Climate Change & Soil and Water Conservation

TRENT FORD

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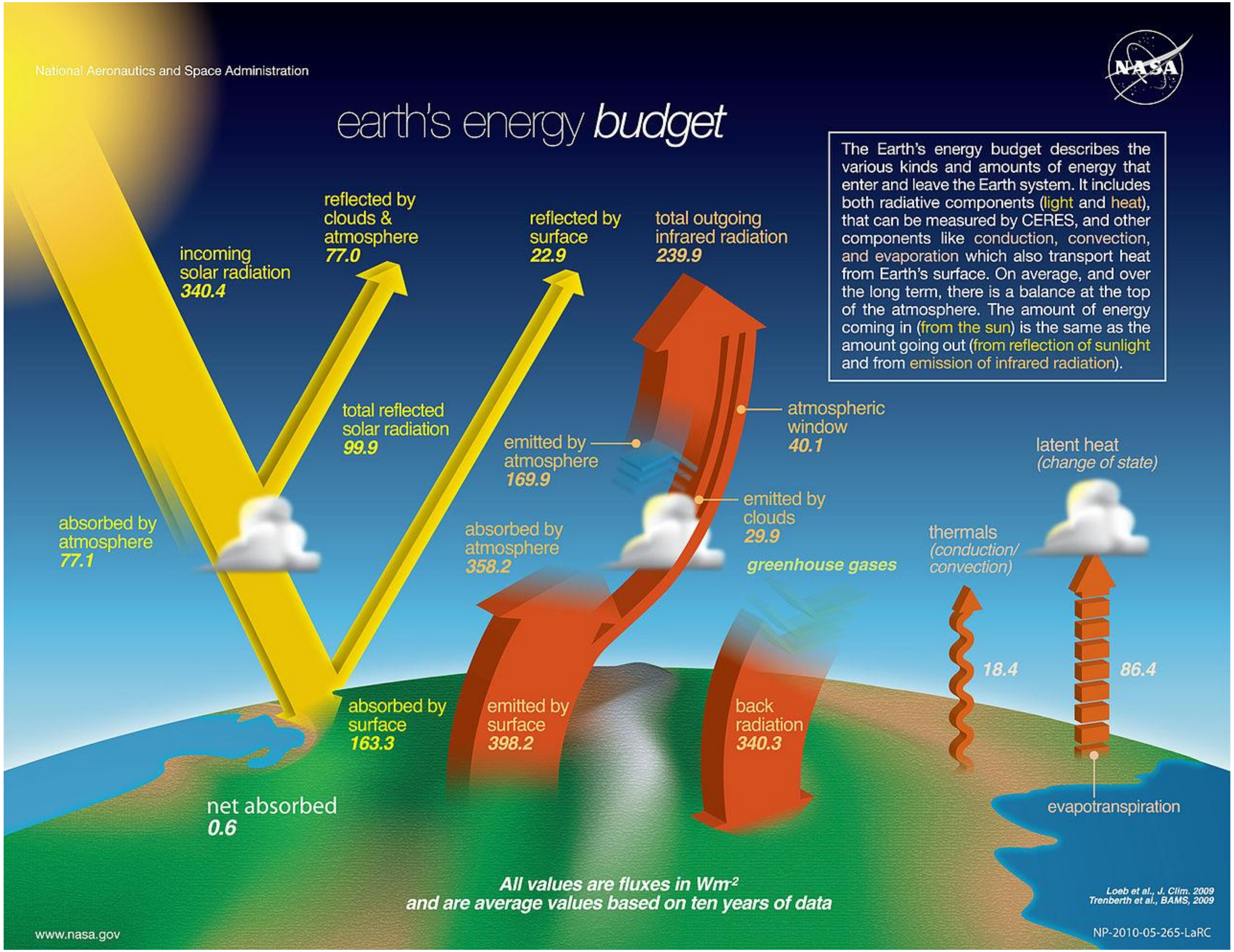
Illinois State Water Survey

PRAIRIE RESEARCH INSTITUTE

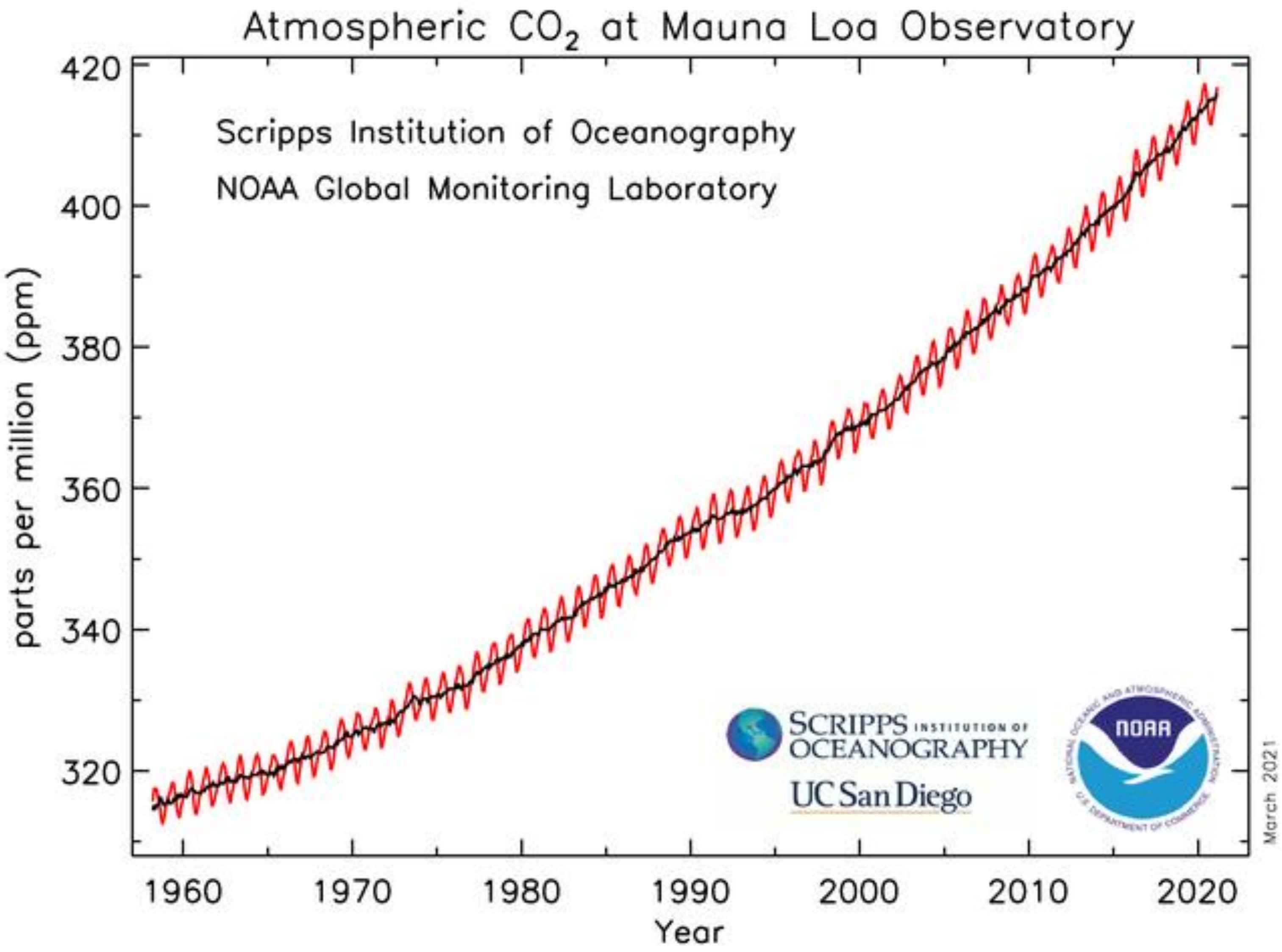
- CO_2, CH_4, H_2O (among others) permit solar radiation to enter the Earth system, but absorb outgoing terrestrial radiation

- Their concentration of these gases, namely CO_2, CH_4, H_2O, varies in time due to natural and anthropogenic causes



