BRACE, UIC:
https://braceillinois.uic.edu/

Soil Temperatures

- Soil temperatures exhibit similar trend as air temperature
- Largest soil temperature increase in late summer/early fall
- 4" soil temperature under sod in Belleville has increased 0.13°F per year since 1989

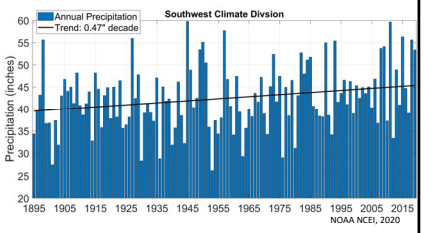


Illinois Climate Network,
https://www.isws.illinois.edu/warm/soil/

Precipitation Changes

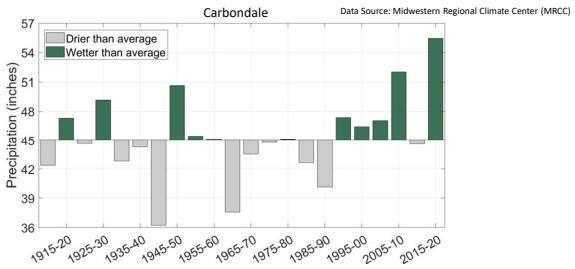
Changes in Precipitation

- Southern IL annual total precipitation has increased 0.47” per decade between 1895 and 2020
- Spring trend is 2 to 4x larger than other seasons



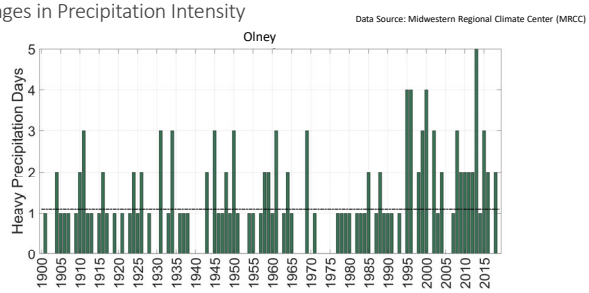
Precipitation Trends (1895 – 2019)	Winter	Spring	Summer	Fall
Southwest IL (inches per decade)	+0.07	+0.21	+0.05	+0.13
Southeast IL (inches per decade)	+0.03	+0.25	+0.09	+0.14

Changes in Precipitation



- Prolonged wetter than average period over the last 30 years

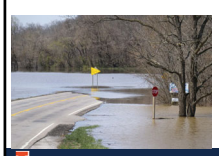
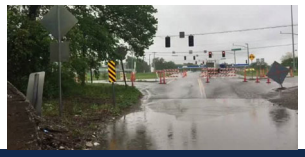
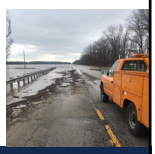
Changes in Precipitation Intensity



- Increase in heavy precipitation days

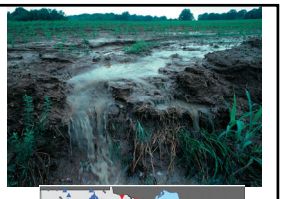
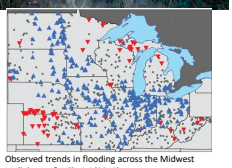
Precipitation – Observed Changes

Event	Rainfall	1989 Estimate	2019 Estimate
May 2017, Chester	11.35” in 10 days	150-year	75-year
January 2020, Vandalia	5.6” in 3 days	20-year	5-year
August 2020, Scott AFB	5.36” in 3 hours	150-year	125-year

Changes in Precipitation Intensity

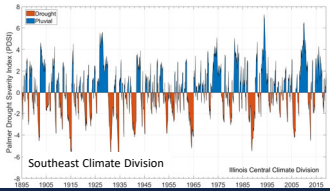
- More intense precipitation increases runoff ratio, nutrient runoff
- More precipitation goes to streamflow, not to soil moisture
- Less precipitation “yielded” for surface storage, could increase likelihood of drought later on

Observed trends in flooding across the Midwest
Mallakpour & Villarini (2015)

