

The Changing Climate and Kansas

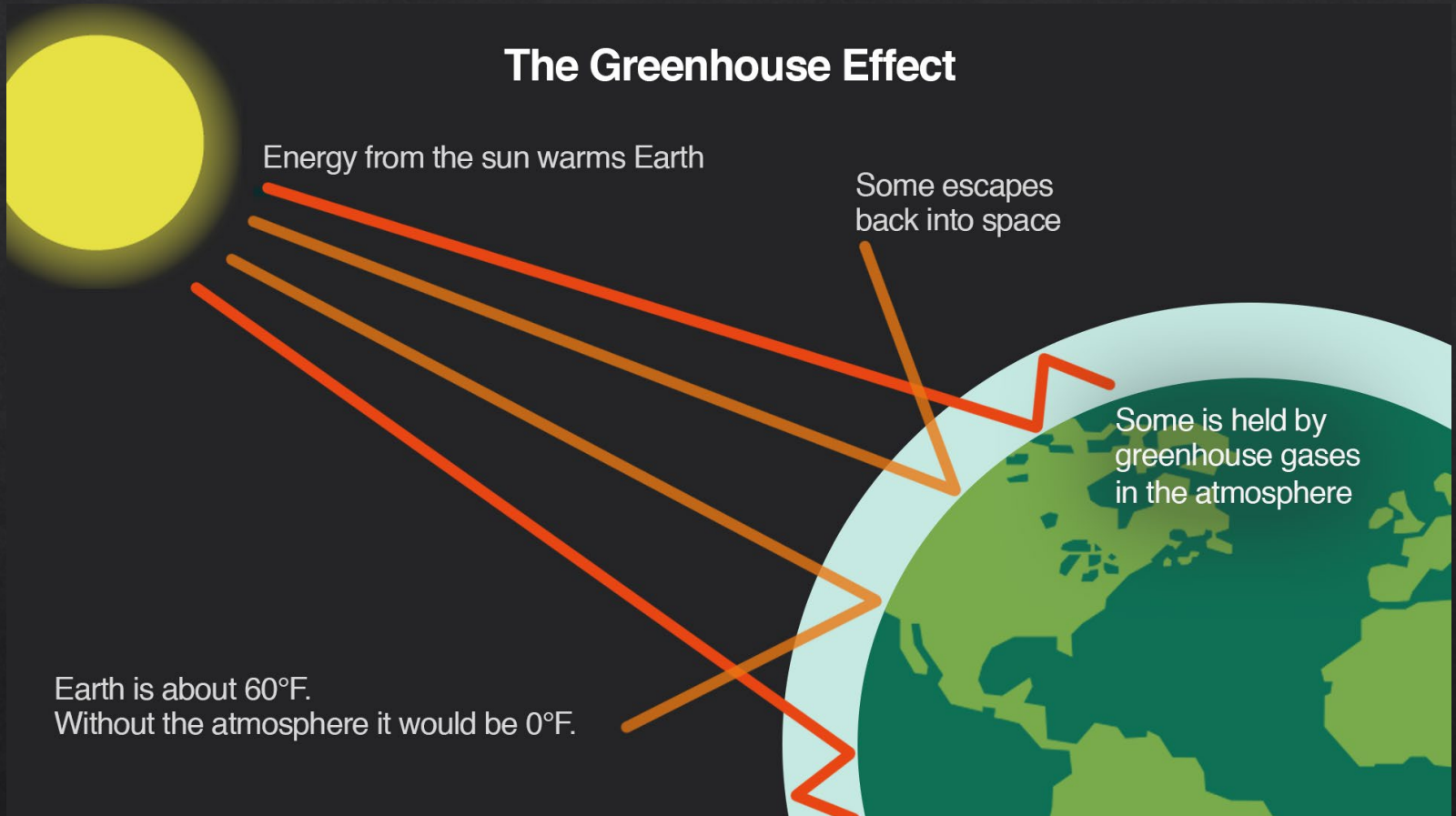


Agenda

- Changing Climate
- Impacts
- Outlooks
–(weeks/months)

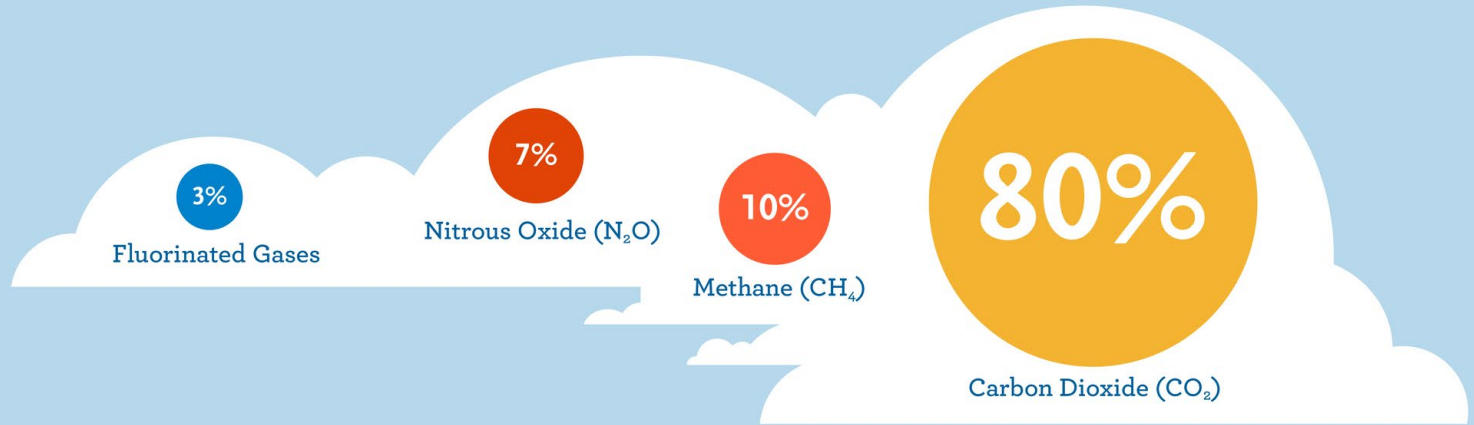


Science: Greenhouse Effect

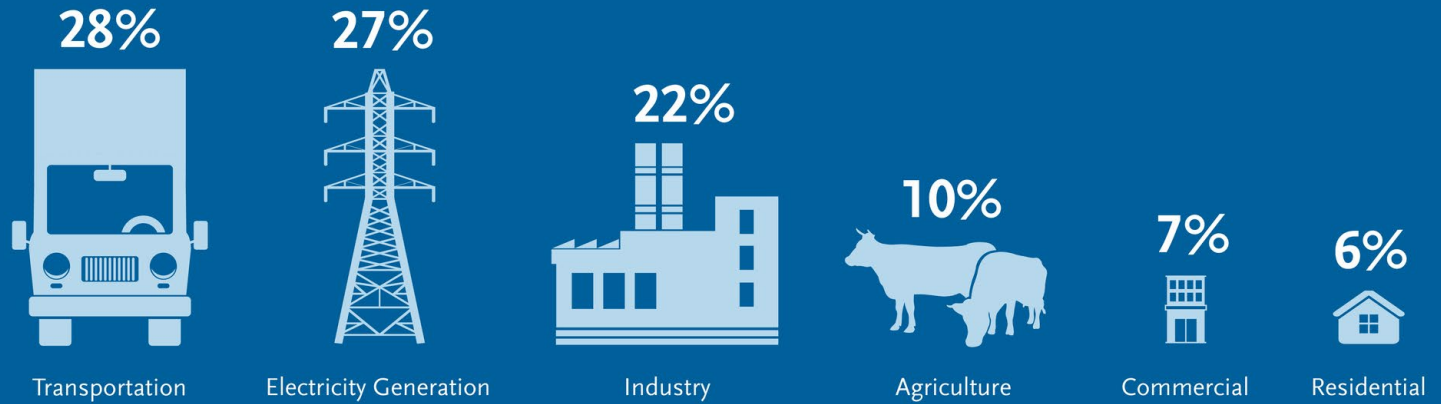


U.S. greenhouse gas emissions in 2018

U.S. Greenhouse Gas Emissions in 2018



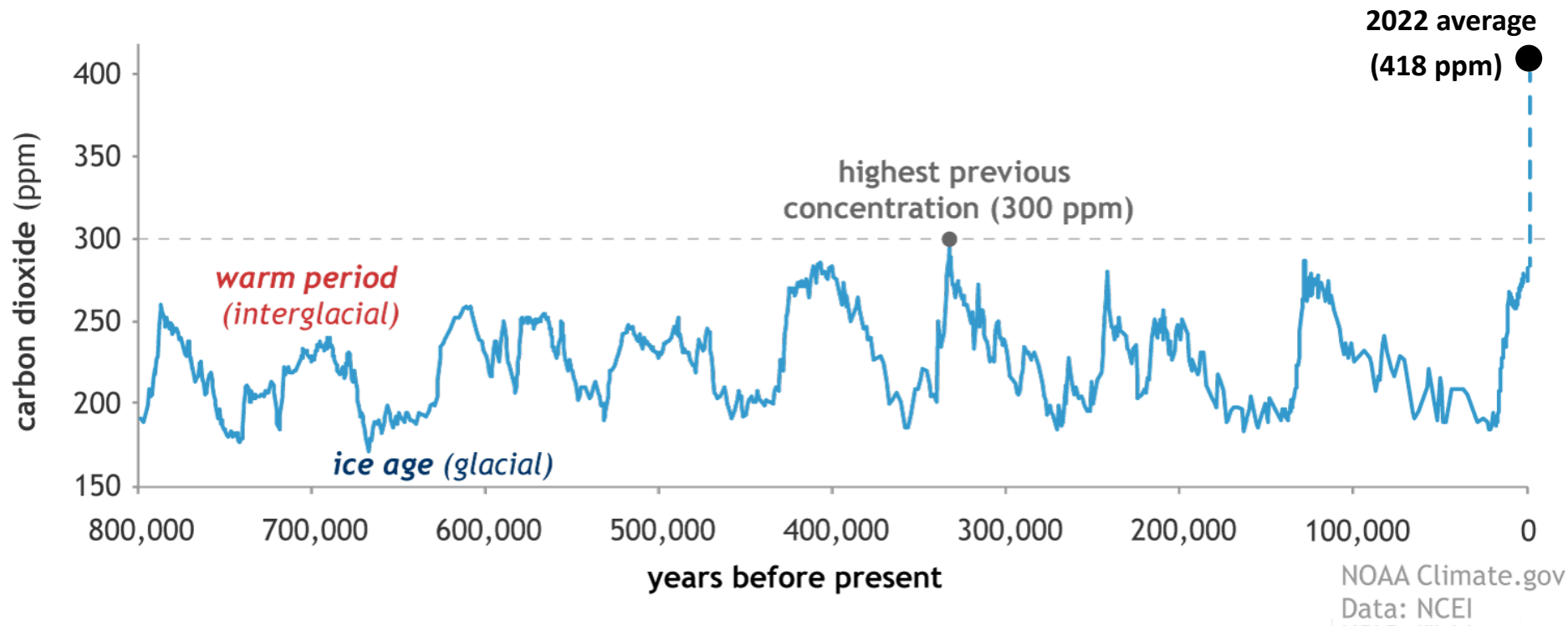
Total U.S. Greenhouse Gas Emissions by Economic Sector in 2018



Data from U.S. EPA.

Today's CO₂ values compared to the long term

CO₂ during ice ages and warm periods for the past 800,000 years



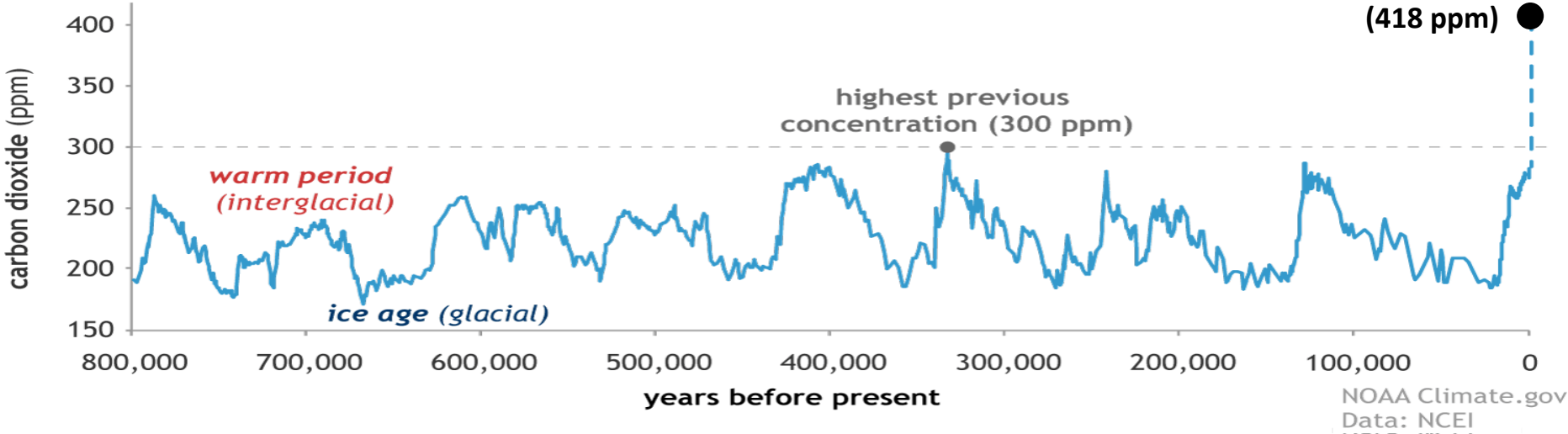
We are outside the historical range and could move WAY outside that range this century.