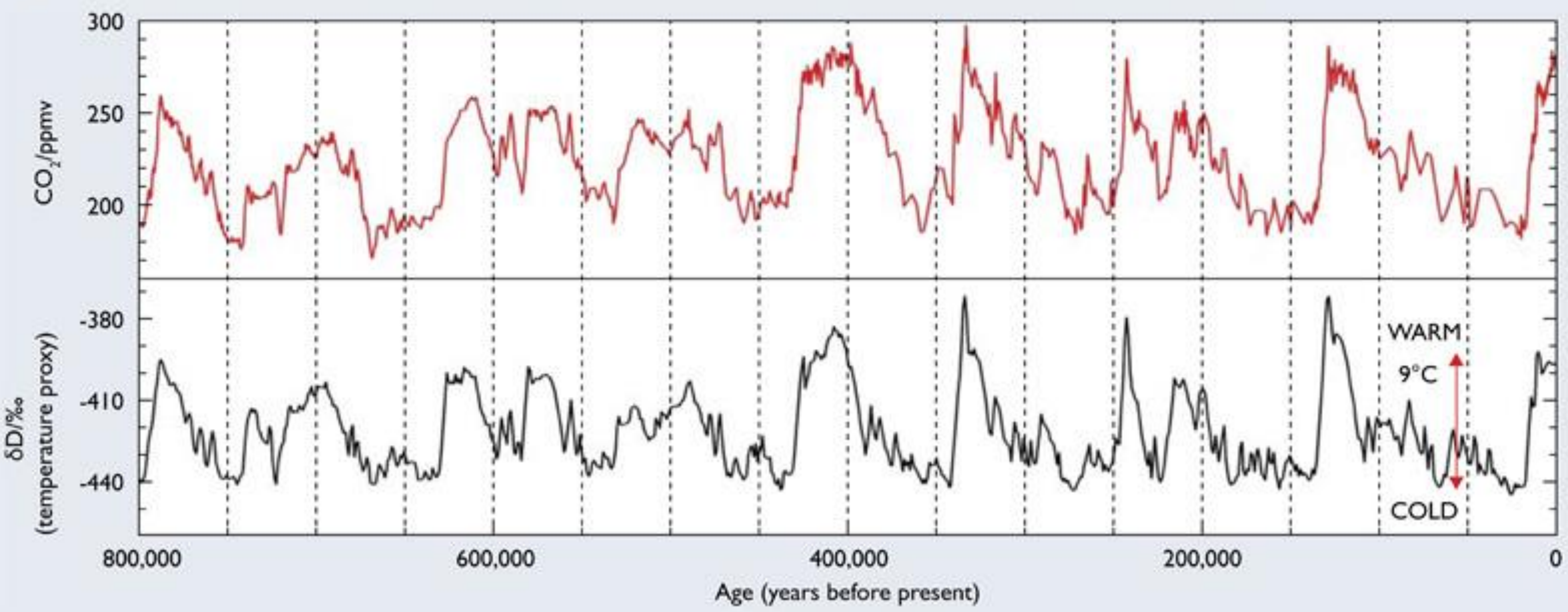
The Earth's greenhouse effect

- We have observed a consistent increase in CO_2 concentrations over the last 60 years
- June 2021: 419 ppm



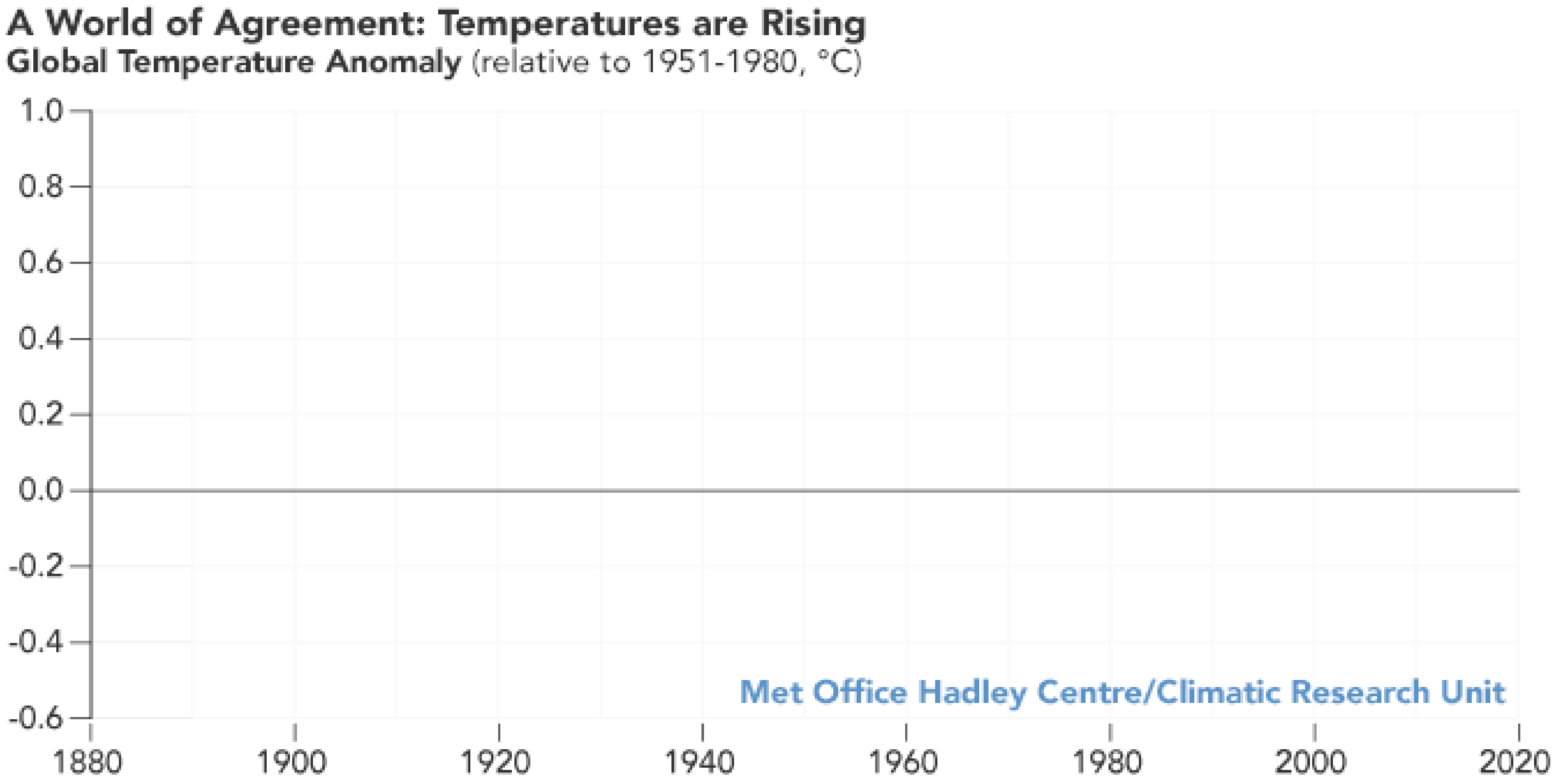
The Earth’s greenhouse effect – Historically

Fig. 3: Ice core data from the EPICA Dome C (Antarctica) ice core: deuterium (δD) is a proxy for local temperature; CO_2 from the ice core air[5,6]