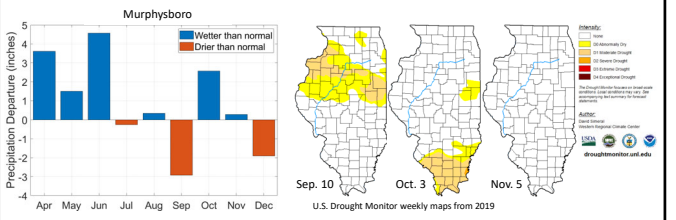
Drought – Observed Recent Changes

- The complexity of drought also complicates its measure and projection
- Using the Palmer Drought Severity Index, “extreme drought” reached in Illinois only 7 times since 1895… only twice since 1965
- The last 30 years are wetter than any 30-year period on record, back to the late 1800s
- Large, multi-year droughts are not happening as frequently



Drought – Observed/Projected Recent Changes

- Projections show more frequent "swings" from wet to dry extremes, particularly moving from wet spring to dry summer/fall
- Short term dryness with little impact on municipal water supply, but large agricultural impact



U.S. Drought Monitor weekly maps from 2019

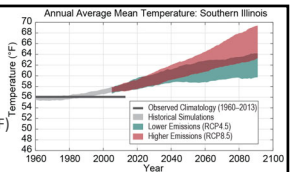
2019 monthly precipitation, as a departure from normal, at Murphysboro

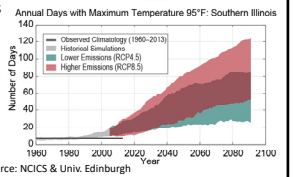
Projected (Future) Changes

Temperature – Projected Changes

- Projections indicate continued increases in all seasons' temperature
- Increase in annual frequency of very hot days (> 95°F)
- Largest increase in very warm nights (> 75°F)
- Continued winter warming, reduced very cold nights

Magnitude of change is very dependent on emission scenario… fewer emissions = less warming

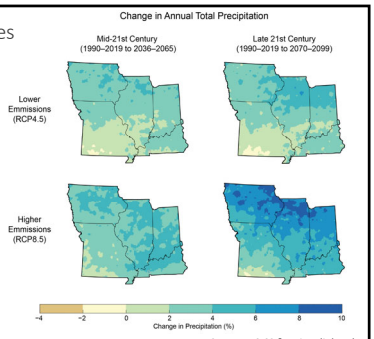




Source: NCICS & Univ. Edinburgh

Precipitation – Projected Changes

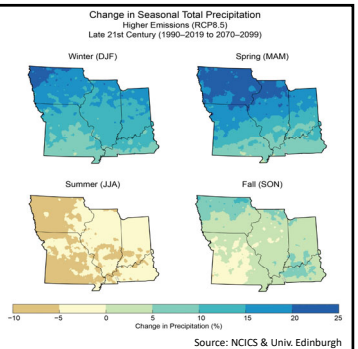
- Projections show continued increased precipitation and intensity



Source: NCICS & Univ. Edinburgh

Precipitation – Projected Changes

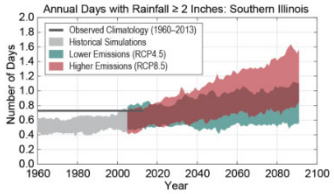
- Projections show continued increased precipitation and intensity
- Unlike temperature, projections show large seasonal differences in future precipitation
- Wetter Winter/Spring – Drier Summer



Source: NCICS & Univ. Edinburgh

Precipitation – Projected Changes

- Projections of extreme precipitation (2"+ in a single day)
- Increased frequency in southern Illinois, up to 1.5 to 2 additional days annually
- Large differences (~ 1 additional day) between higher and lower emissions scenarios



Summary

- Climate change – present and future – poses a significant issue for agriculture and ecosystems in Illinois
- Over the past 30 years...
  - Increased precipitation – and precipitation intensity have caused considerable soil erosion, runoff, flooding issues
  - Increased evaporation driven by higher temperatures has been more than offset by additional precipitation, but enhanced evaporation *during* dry spell could intensify dryness
  - Wettest period on record in this region, fewer long-term droughts
  - Increased winter temperature promotes higher VBD incidence and creates phenology issues (chill hours, false springs)
  - Increased summer minimum temperatures reduce crop efficiency
- Future climate projections show **very high confidence** that temperatures will continue to increase in Illinois, impacting:
  - Heat – human & animal heat stress
  - Nighttime temps
  - Evaporation – exacerbating dry conditions during drought
- Future climate projections show **moderate confidence** that precipitation will continue to increase in Illinois, particularly in spring and winter

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