2100 Higher Emission Scenario (900 ppm)

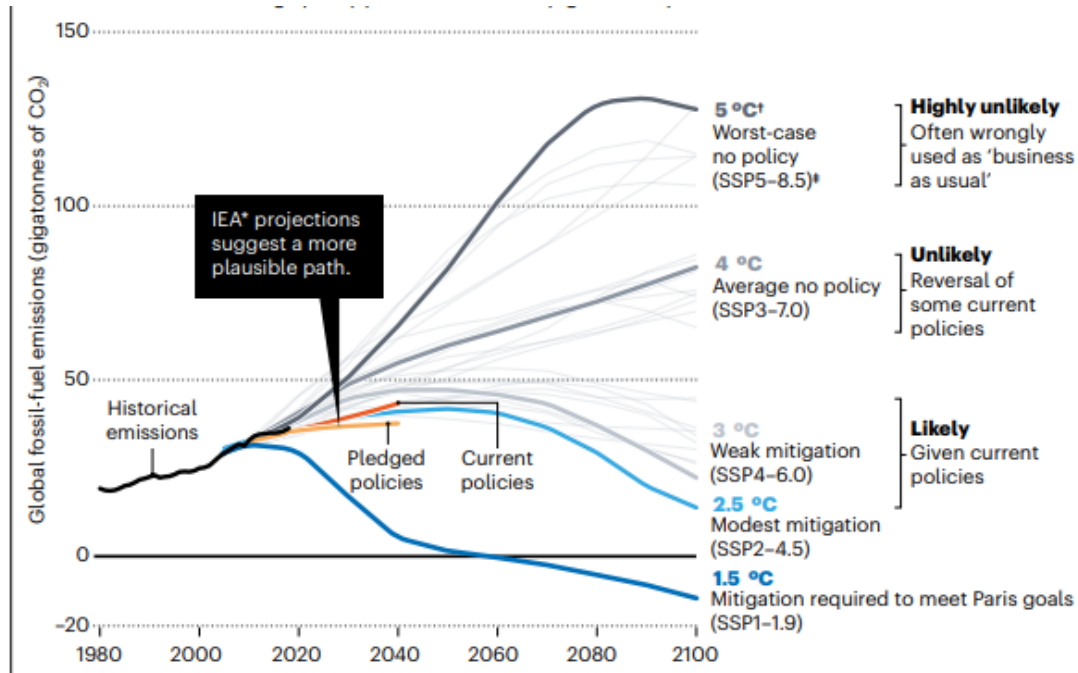
2100 Lower Emission Scenario (550 ppm)

2022 average (418 ppm)

CO₂ during ice ages and warm periods for the past 800,000 years



Good news and Bad news...Worst Case scenario implausible (good)...more likely 2.5-3C warming (bad)



Source: IEA/IPCC

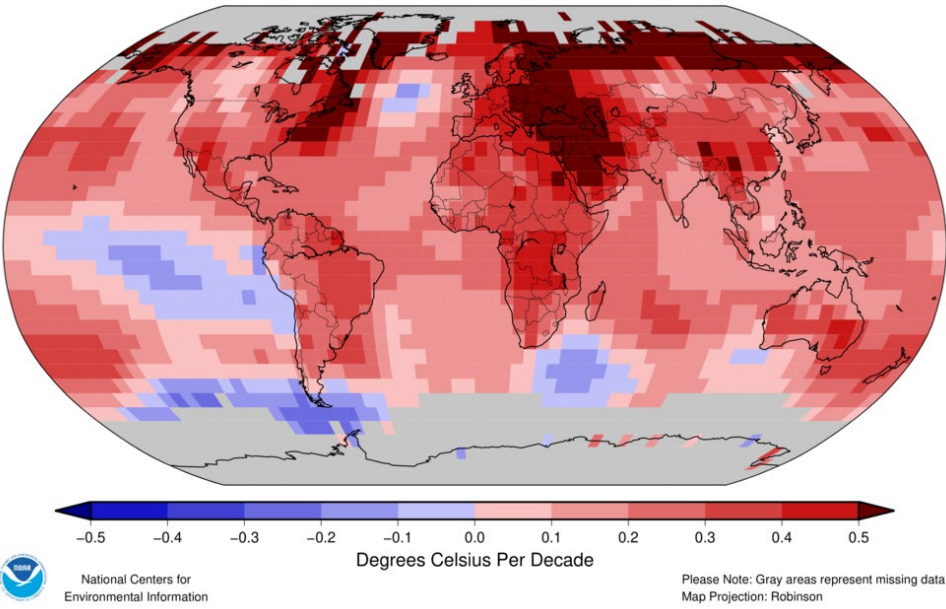
Annual Trends through 2020

Increase in rate of warming over the past three decades in most areas

Jan–Dec Land & Ocean Temperature Trends

Period: 1991–2020

Data Source: NOAA GlobalTemp v5.0.0–20210106

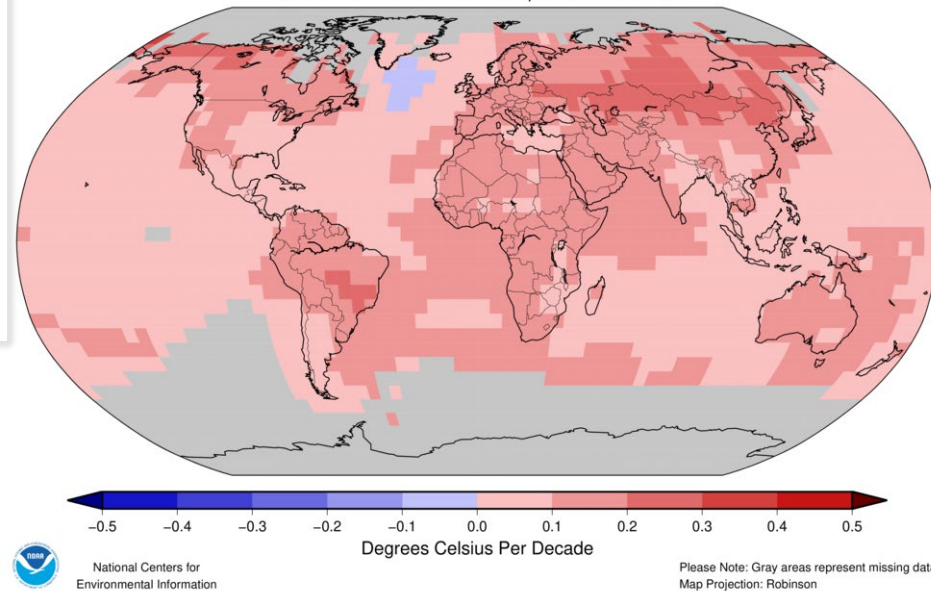


Last 120 years

Jan–Dec Land & Ocean Temperature Trends

Period: 1901–2020

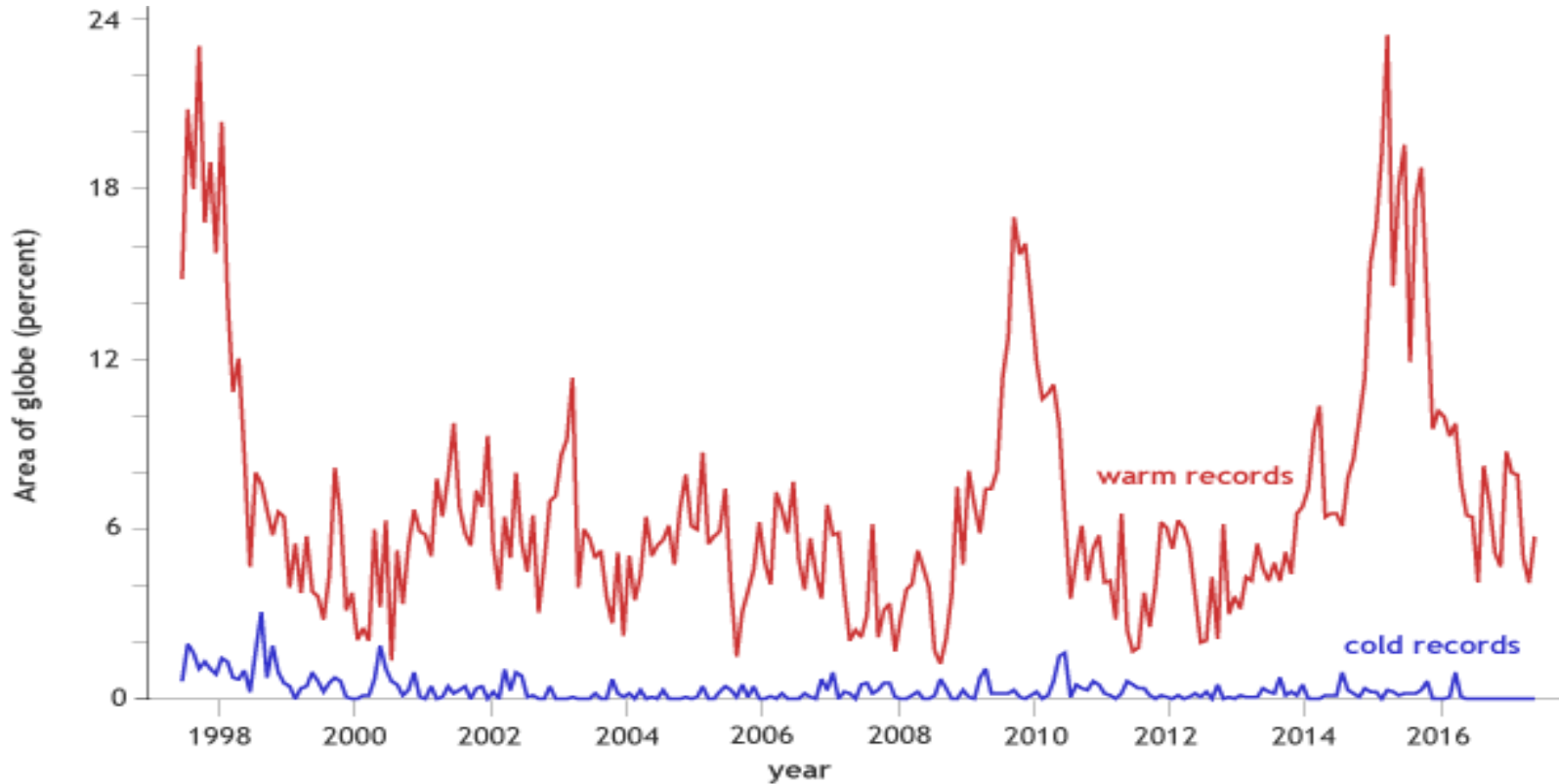
Data Source: NOAA GlobalTemp v5.0.0–20210106



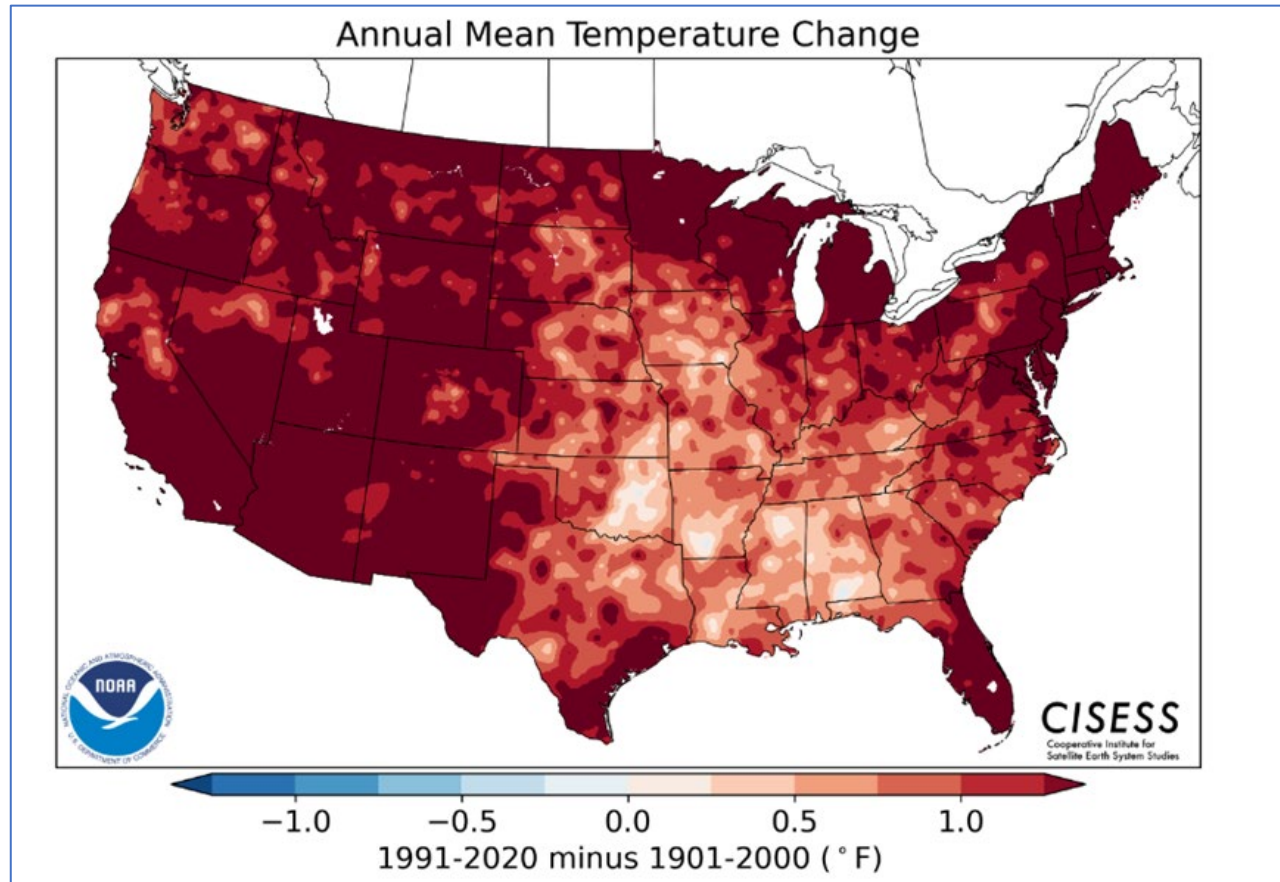
Last 30 years

Winter will still occur, but the odds favor more warm temperature records being broken than cold records