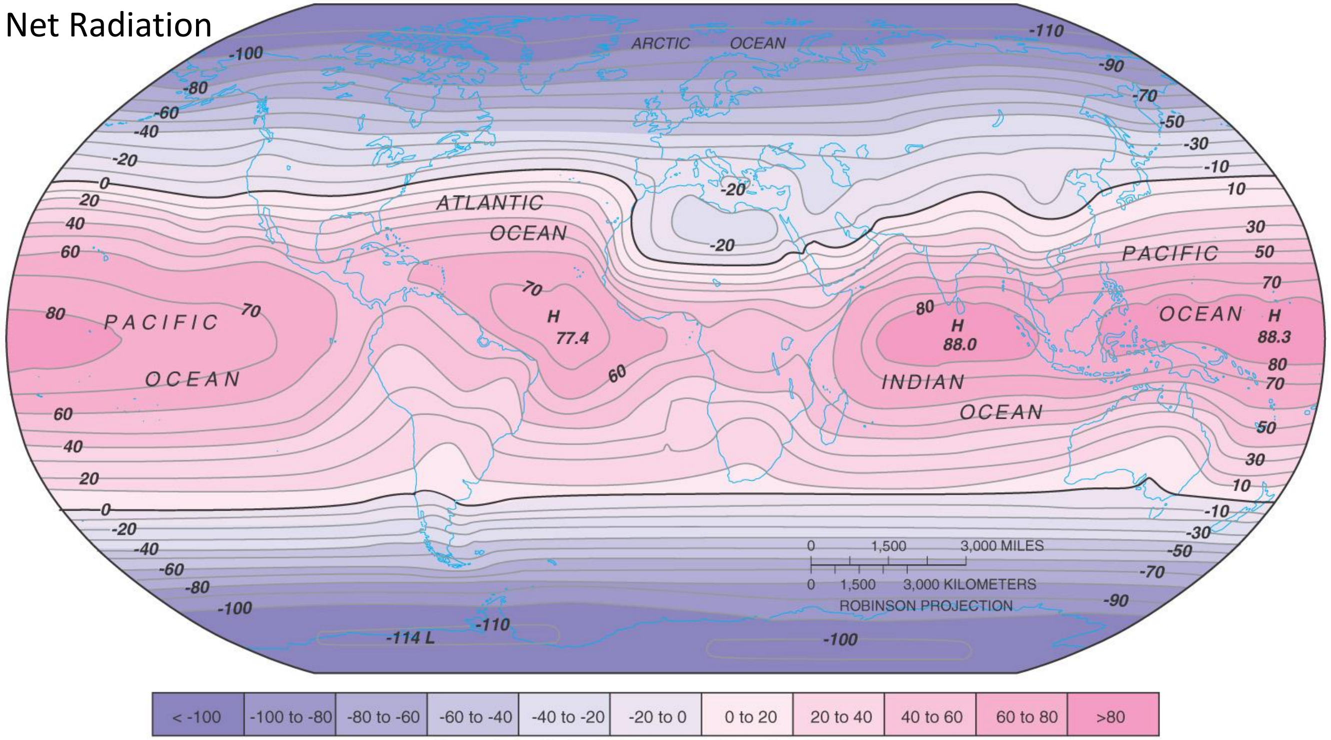
British Antarctic Survey

Global Warming



Climate Change

Annual Net Radiation



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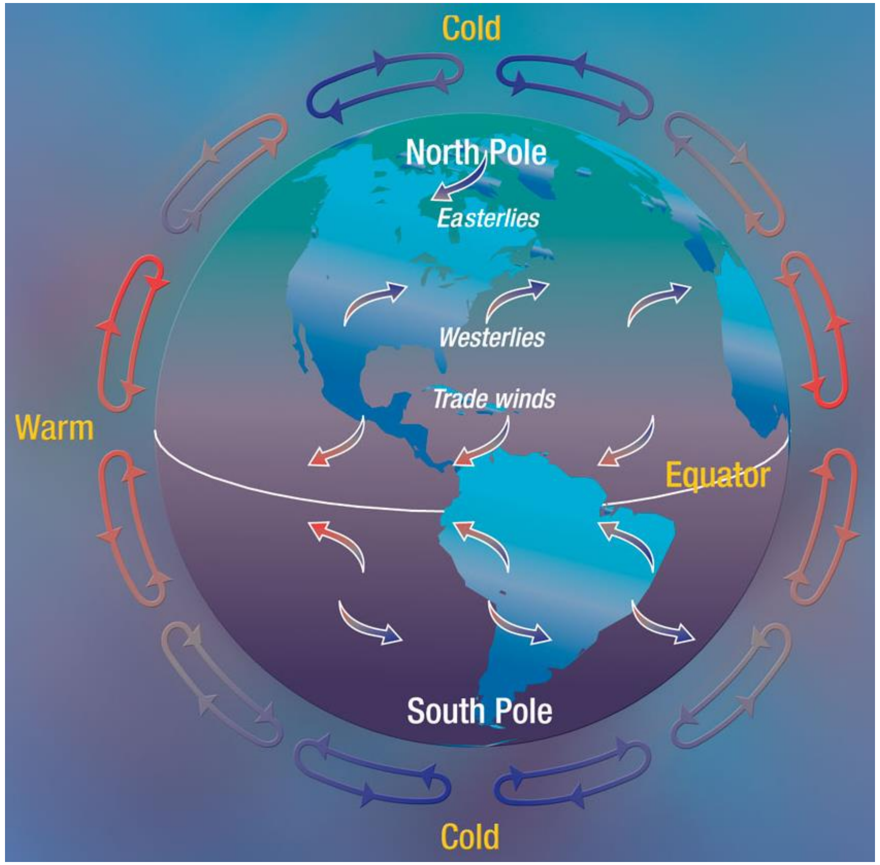
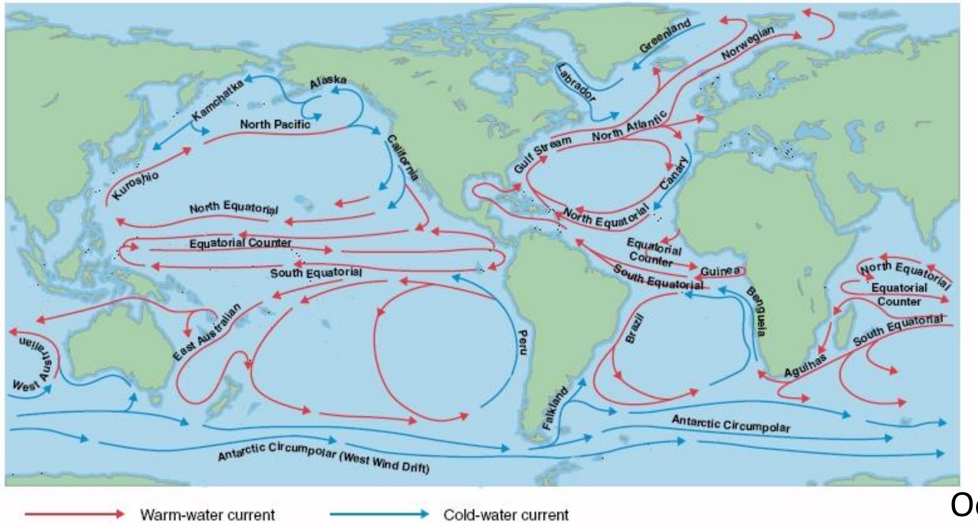


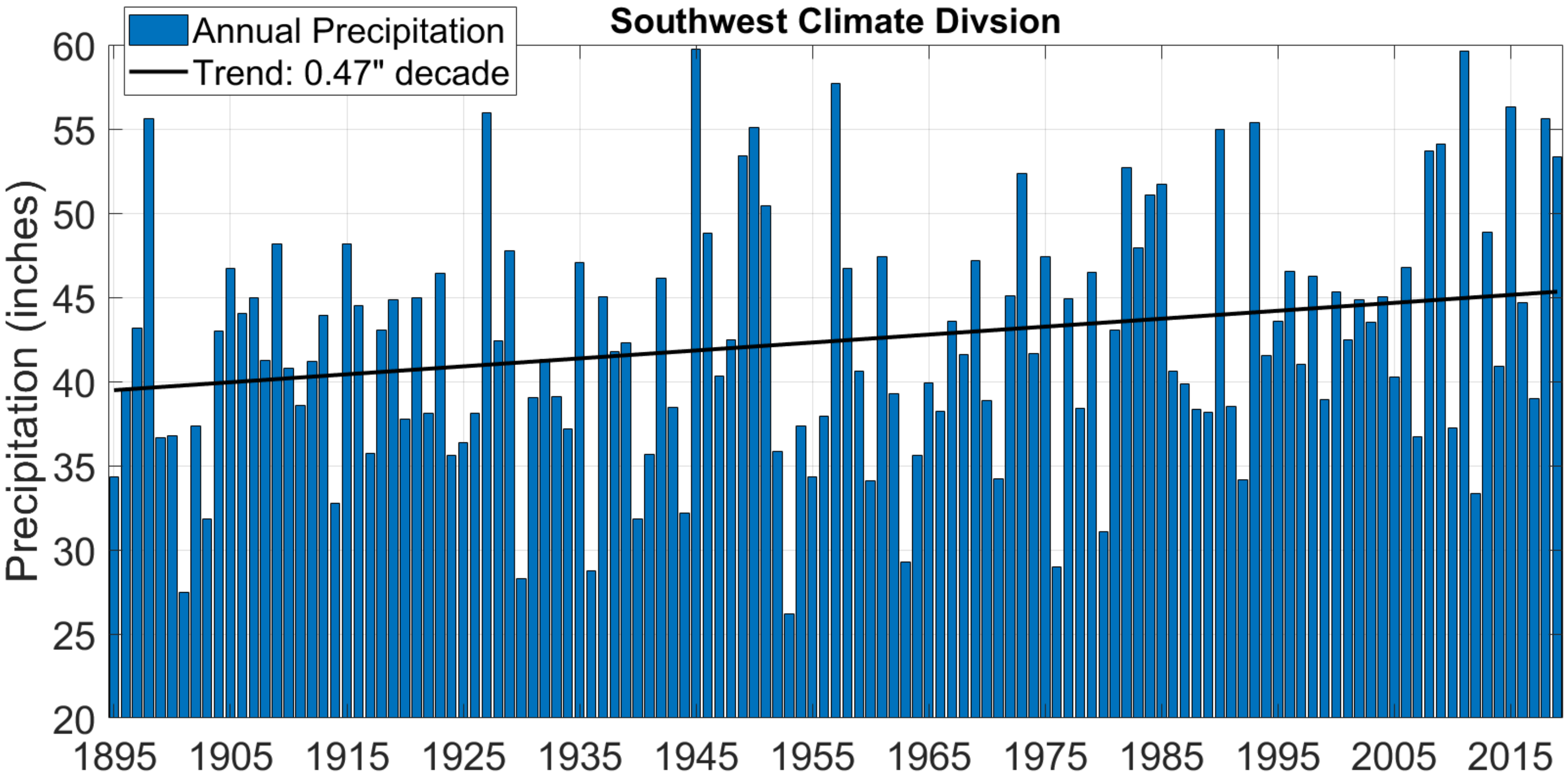
Atmospheric Circulation



Ocean Circulation

Precipitation

We’re Getting Wetter

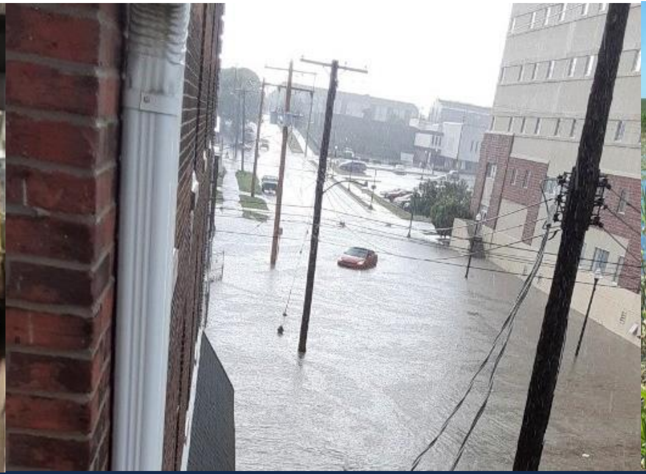


Precipitation Trends (1895 – 2020)	Winter	Spring	Summer	Fall
Northern IL (inches per decade)	+0.06	+0.16	**+0.25**	+0.11
Central IL (inches per decade)	+0.03	+0.10	**+0.18**	+0.08
Southern IL (inches per decade)	+0.03	**+0.25**	+0.09	+0.14