Monthly warm & cold records (1998-2017)



Comparing 1991-2020 to 1901-2000



- Warming trend is clearly seen in comparing the new normals to the Twentieth Century averages “teasing out” short term trends from longer term data

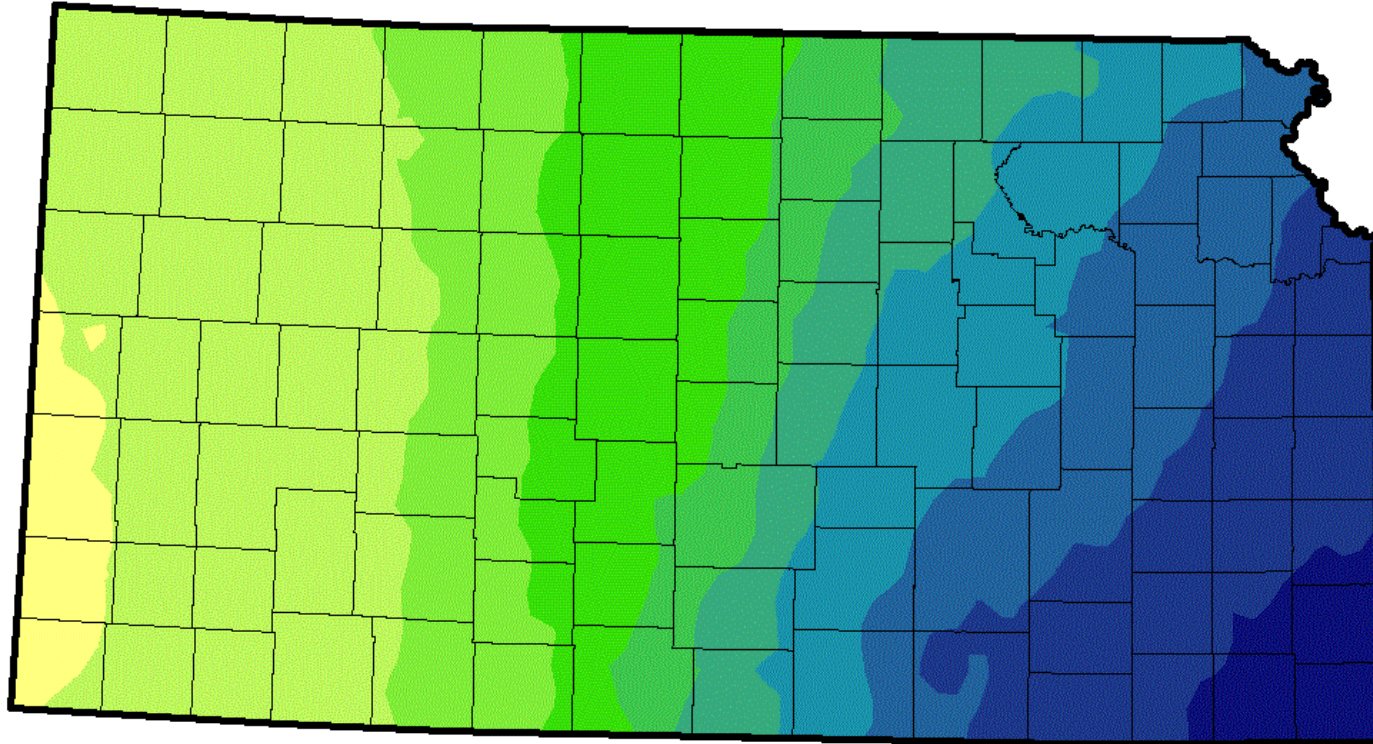
Kansas Changes

KEY MESSAGE 1

Temperatures in Kansas have risen about 1.5°F since the beginning of the 20th century, with greater warming in the winter and spring than in the summer and fall. The number of very cold nights has been below average since 1990. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

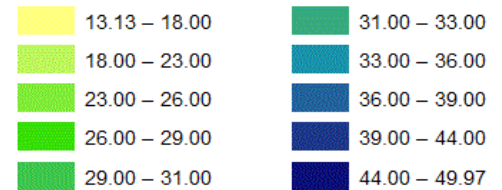
Normal Annual Precipitation

based on data from 1991-2020



0 25 50 100 Miles

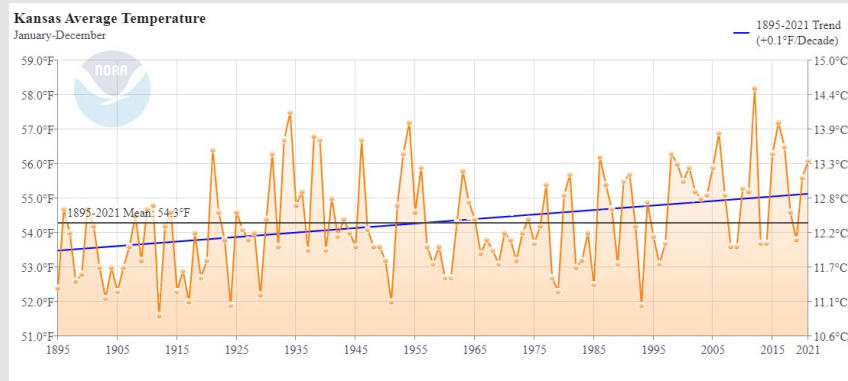
Total Precipitation (Inches)



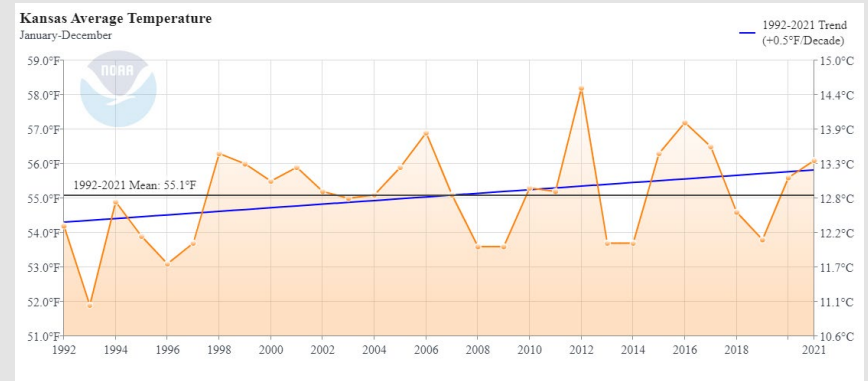
Produced by Weather Data Library
Department of Agronomy
Kansas State University

Kansas Trends Temperature

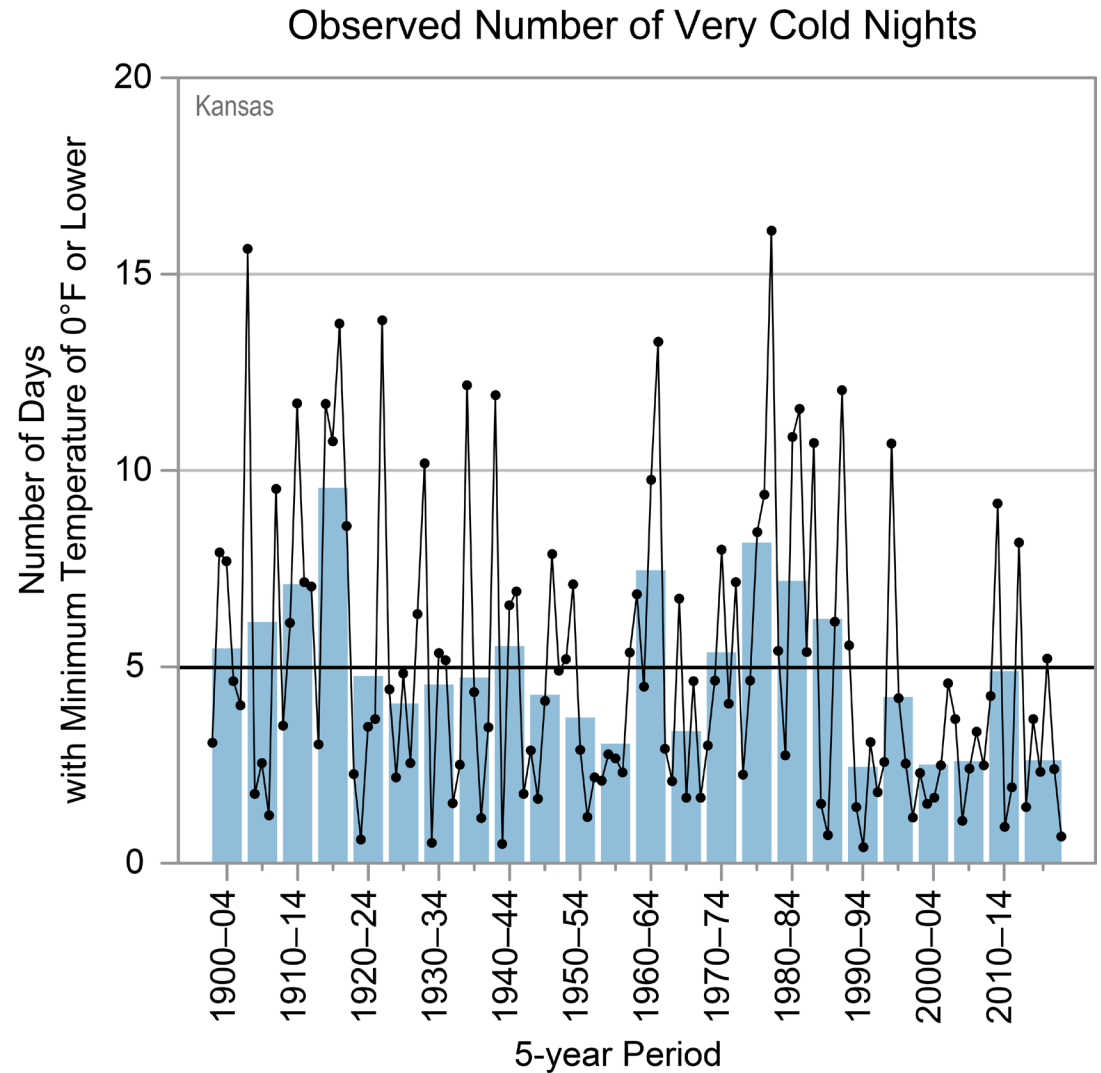
1895-2021 Avg Temp



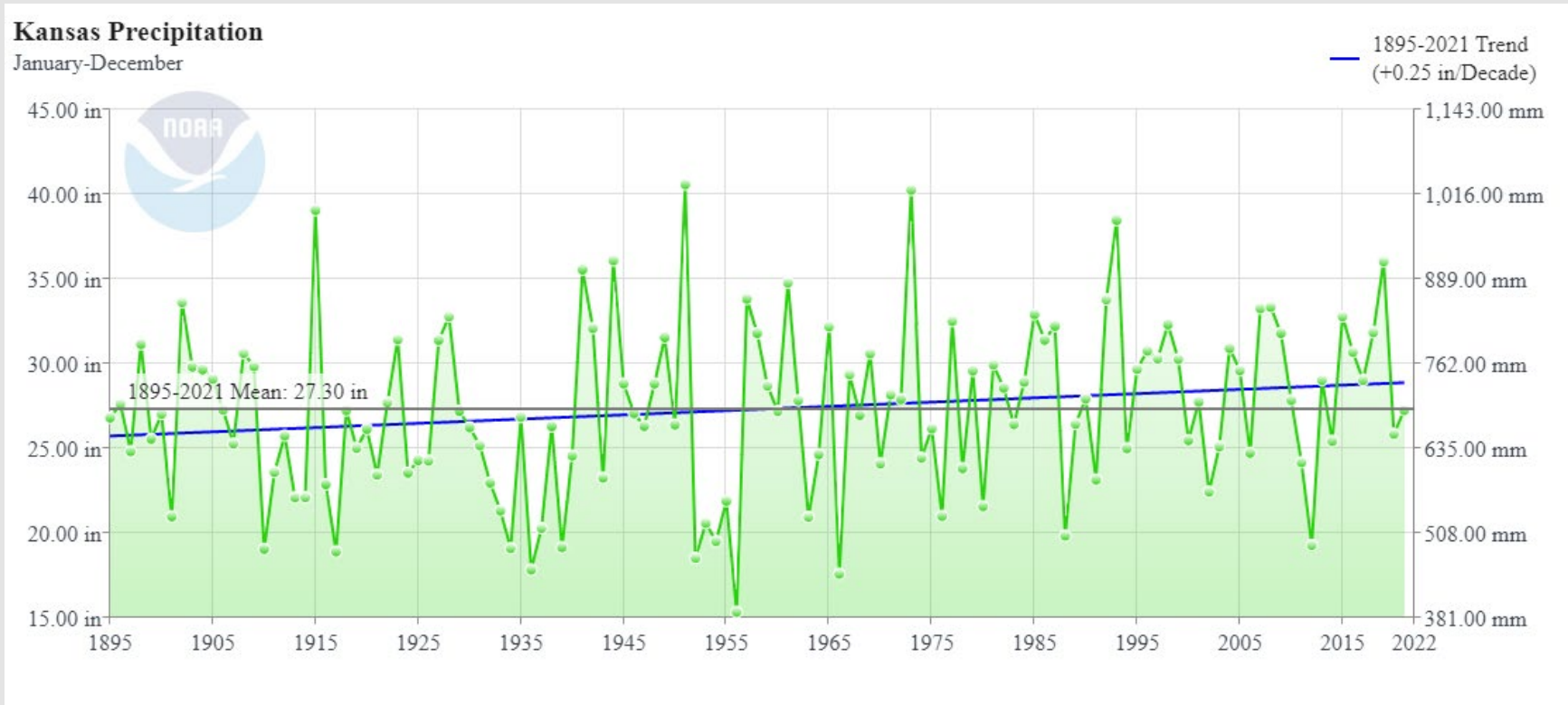
1992-2021 Avg Temp



Observed number of low temperatures below zero since 1900 in Kansas has decreased in frequency i.e. fewer extreme cold outbreaks in winter