Source: NOAA NCEI

More Intense Precipitation

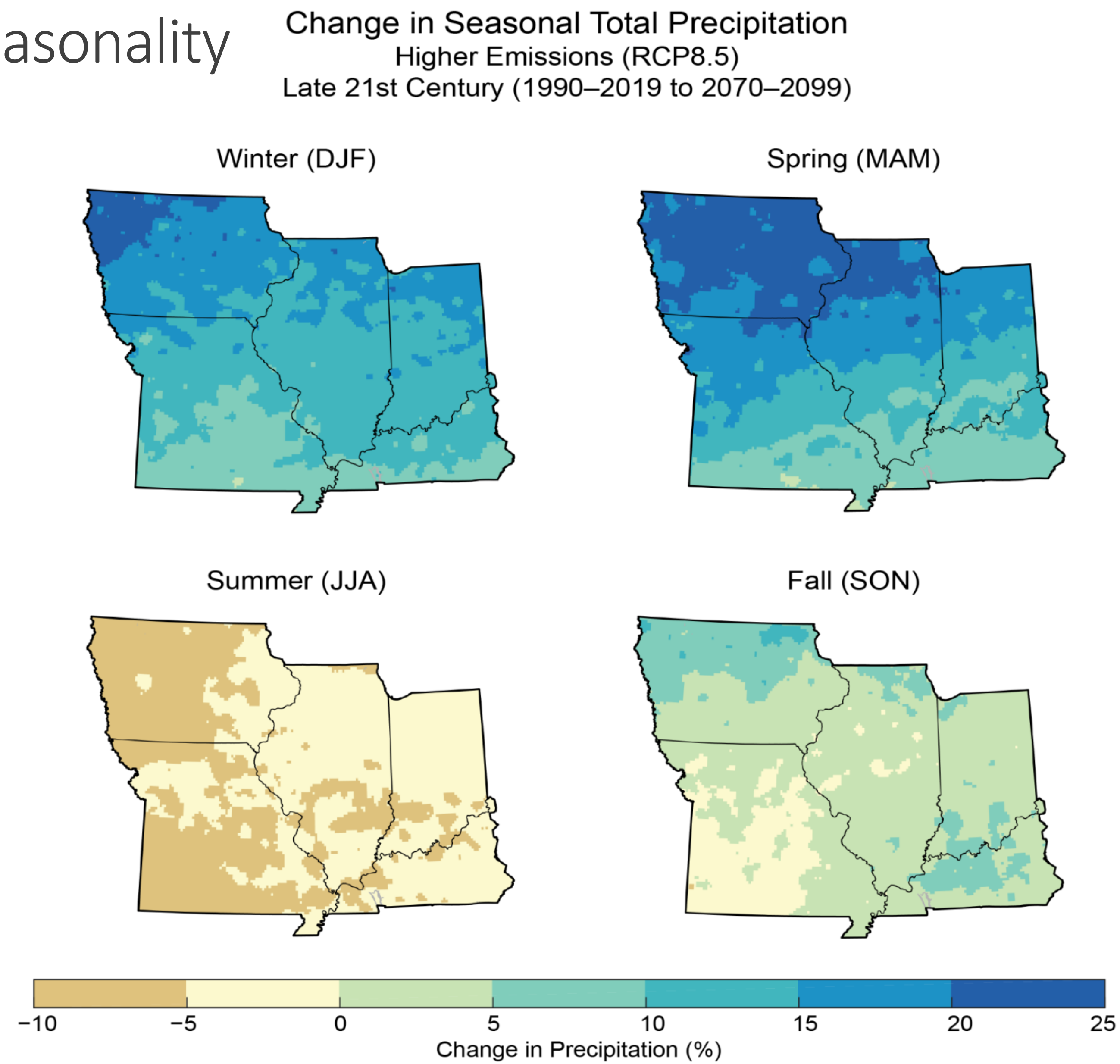
Event	Rainfall	1989 Estimate	2019 Estimate
January 2020, Vandalia	5.6” in 3 days	20-year	5-year
May 2020, Chicago	7.88” in 4 days	50-year	25-year
June 2020, Quincy	6.85” in 4 days	20-year	10-year
July 2020, Peoria	5.80” in 6 hours	???	100-year
August 2020, Scott AFB	5.36” in 3 hours	???	125-year
June 2021, Bloomington	10.19” in 3 days	???	250-year


Projections: Wetter Overall, Changing Seasonality

Model Projections:

- Continued increased precipitation & intensity – largest in northern IL
- Large seasonal differences – majority of projected increase in winter + spring
- Uncertainty of summer precipitation – no change to small decrease

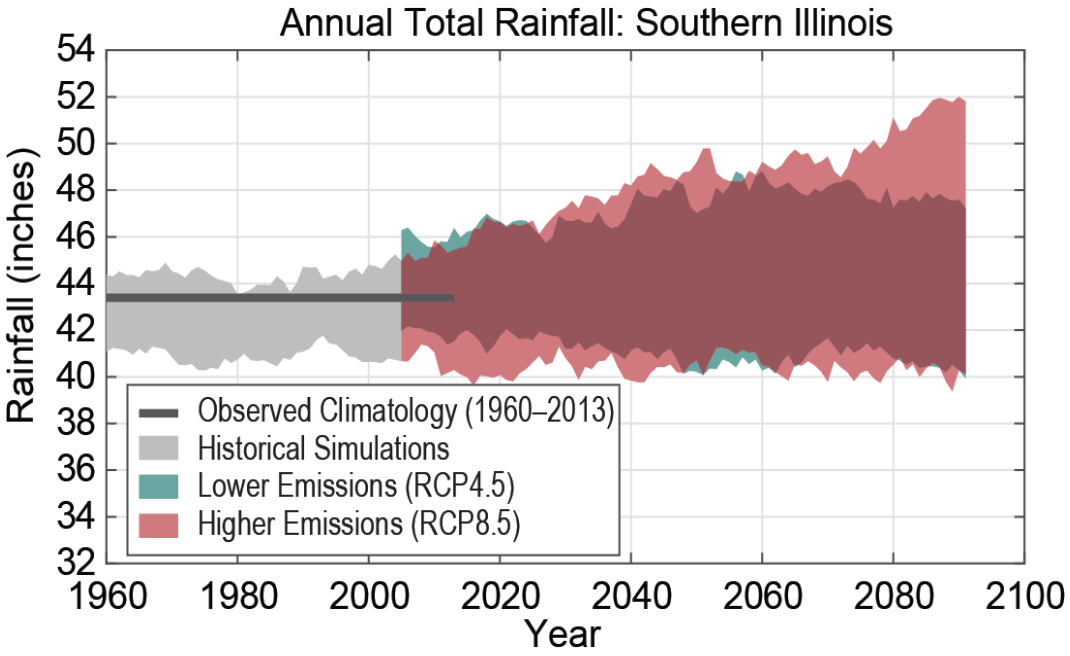


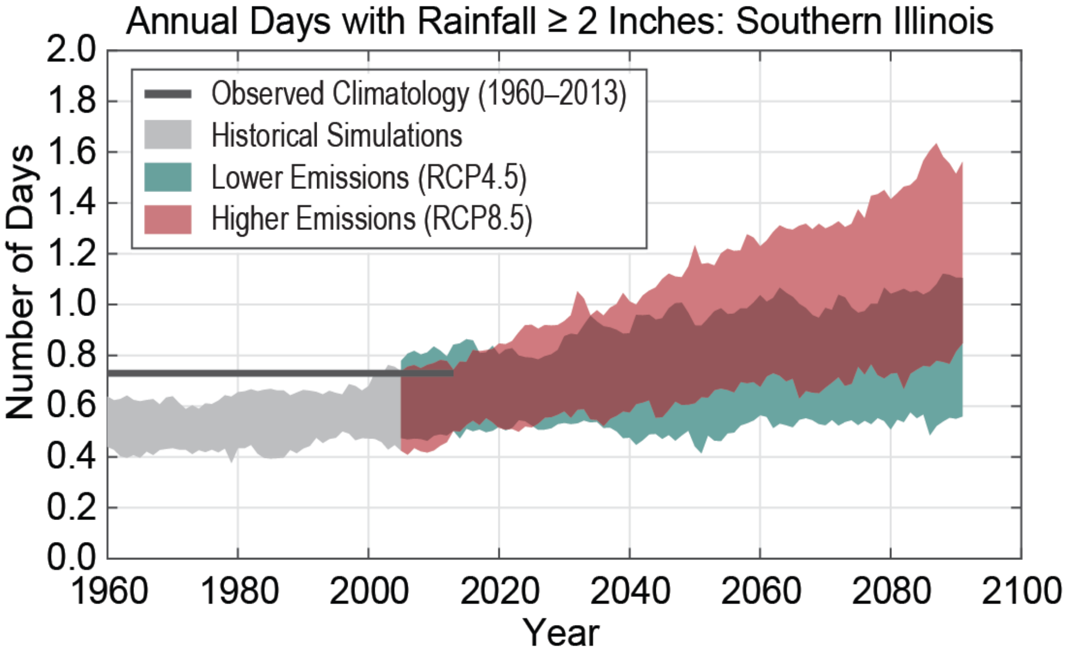
Source: NCICS & Univ. Edinburgh

Projections: More Intense Rainfall

Model Projections:

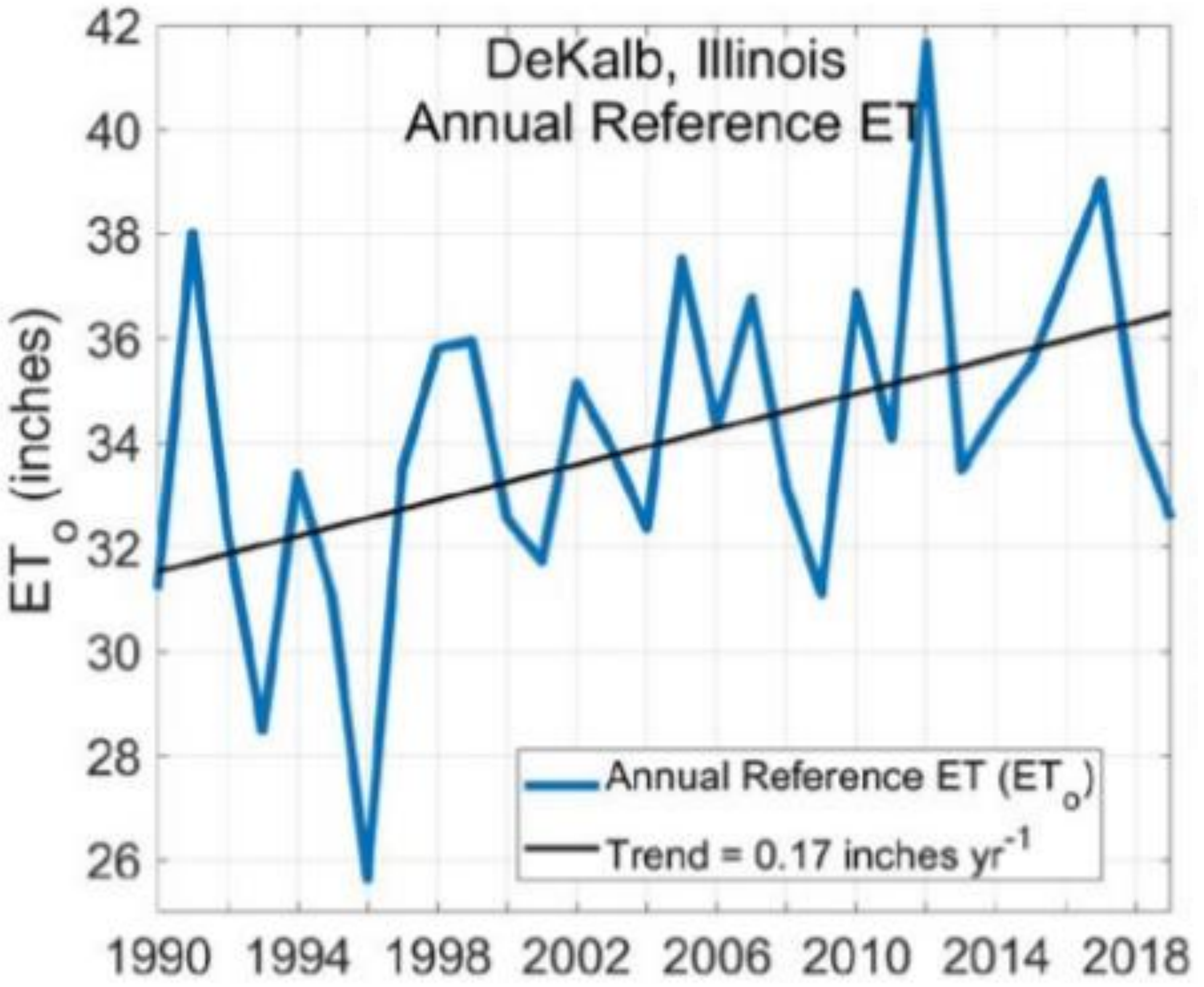
- (Top panel) Increases in total annual precipitation, not segregated by emission scenario
- (Bottom panel) More intense precipitation increases, but is more sensitive to emissions
- 6 additional extreme rainfall days per decade between high and low emission scenarios





Drought

- Summer precipitation projected to change by 0 to 5% by late century (medium-low confidence)
- Summer evaporation increases - demand at DeKalb has increased by 0.17" per year since 1990
- Low confidence in summer precipitation, evaporative demand, and response to changes in both/either