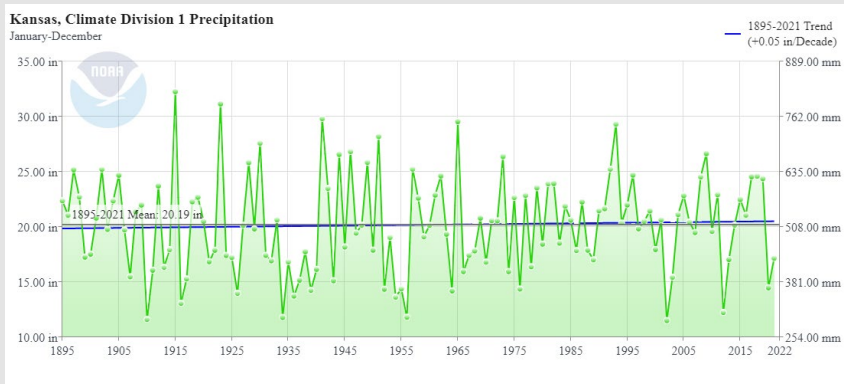


Kansas Precipitation Trends

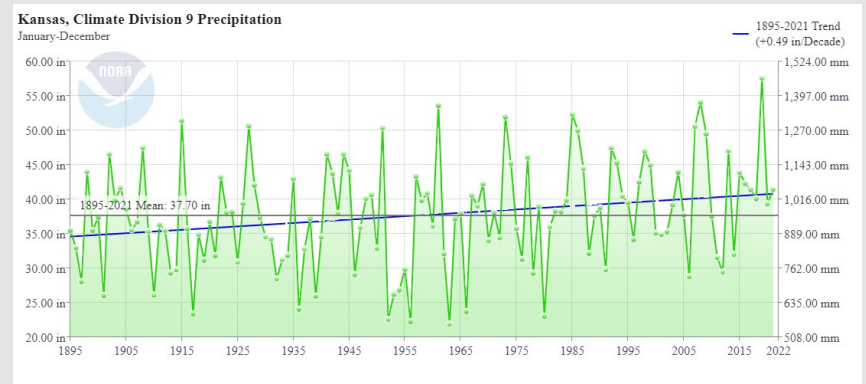


Kansas Trends Precipitation

1895-2021 Avg Precip NW Kansas

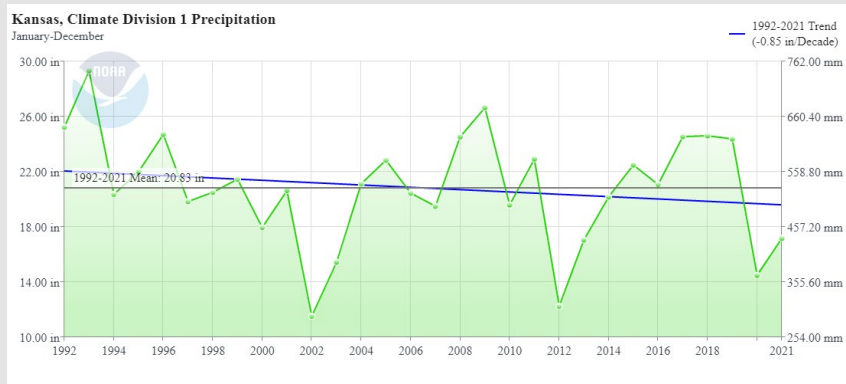


1895-2021 Avg Precip SE Kansas



Kansas Trends Precipitation

1992-2021 Avg Precip Trend NW Kansas



1992-2021 Avg Precip Trend SE Kansas

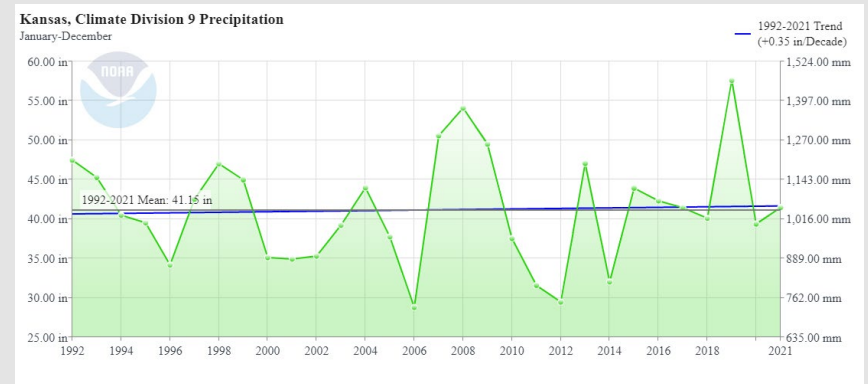
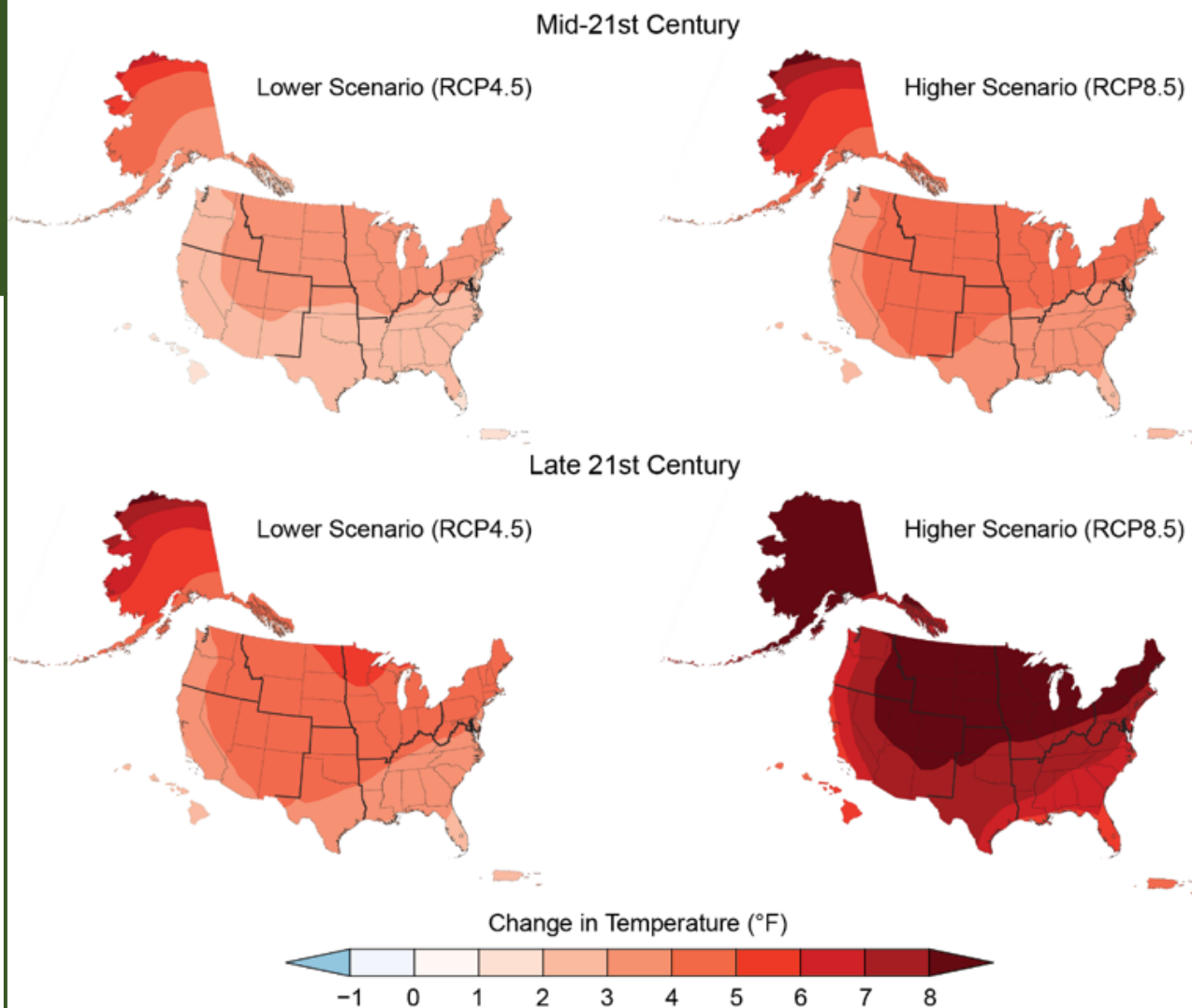


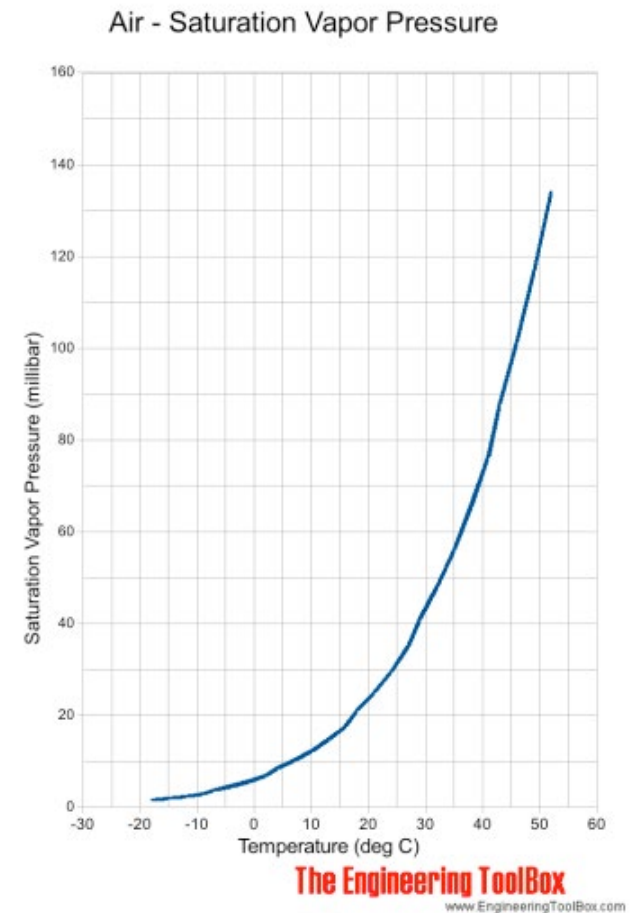
Fig. 1.3: Projected Changes in U.S. Annual Average Temperature

Annual average temperatures across the United States are projected to increase over this century, with greater changes at higher latitudes as compared to lower latitudes, and under a higher scenario (RCP8.5; right) than under a lower one (RCP4.5; left). This figure shows projected differences in annual average temperatures for **mid-century (2036–2065; top)** and **end of century (2071–2100; bottom)** relative to the near present (1986–2015). *From Figure 2.4, Ch. 2: Climate (Source: adapted from [Vose et al. 2017](#)).*



Warm Air Holds More Water Vapor: A lot more

- Saturation vapor pressure is the total amount of pressure exerted if the air were saturated (relative humidity 100%)
 - Nearly doubles for every 10 deg C increase in temperature
 - Warm tropical air can hold 4-10 times as much vapor as cold, dry air
 - Consequently more latent heat release in storms, more precipitation



Recent 30 years (1991-2020) compared to the past (1901-2000)