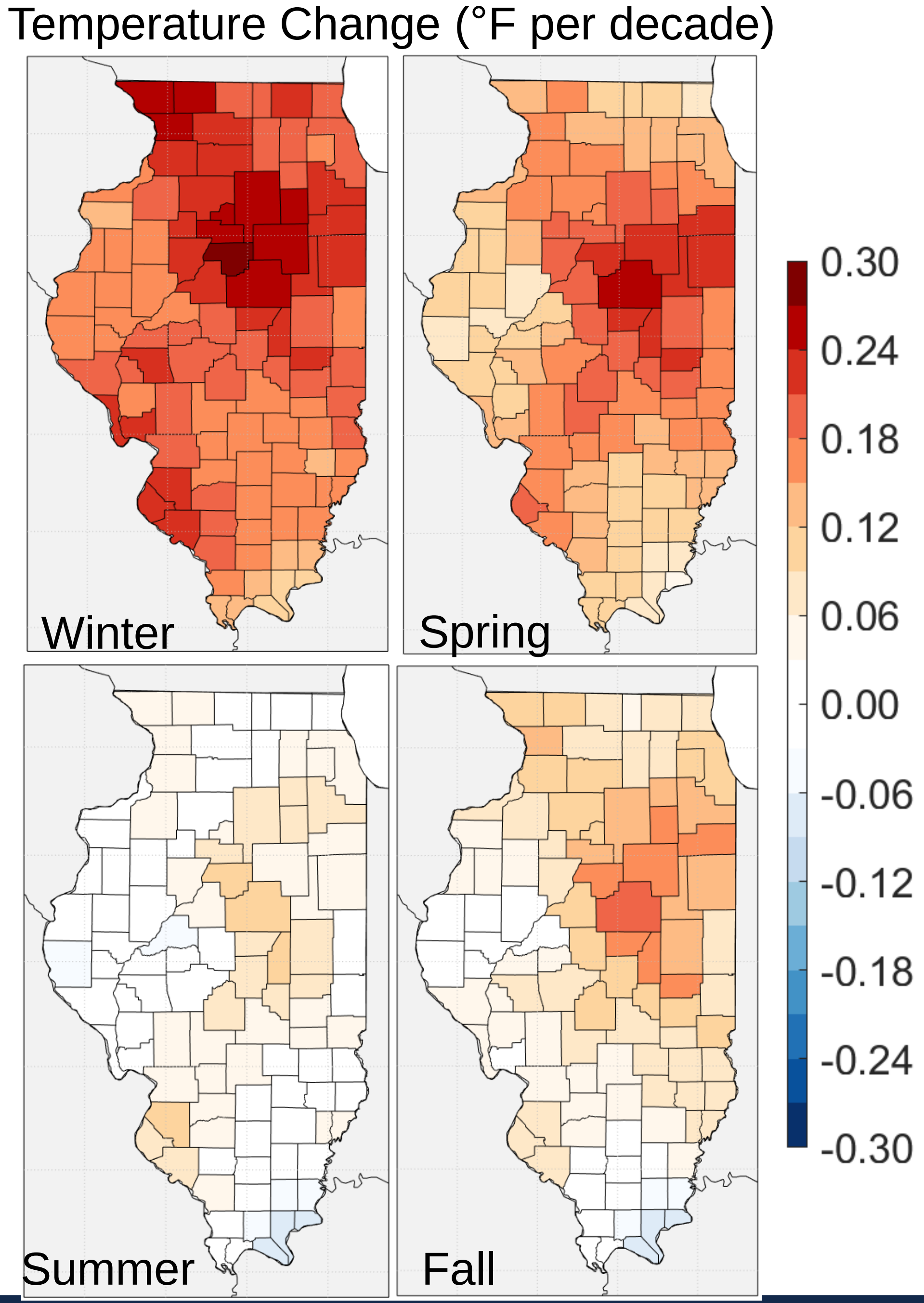


Temperature

We’re Getting Warmer

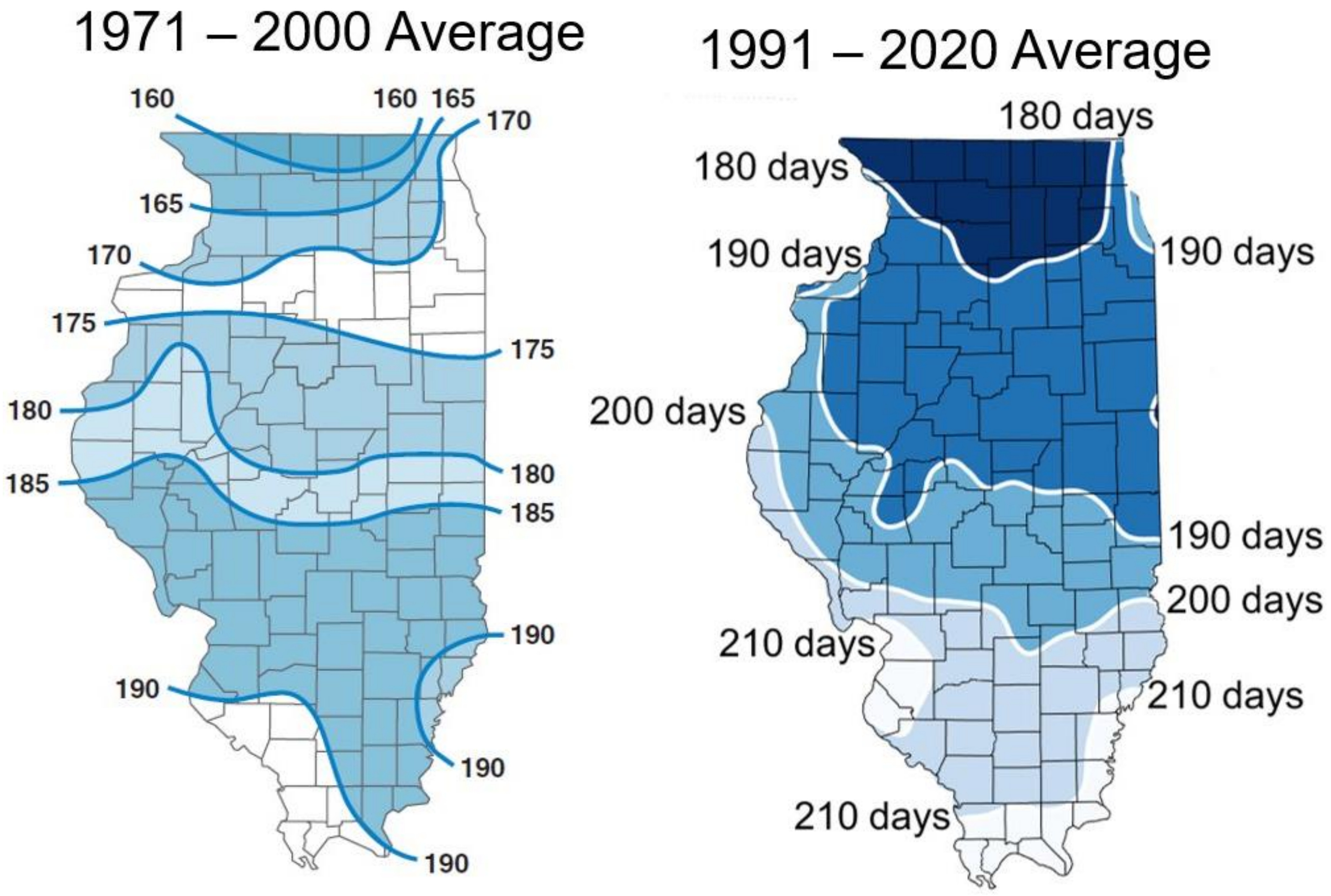
Last 120 Years:

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



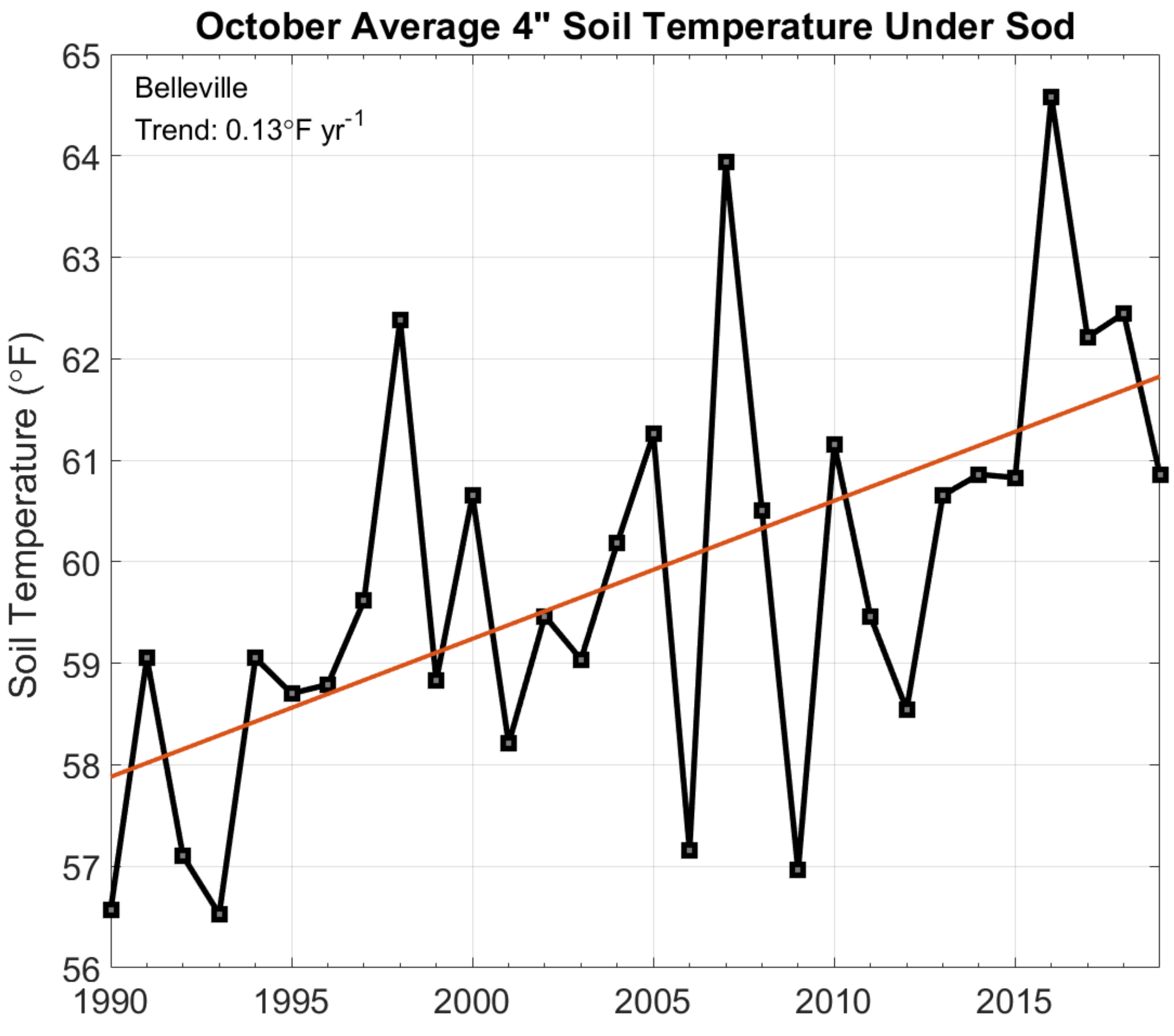
Longer Growing Season

- Earlier last spring freeze + later first fall freeze = longer growing season
- New 30-year average growing season is 10 to 25 days longer than 1971-2000 average



Soil Temperatures

- Soil temperatures have similar increasing trend as air temperature
- Soil temperatures in Illinois have increased in all seasons, but largest change in late summer/early fall
- October 4” soil temperature under sod in Belleville has increased 0.13°F per year since 1989
- September 4” soil temperature in DeKalb has increased 0.17°F per year since 1989