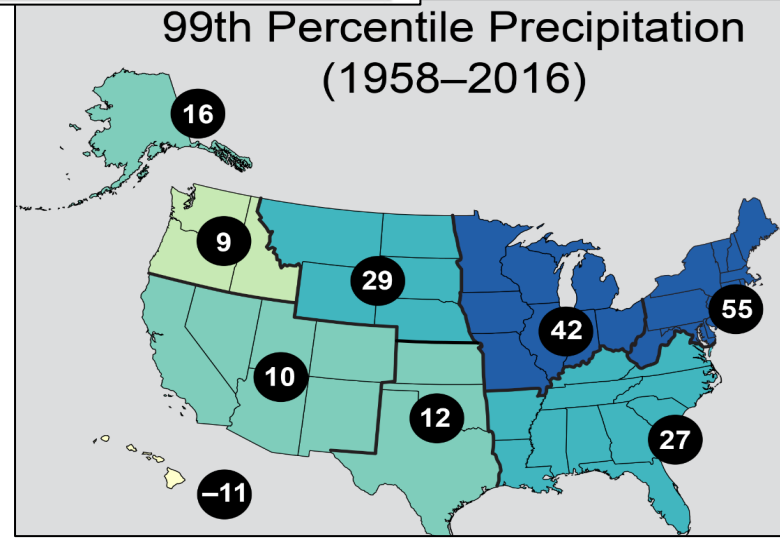
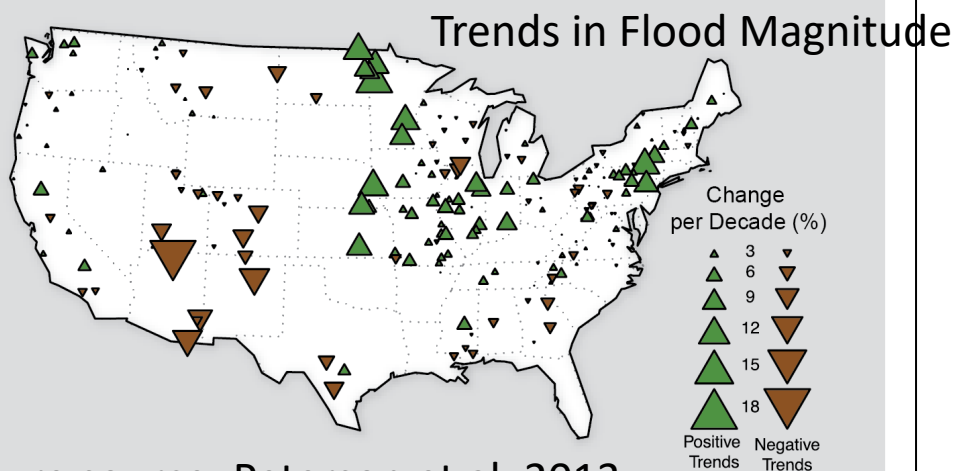
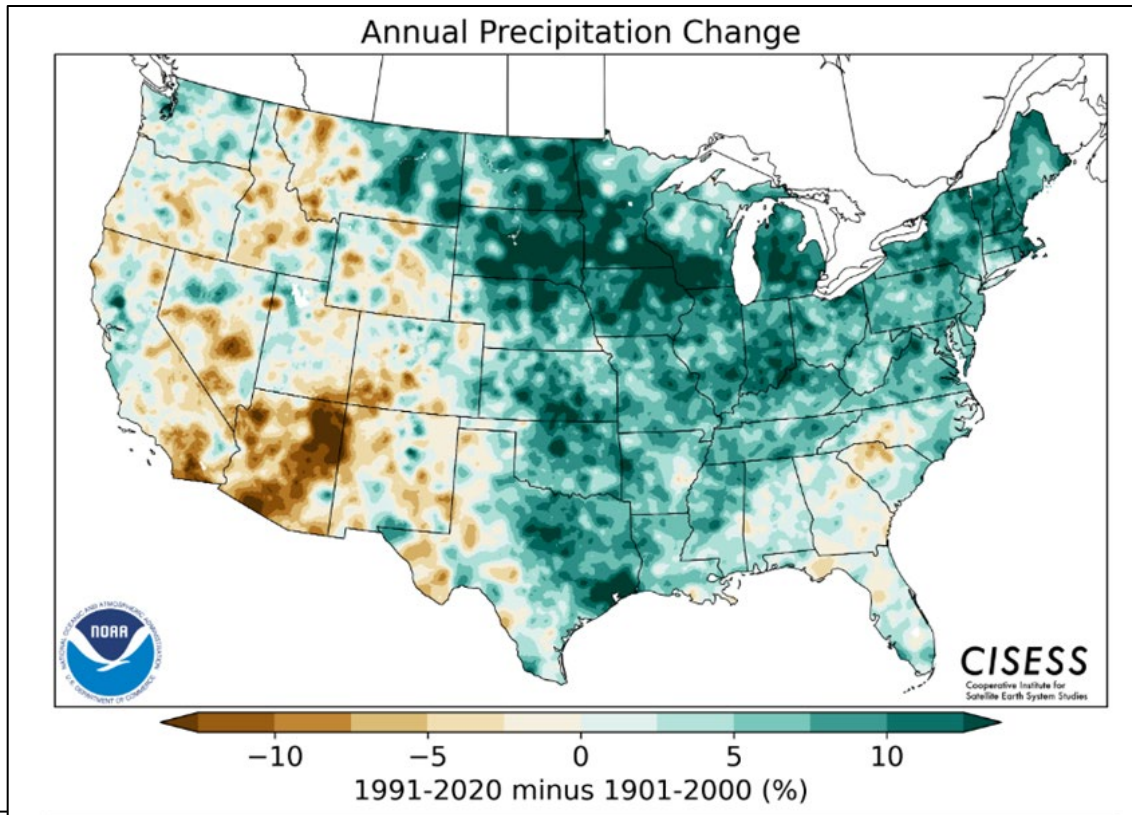
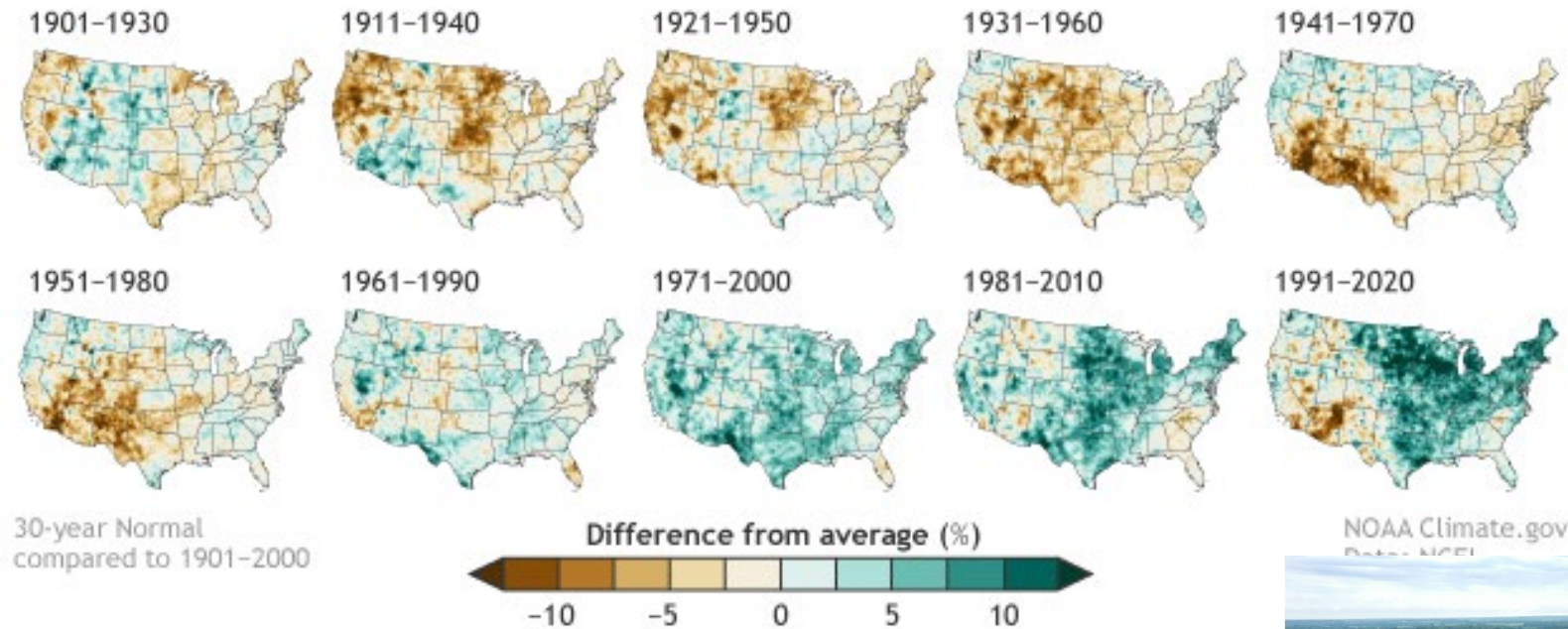


Figure source: Peterson et al. 2013

Precipitation Changes Over the Decades (1901 -2020)

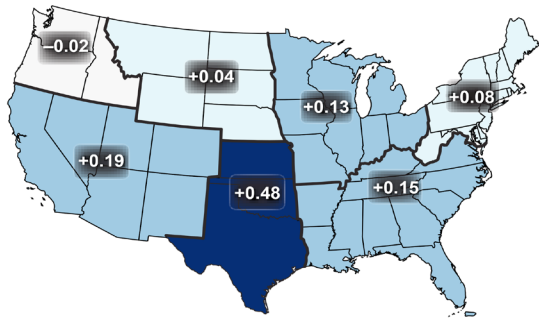
U.S. ANNUAL PRECIPITATION COMPARED TO 20th-CENTURY AVERAGE



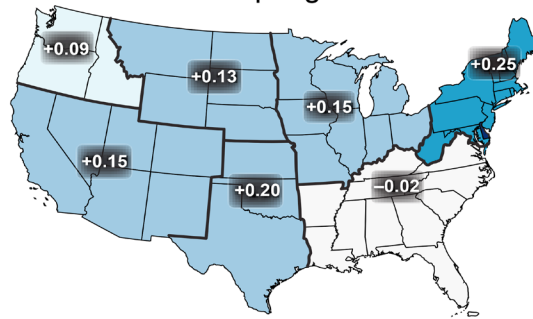
Heavy Rainfall

Observed Change in Daily, 20-year Return Level Precipitation

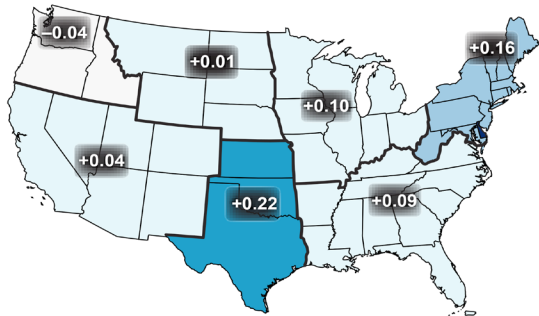
Winter



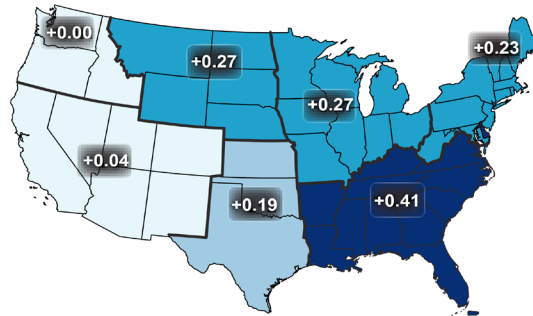
Spring



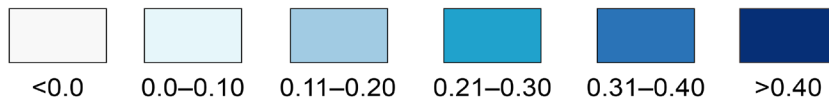
Summer



Fall



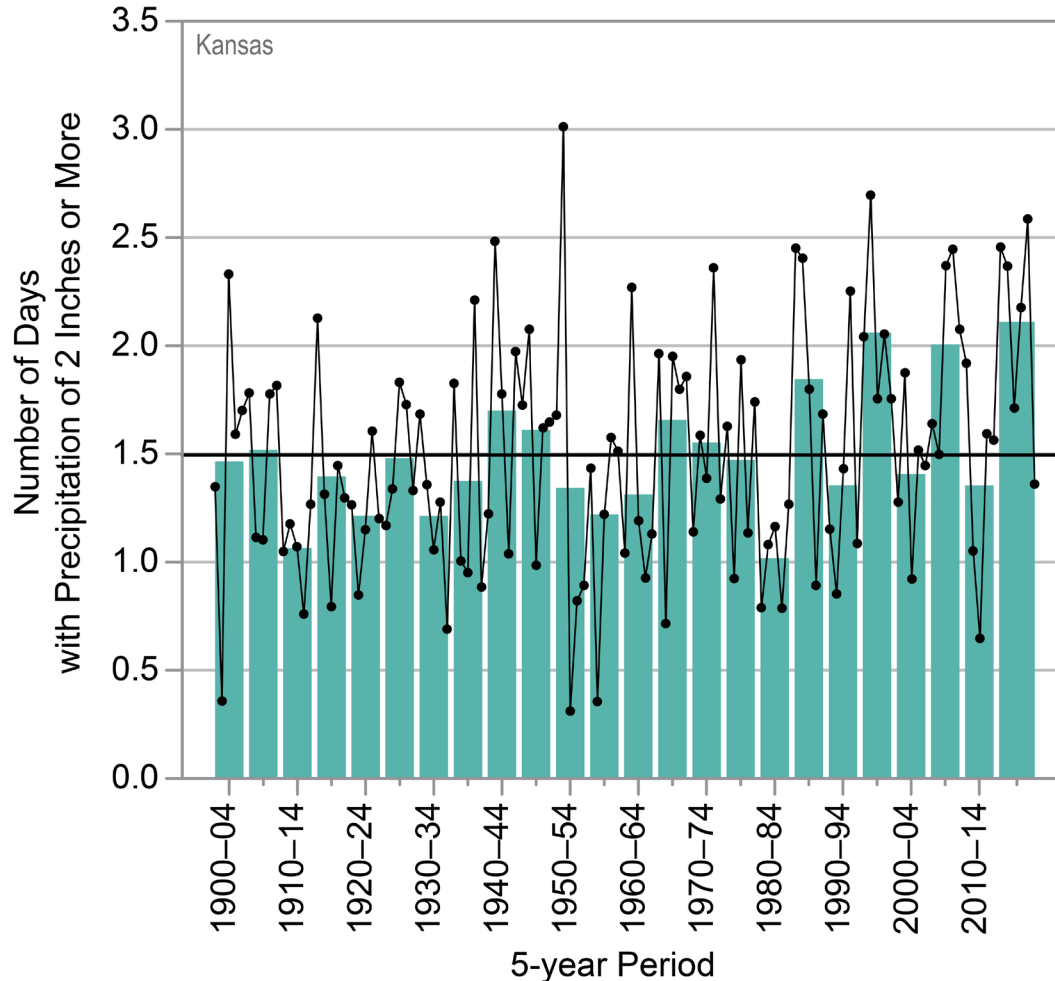
Change (inches)



- Daily 20-year Return means amount of rainfall expected to occur, on average, once every 20 years
- Amounts have increased more than 0.4 inch in places (slight decrease in some places)
- Varies geographically by season

Heavy Rainfall

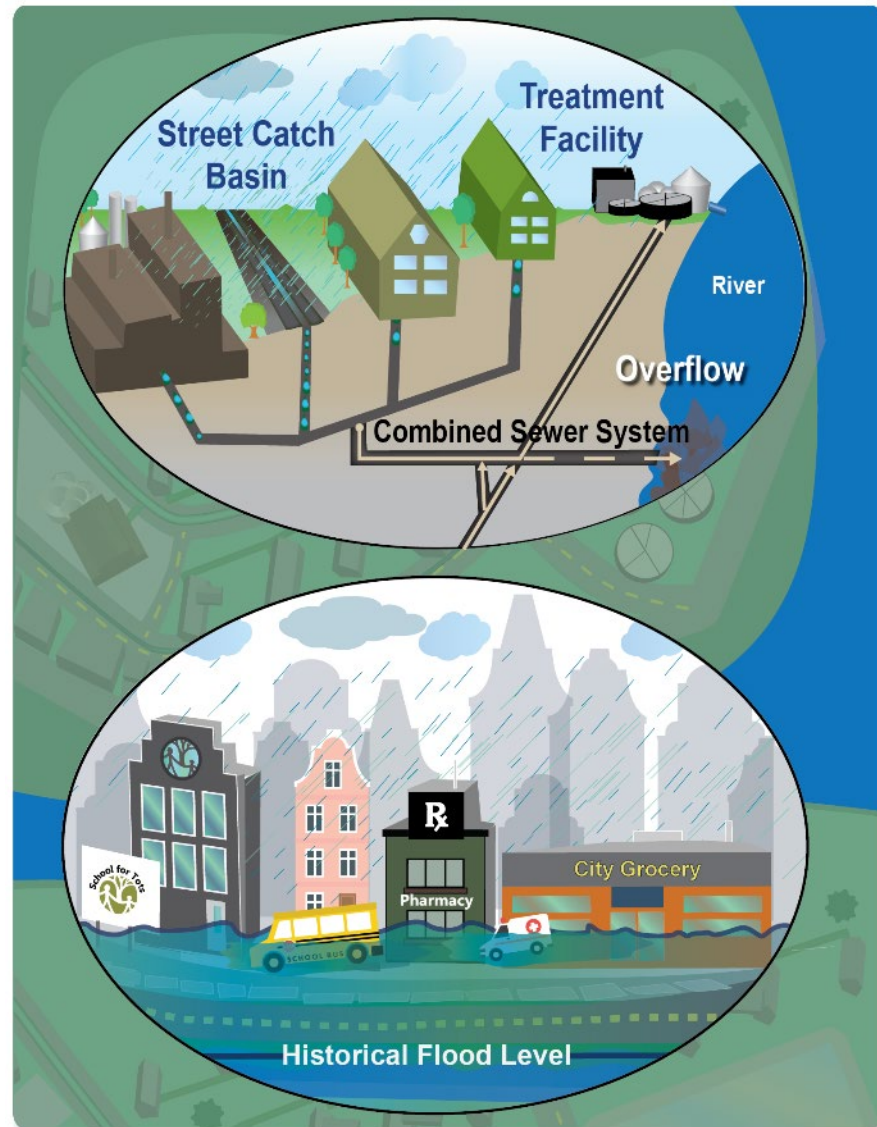
Observed Number
of 2-Inch Extreme Precipitation Events



- Daily 2+ inch rainfall events has shown an increase in occurrence since 1900 across Kansas
- Varies geographically by season

Fig. 11.6: Cascading Consequences of Heavy Rainfall for Urban Systems

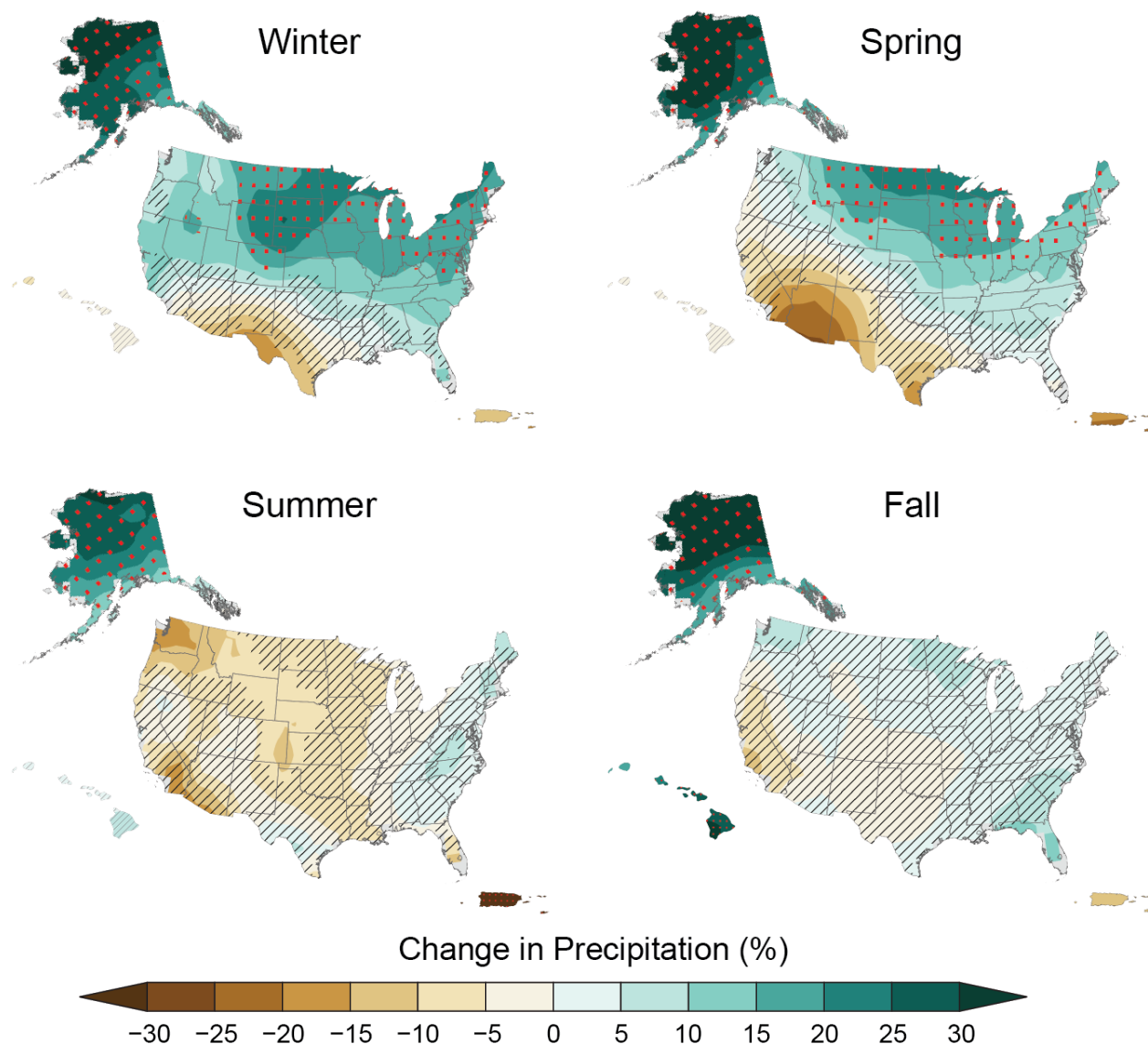
With heavy downpours increasing nationally, urban areas experience costly impacts. (top) In cities with combined sewer systems, storm water runoff flows into pipes containing sewage from homes and industrial wastewater. Intense rainfall can overwhelm the system so untreated wastewater overflows into rivers. Overflows are a water pollution concern and increase risk of exposure to waterborne diseases. (bottom) Intense rainfall can also result in localized flooding. Closed roads and disrupted mass transit prevent residents from going to work or school and first responders from reaching those in need. Home and commercial property owners may need to make costly repairs, and businesses may lose revenue. *Source: EPA.*



Late 21st Century, Higher Scenario (RCP8.5)

Fig. 2.5: Projected Changes in U.S. Seasonal Precipitation Amounts

In the future, under the higher scenario, the northern U.S. is projected to receive **more precipitation, especially in winter and spring** by 2070-2099, relative to 1986-2015. Areas with red dots show where projected changes are large compared to natural variations; areas that are hatched show where projected changes are small and relatively insignificant. *Adapted from Easterling et al. 2017.*



Extremes...Recent Past



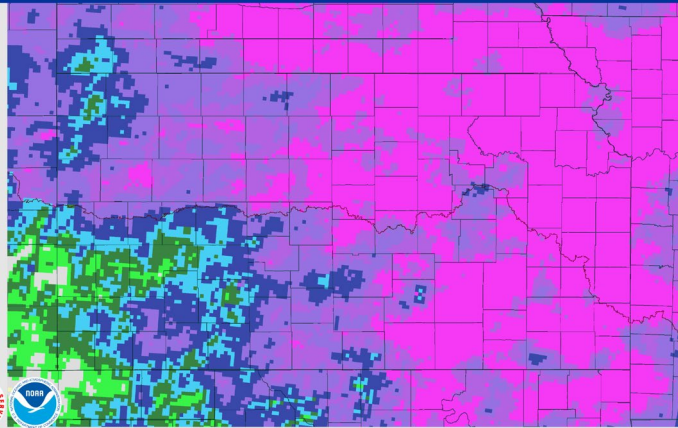
Recent Extremes

2019 Precip Departure

2022 Precip Departure

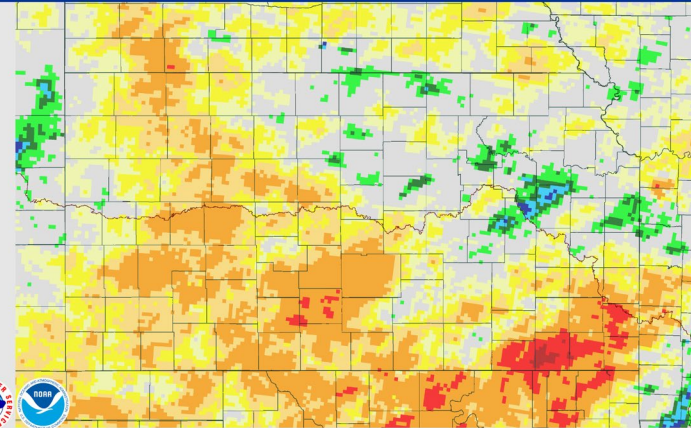
October 01, 2019 Water Year (Oct. 1) Departure Precipitation

Created on: December 21, 2022 - 18:38 UTC
Valid on: October 01, 2019 12:00 UTC



October 01, 2022 Water Year (Oct. 1) Departure Precipitation

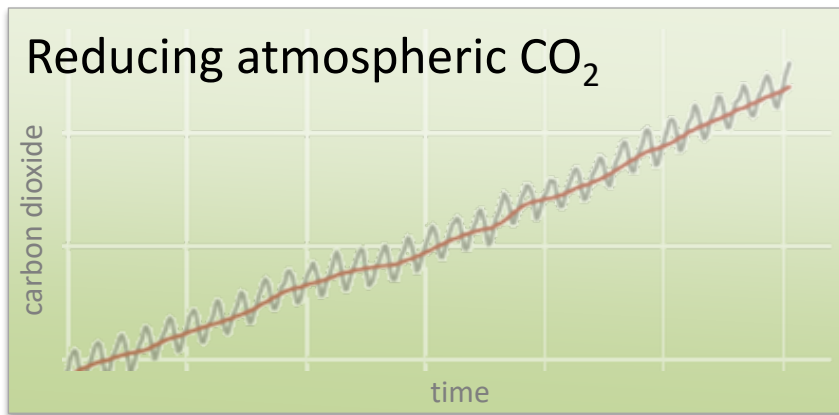
Created on: December 21, 2022 - 18:38 UTC
Valid on: October 01, 2022 12:00 UTC



What Can We Do About It?

Mitigation

Reducing greenhouse gas emissions &/or removing carbon dioxide from the atmosphere may be able to lessen the severity of climate change & its impacts over the very long term.



Adaptation

Improving our ability to cope with or avoid harmful impacts; or taking advantage of newly favorable conditions. Reducing risk and vulnerability, and exploiting opportunities.



Adaptation: Anticipating & adjusting to new conditions

What changes are coming?

What changes do we need to make?

- **Stop building and re-building in vulnerable areas (exposure and vulnerability are driving many of the losses)**
- Develop infrastructure to manage water extremes
- Plant different crops
- Install green roofs or reflective roofs
- Make assets & supply chains more resilient



Assessing a region's ability to handle sea level rise and flooding

Kansas Impacts

- **It is getting warmer ~1.5F since 1900 and potential for another ~5F by end of century**
- **Increased evaporation and water loss even with average precipitation**
- **Heavier rainfall events/more intense could exacerbate erosion and sedimentation of reservoirs**
- **Longer growing season later frost and earlier green up –Ag impacts**

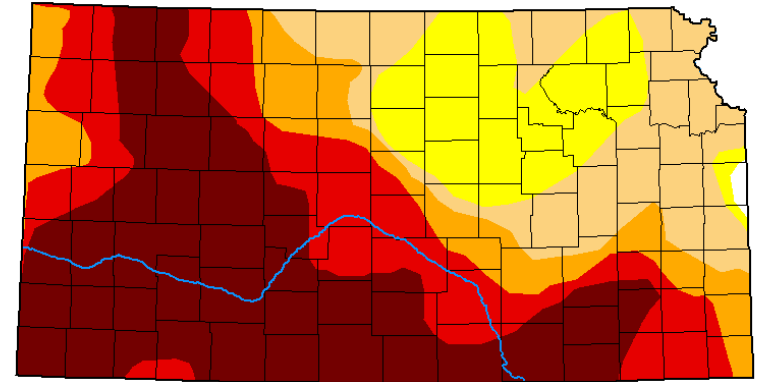
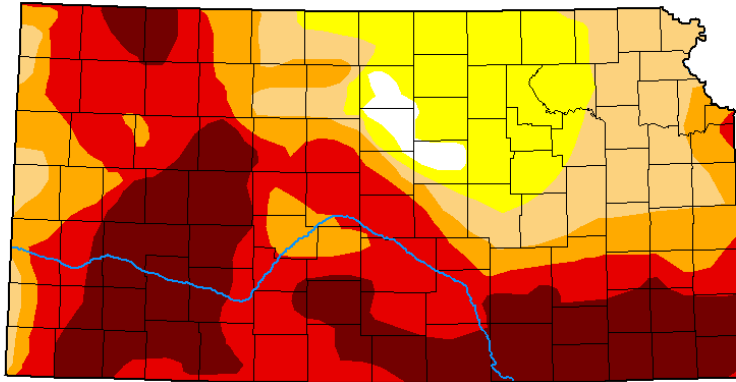
Kansas Impacts

- The *intensity* of future droughts is projected to increase (increased evaporation soil drying. *Frequency* of droughts uncertain
- Frequency and severity of wildfires could also increase especially if the precipitation projections below occur
- It is getting wetter in some places
 - Increase in winter/spring but less in summer/fall good for winter wheat bad for corn other summer crops?