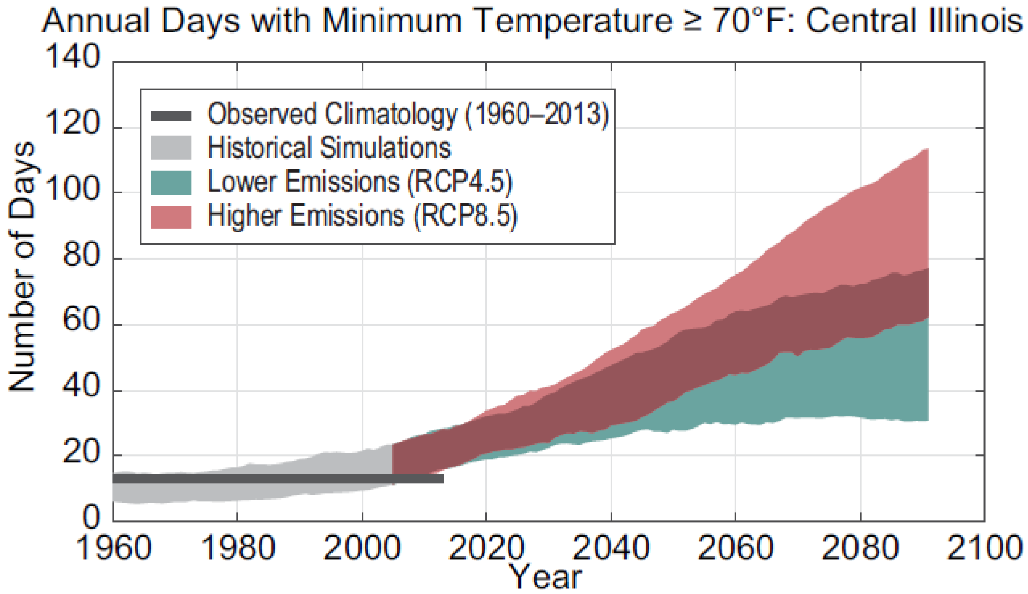


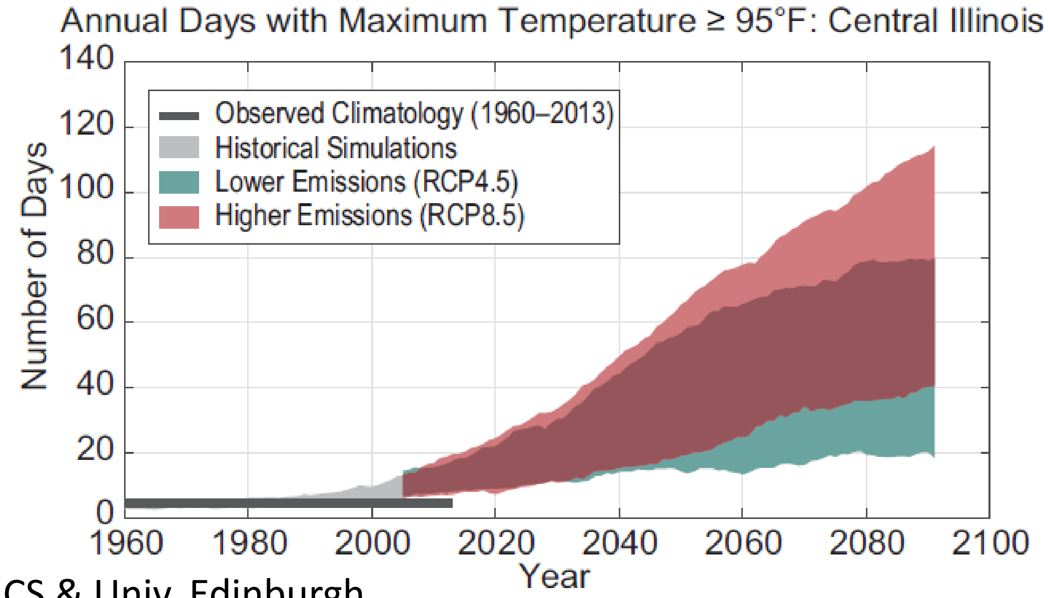
Illinois Climate Network,
https://www.isws.illinois.edu/warm/soil/

Projections: Much of the Same

Model Projections:

- Continued warming in all seasons – largest in winter
- Higher frequency of very hot days (> 95°F) and very warm nights (> 70°F)
- Magnitude of change is very dependent on emission scenario… fewer emissions = less warming
- 30 fewer 95°+ days and 70°F nights between lower and higher emission scenarios by 2080 in central Illinois





Source: NCICS & Univ. Edinburgh

Impacts

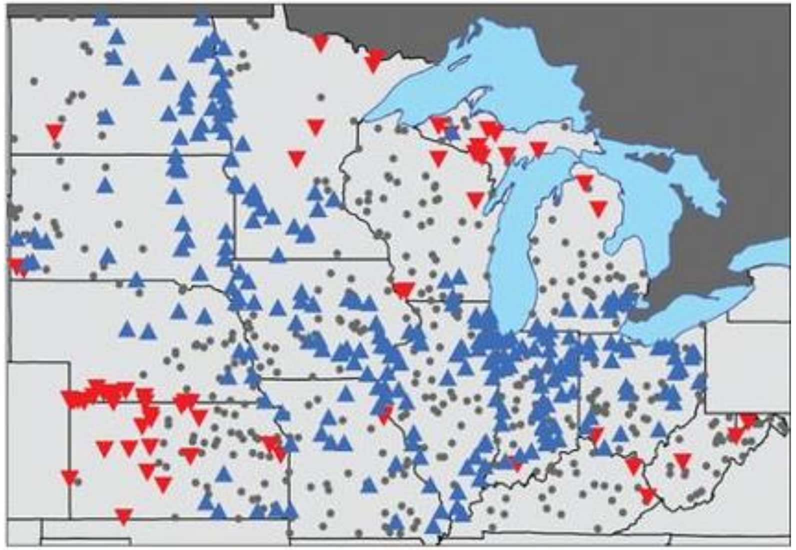
More Intense Precipitation

- Increased runoff and more rainfall going to streamflow
- Higher risk of flooding
- Less precipitation "yielded" for surface storage, could increase likelihood of drought impacts

Annual average precipitation, streamflow, and evapotranspiration for the Vermilion River Watershed (inches yr^{-1}) .

Periods	Precipitation	Streamflow	Estimated Evapotranspiration
1932-2016	37.1	9.9	27.2
1932-1964	35.0	7.7	27.3
1970-2016	38.5	11.6	26.9

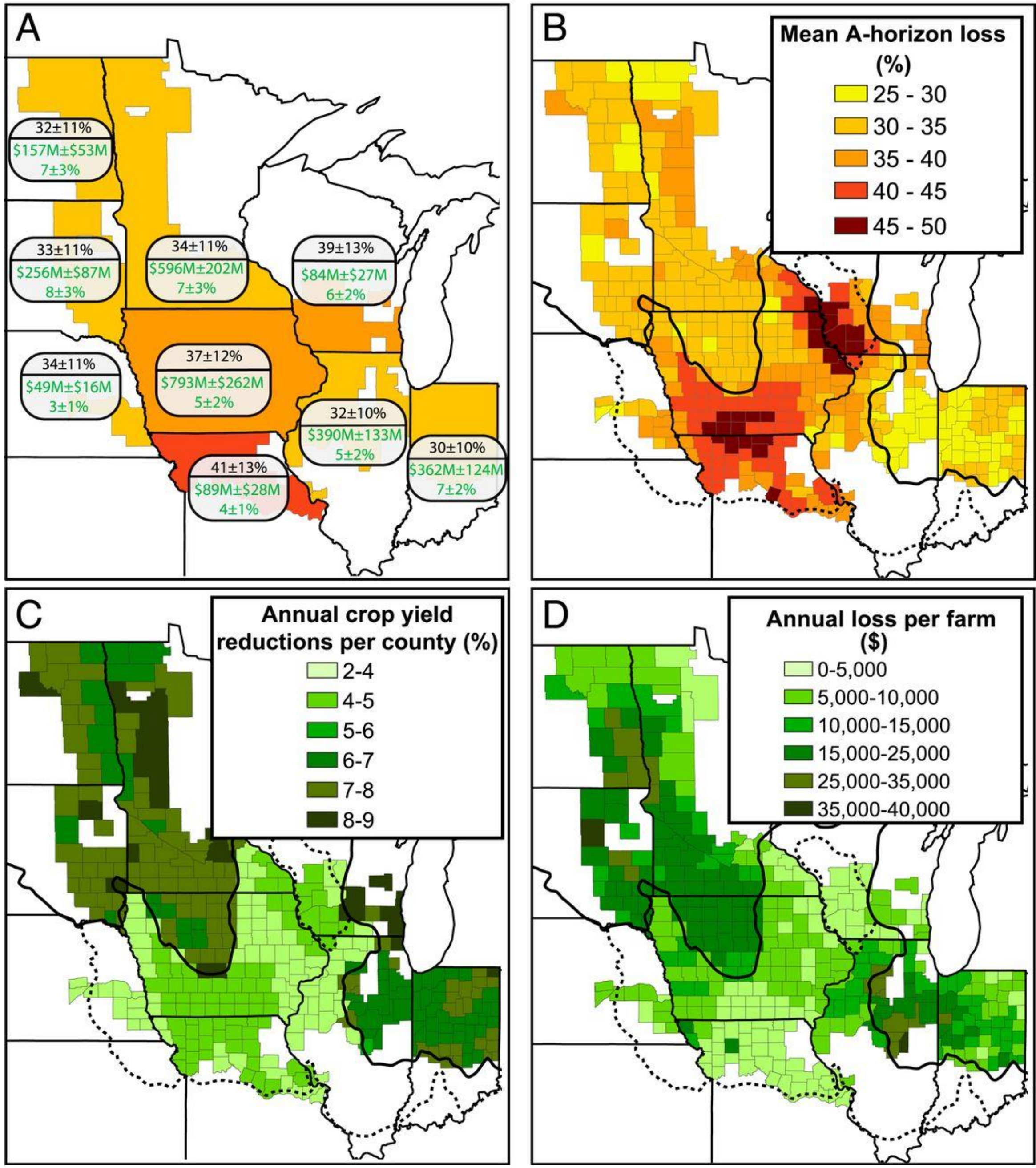
Kelly *et al.* (2018)



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

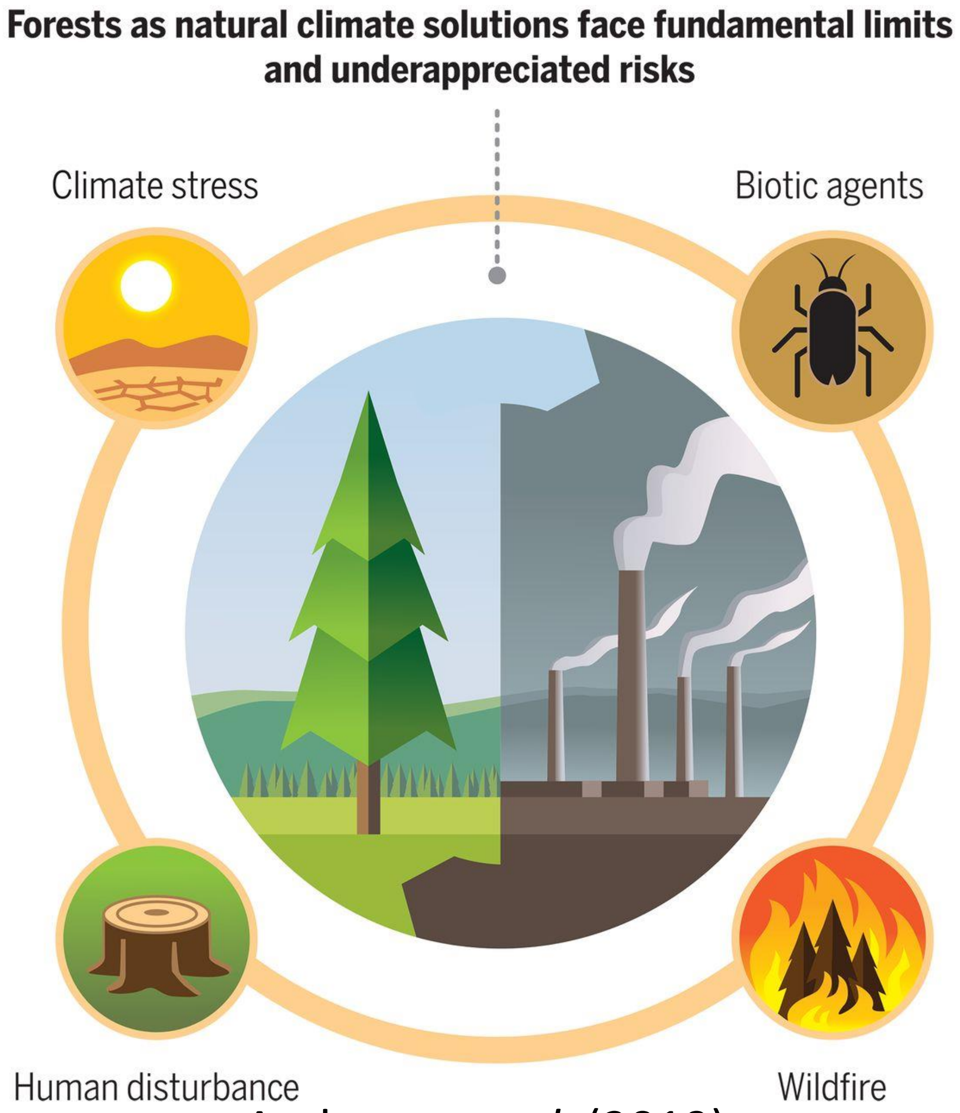
Soil Erosion

- New estimates suggest 30 – 50% of A-horizon has been lost in the Midwest since 1800s
- Estimated annual crop losses related to soil erosion range from $10,000 to $40,000 per farm in Illinois
- Reduced resilience to prolonged dry conditions
- Higher sedimentation rates and water quality issues from nutrient runoff
- Soil health degrades with erosion, economic losses difficult to quantify

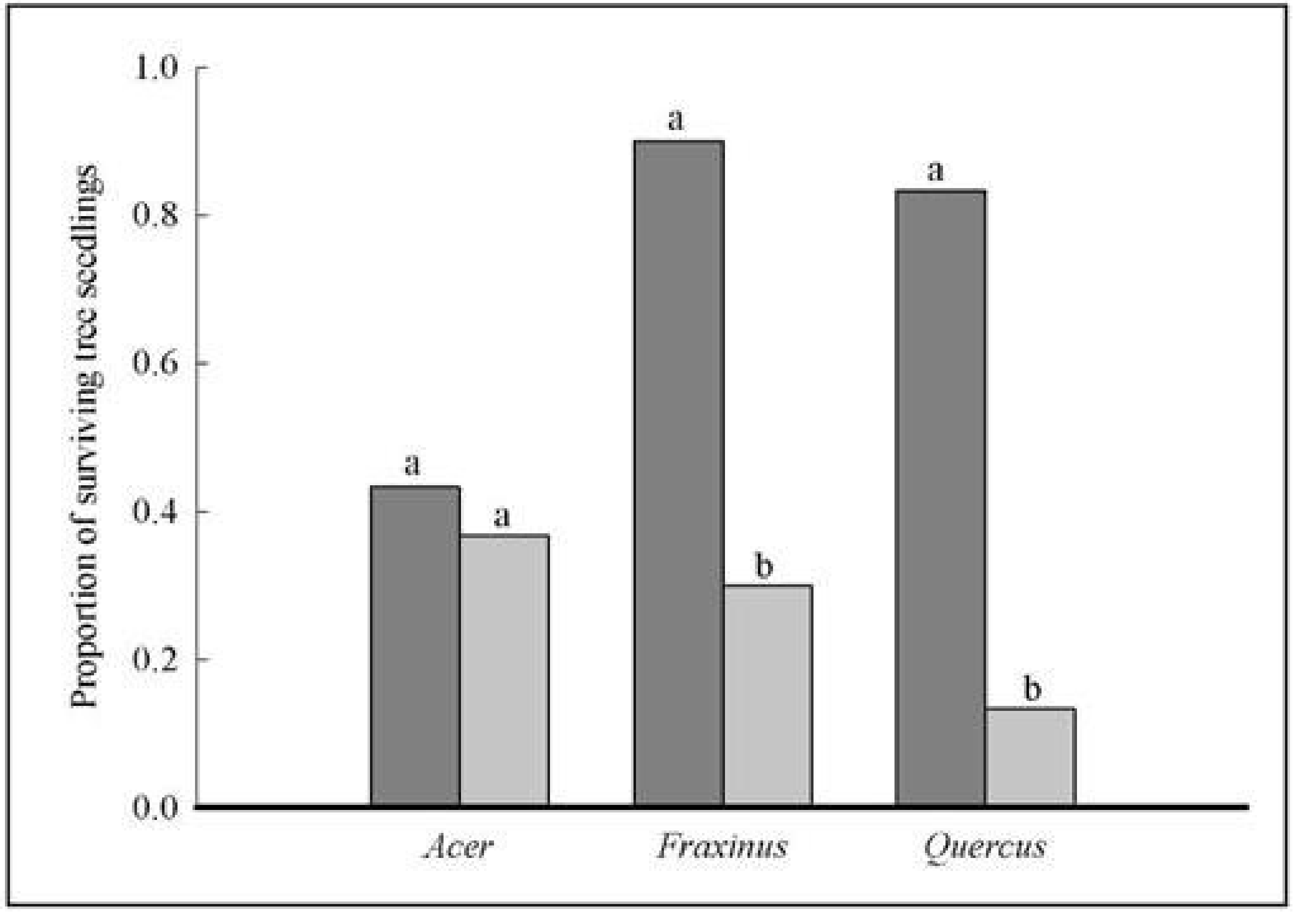


Thaler *et al.* (2021)

Forest Ecosystems



Anderegg *et al.* (2019)



Tree survival rate with (light gray bars) and without (dark gray bars) Japanese stiltgrass in eastern U.S. (from Aronson & Handel, 2011)

Aquatic Ecosystems

- Higher water temperature affects suitability, reproduction, survival rates
- Warm vs. cold water fish species impacted differently
- Warmer water + nutrient runoff from agricultural fields increase risk of harmful algal bloom in lakes and streams
- Pressure from invasive species that may be more suitable for warmer environment

Agriculture

- Longer growing season + higher CO_2 ***could*** benefit commodity crops
- Warmer winters = more insect pests, crop/livestock disease risk, fewer winter chill hours
- Wetter springs & more intense rainfall = soil erosion and nutrient runoff issues, less flexible treatment and planting
- Hotter summers = more evaporation and higher risk of drought impacts when dry
- Physical health impacts from exposure to heat, wet soils, and higher risk of injury from compressed windows
- Mental health impacts from a more challenging climate + market issues

What Can We Do?

Mitigation & Adaptation

- Decrease GHG emissions + increase sequestration
- Climate Resilient Agriculture
  - Widespread soil conservation practices
  - Forages and small grains, conservation grazing
  - Local food supply/demand chains
- Sustainable development
  - Greenspace, accessible transportation
  - Diverse, climate resilient urban canopy
  - Water management through engineering and design
- Natural Resources
  - Habitat restoration – water/flood management
- Planning
  - ***Just transition***
  - Hazard mitigation plans include changing climate/risk

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