Current Drought Status

October 4 2022

December 27th 2022



Drought Classification

None

D0 (Abnormally Dry)

D1 (Moderate Drought)

D2 (Severe Drought)

D3 (Extreme Drought)

D4 (Exceptional Drought)

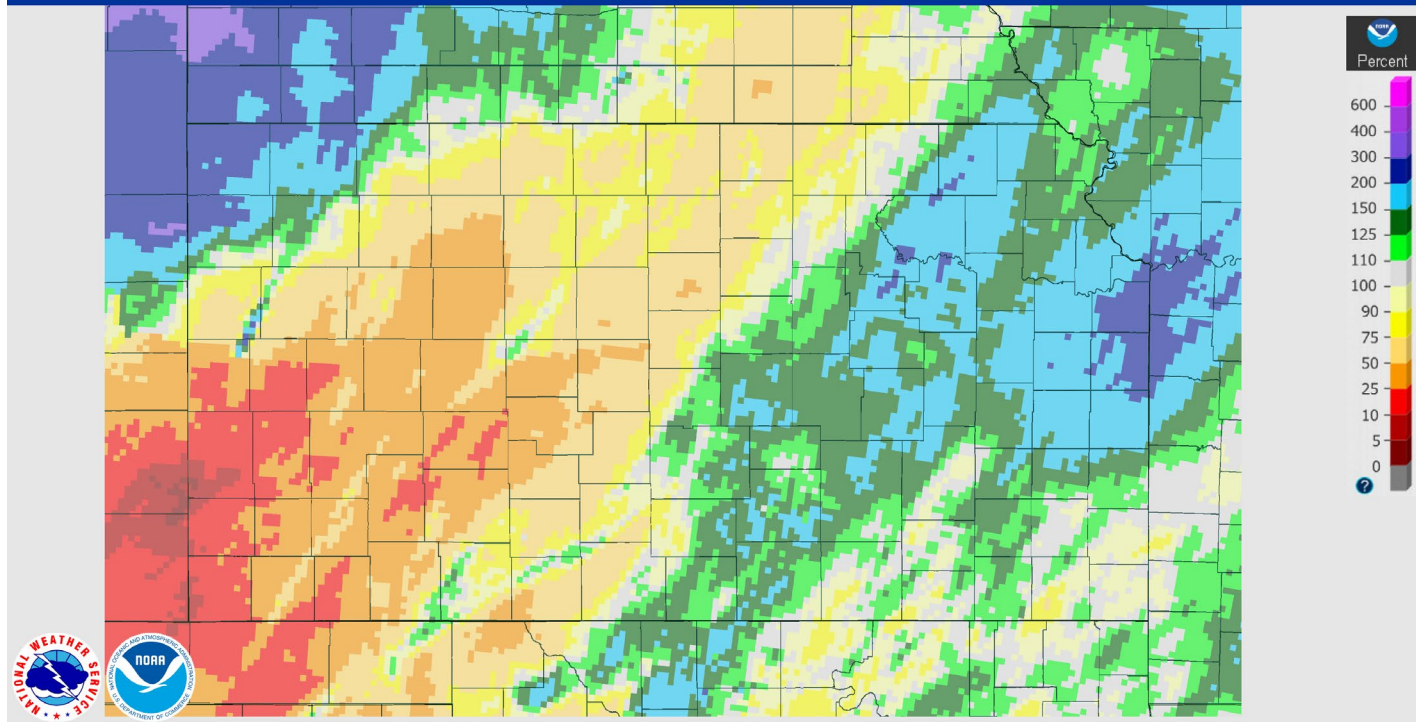
No Data

Last 60 days Precip % of Average

January 03, 2023 60-Day Percent Precipitation

Created on: January 03, 2023 - 13:52 UTC

Valid on: January 03, 2023 12:00 UTC

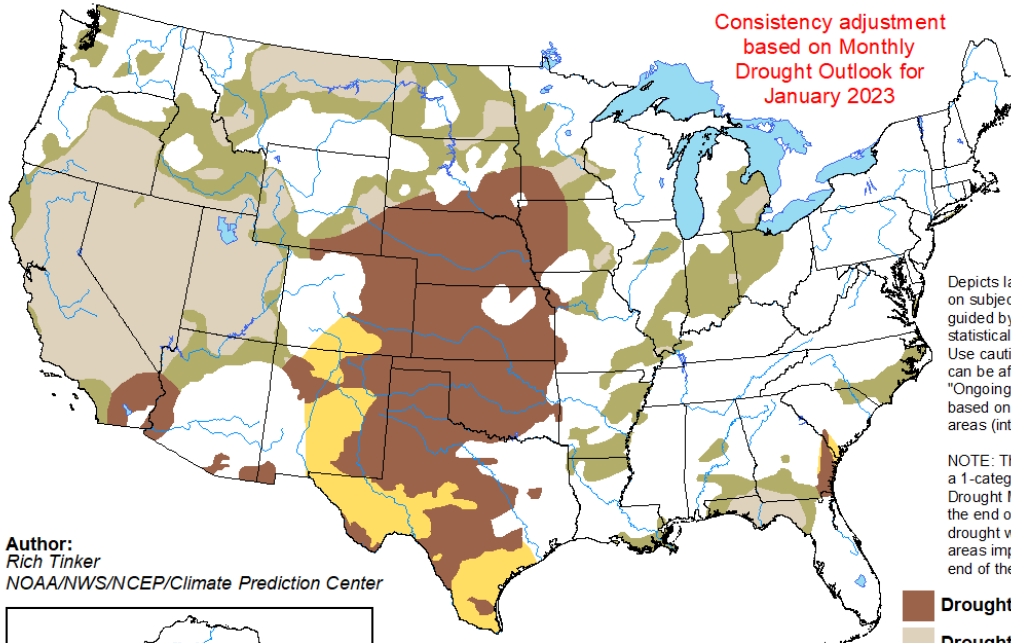


Seasonal Drought Outlook

U.S. Seasonal Drought Outlook Drought Tendency During the Valid Period

Valid for January 1 - March 31, 2023
Released December 31, 2022

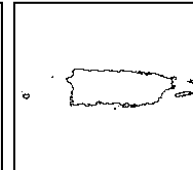
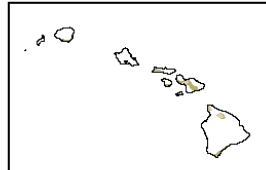
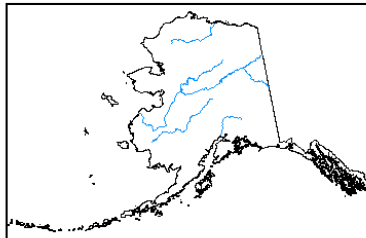
Consistency adjustment
based on Monthly
Drought Outlook for
January 2023



Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

Author:
Rich Tinker
NOAA/NWS/NCEP/Climate Prediction Center



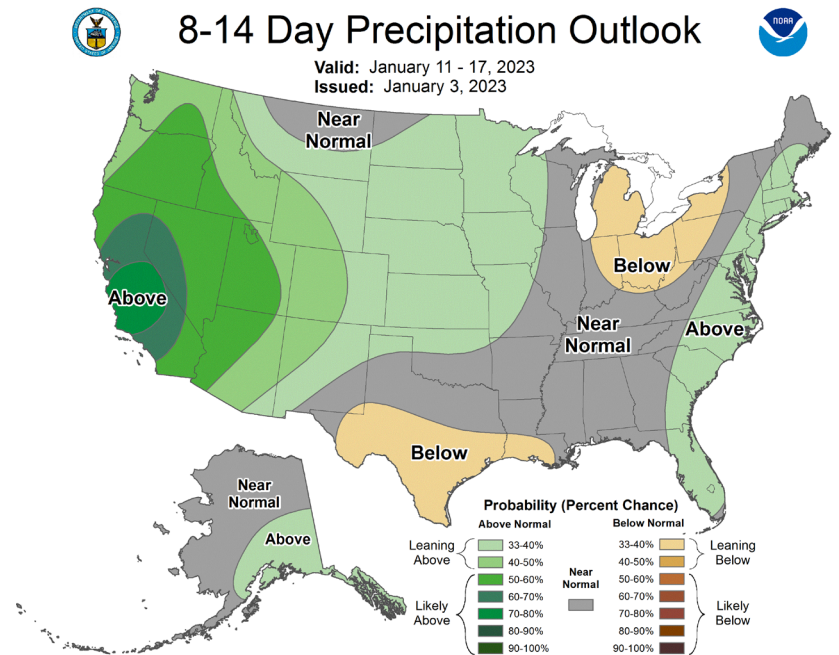
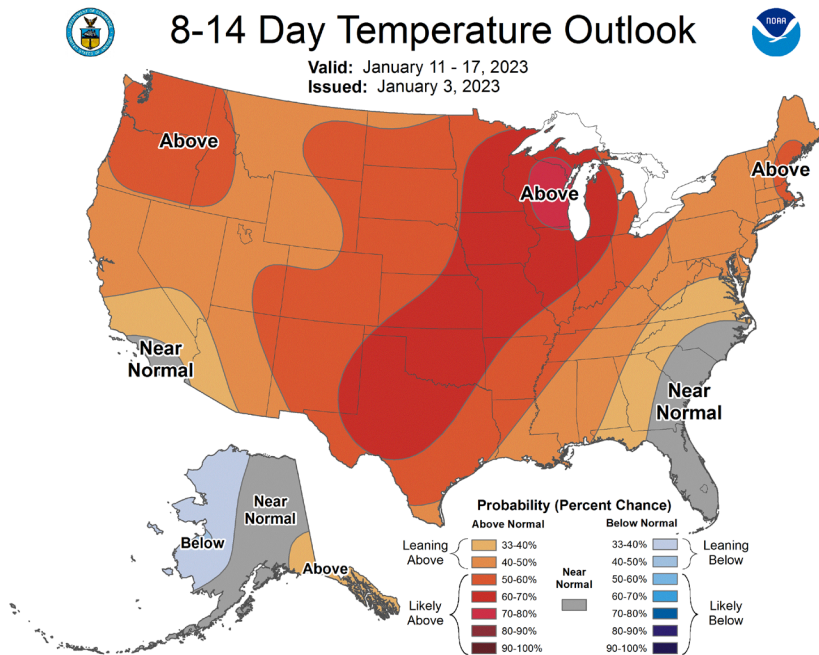
- Drought persists**
- Drought remains but improves**
- Drought removal likely**
- Drought development likely**



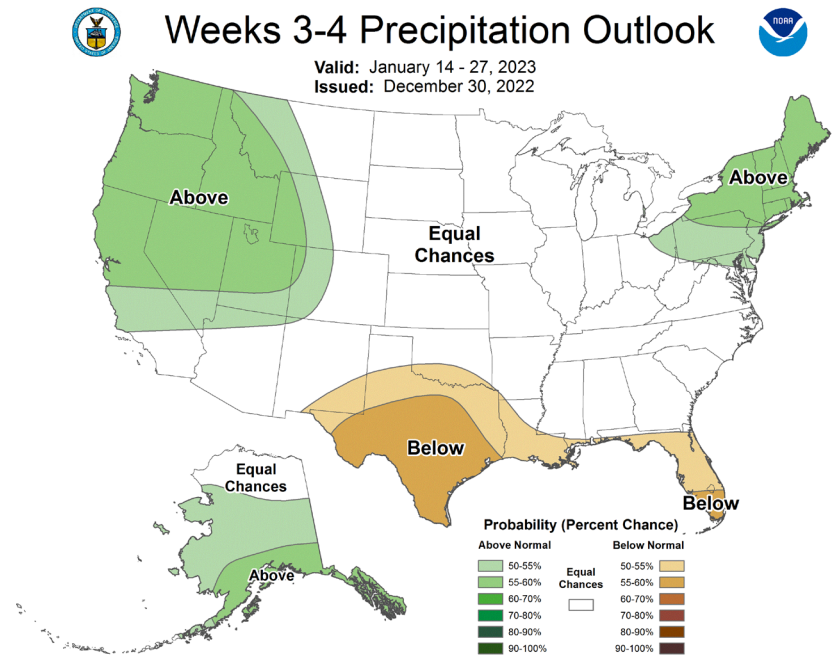
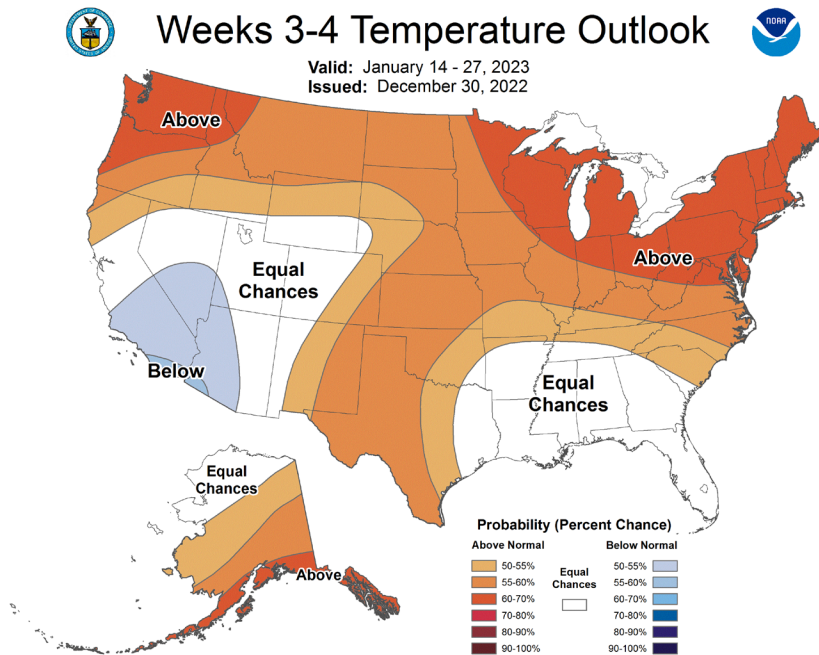
<http://go.usa.gov/3eZ73>

8-14 Day Outlook caution (old data) see

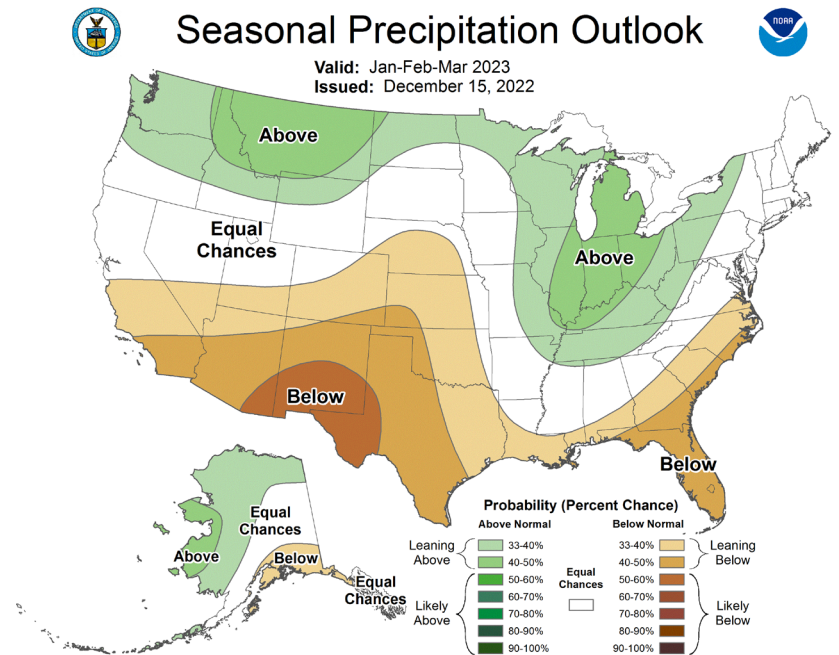
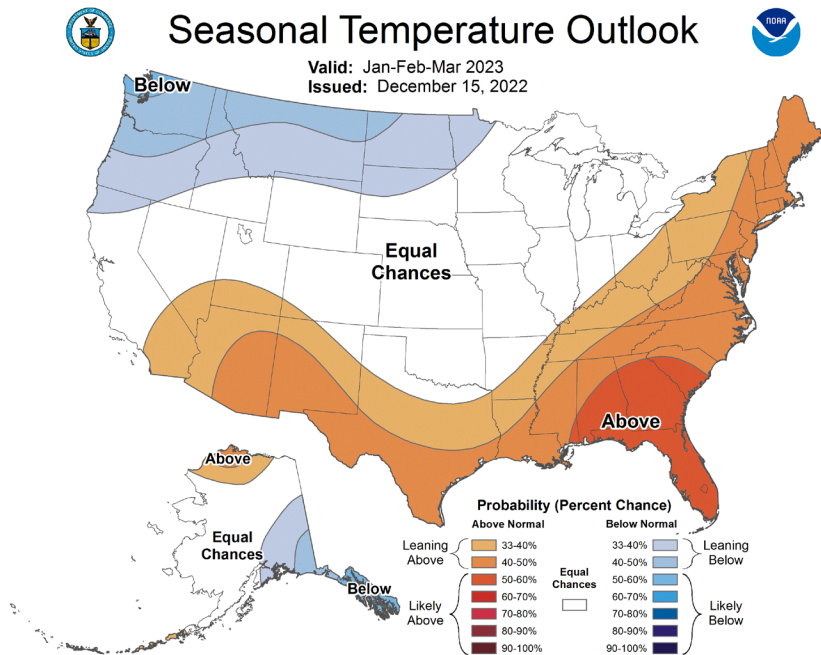
<https://www.cpc.ncep.noaa.gov/products/predictions/814day/814temp.new.gif>



Weeks 3-4 Outlook for updated forecast see <https://www.cpc.ncep.noaa.gov/products/predictions/WK34/gifs/WK34temp.gif>



3 Month Outlook Jan-Feb-Mar 2023



**Free, authoritative online sources of
information about climate change,
impacts, and projections.**

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FEATURED

June 2021 was fifth-warmest on record
NEWS AND FEATURES | JULY 14, 2021

U.S. climate summary for June 2021: hottest June on record
NEWS AND FEATURES | JULY 9, 2021

April 2021 ENSO update: spring triathlon
NEWS AND FEATURES | APRIL 7, 2021

March 2021 was warmer than average for much of the contiguous U.S., with a wet bull's-eye in the heart of the country
NEWS AND FEATURES | APRIL 5, 2021

It's official: March 2012 warmth topped the charts
NEWS AND FEATURES | APRIL 5, 2021

Climate.gov tweet chat: Talk El Niño and La Niña with the ENSO bloggers
NEWS AND FEATURES | JUNE 3, 2021
On June 3, 2021, our ENSO Bloggers did a Tweet Chat to talk all things El Niño and La Niña. [Here's the transcript.](#)

Global Climate Dashboard
Tracking climate change and natural variability over time

Sort by indicator: Climate Change Apply

Greenhouse Gases | Arctic Sea Ice | Carbon Dioxide | Mountain Glaciers

Ocean Heat | Sea Level | Spring Snow | Incoming Sunlight

Surface Temperature

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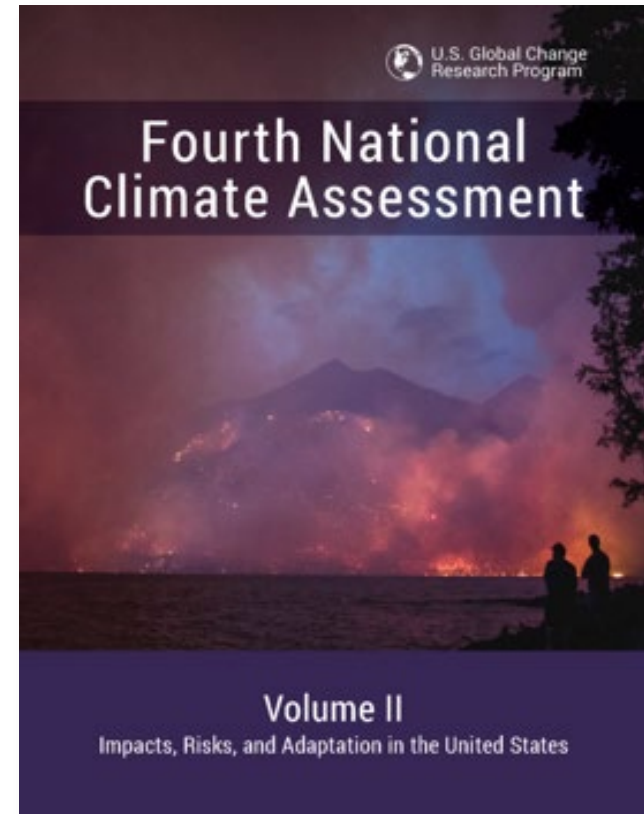
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FOURTH NATIONAL CLIMATE ASSESSMENT

- <https://nca2018.globalchange.gov/>
- <https://statesummaries.ncics.org/>
- [NOAA ATLAS point precipitation frequency estimates](#)



Intergovernmental Panel on Climate Change (IPCC)

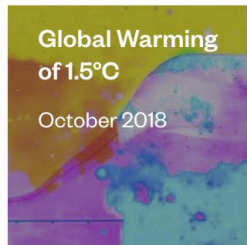
<https://ipcc.ch>



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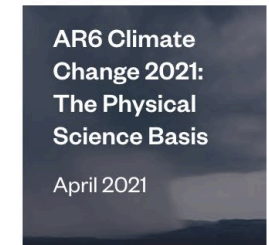
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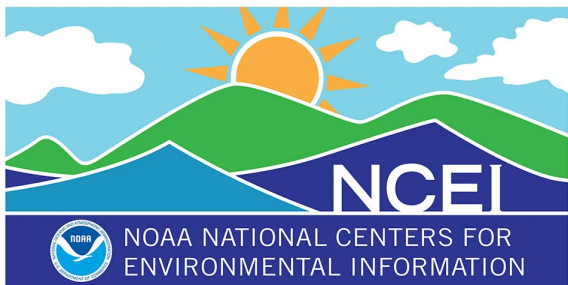


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Thank You

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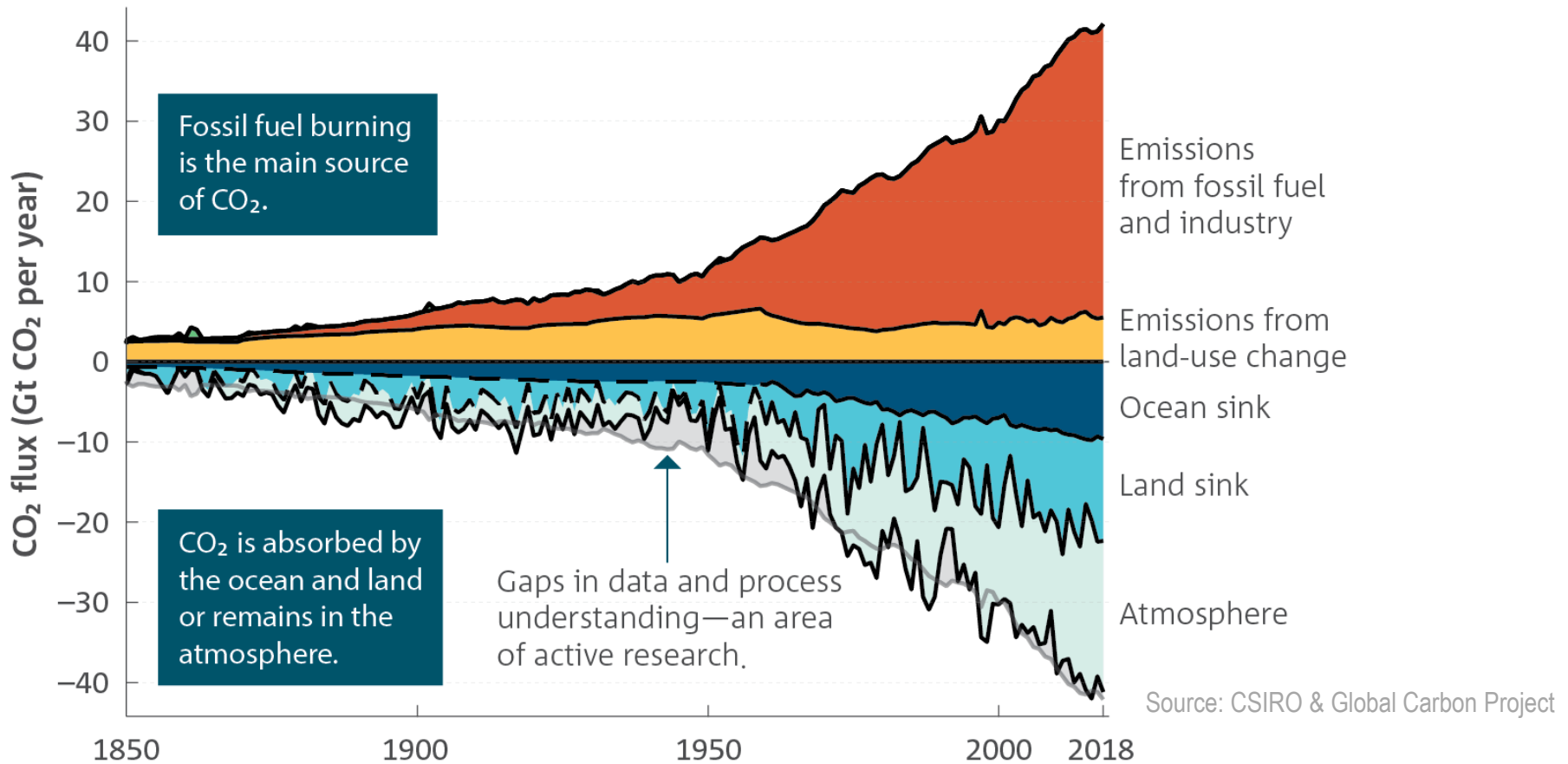
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NCEI Climate Twitter (@NOAANCElclimate): <http://www.twitter.com/NOAANCElclimate>

NCEI Ocean & Geophysics Twitter (@NOAANCElocngeo): <http://www.twitter.com/NOAANCElocngeo>



Global sources & sinks of CO₂ from 1850-2018



Our Changing Climate: *Regions*

