GEO409-FS2025 (3 credits)

Global Climate Change and Variability

Webpage: http://lees.geo.msu.edu/courses/geo409

Reading

1) NASA Video : https://www.youtube.com/watch?v=bk6mCWfVtbw

Quiz #1:

Grading

Midterm Exam: 100 points

Final Exam: 120 points (Dec. 8)

Quizzes: 60 points

Topic presentation: 42 points

Attendance: 28 points

Total: **350** points

Quick calculations

What is the temperature of an object in English Unit and SI?

Object	English (°F)	SI (°C)	SI (K)
Earth surface	?	?	~288 K
Sun's surface	?	?	~5,500 K
Normal human body	?	37	X
Water boiling temperature	?	100	X
Ice temperature	?	0	X
Temp in E Lansing	75	?	X
			X
			X

English Unit vs International System of Units (SI)

2. Length, Area, & Volume

1 inch = 2.54 cm
1 m = 3.28 ft
1 mile = 1.61 km
1 ha = 2.47105 acres
1 acre = 0.404686 ha
1 yard = 0.9144 m
1 m = 1.09361 yards
1 m^3 ≈ 1.30795 yd^3
1 yd^3 ≈ 0.764555 m^3
1 bushel = 8 gallons
1 U.S. gallon ≈ 3.78541 liters
1 U.S. bushel ≈ 35.24 liters
1 Board feet = 1 ft × 1 ft × 1 in
= 144 cubic inches

Object	SI (°C)	En. Unit (inch)
Rainfall	800 m/year	? Inches/year
Snow fall	? m/year	218 ft/year
Wind speed	? km/hour	20 miles/hour
Water in Lake Michigan	~4,918 km^3	? ft^3
Visibility in Lansing	? km	10 miles
Timber production	150 m^3/ha/year	? Bushels/acre
Corn yield	? m^3/ha	180 bushels/acre

Temperature (climate) change and variability

How do we quantify temperature and changes?

- Mean, median, and mode (average)
- Minimum and Maximum
- Range
- Skewness
- Anomalies (+, -)
- Extremes
    - Magnitude
    - Timing
    - Duration
    - Frequency
    - Location
    - Extent
    - Distribution

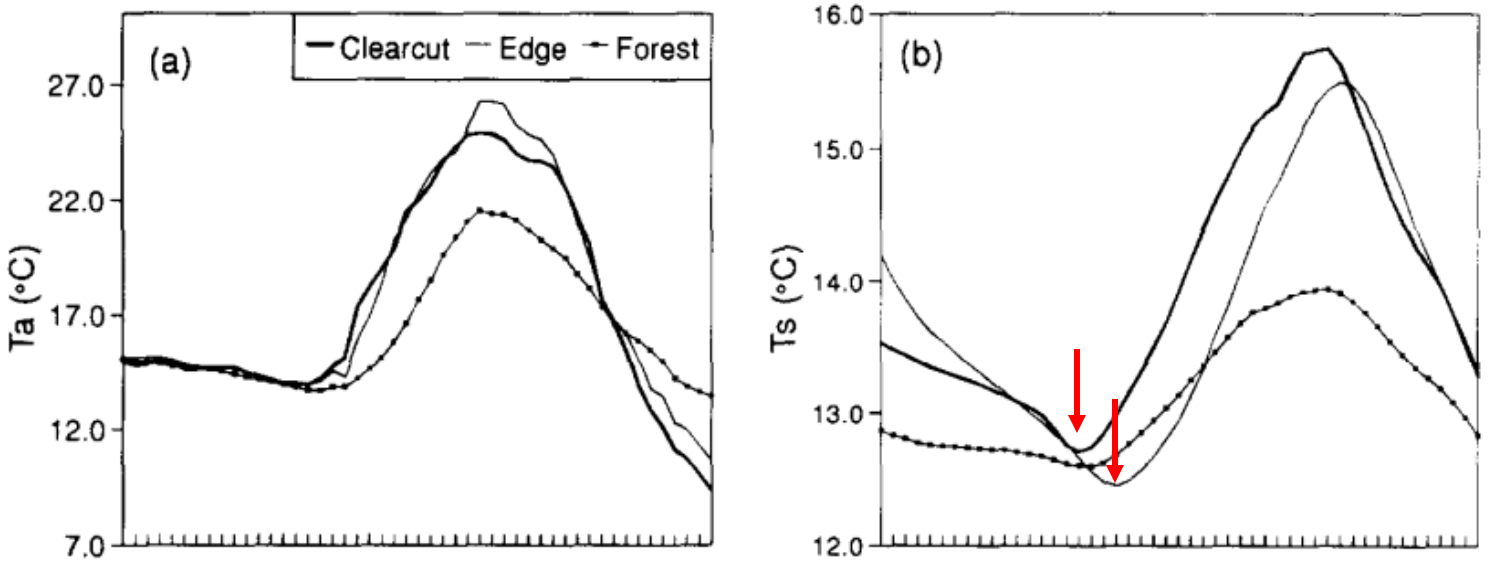
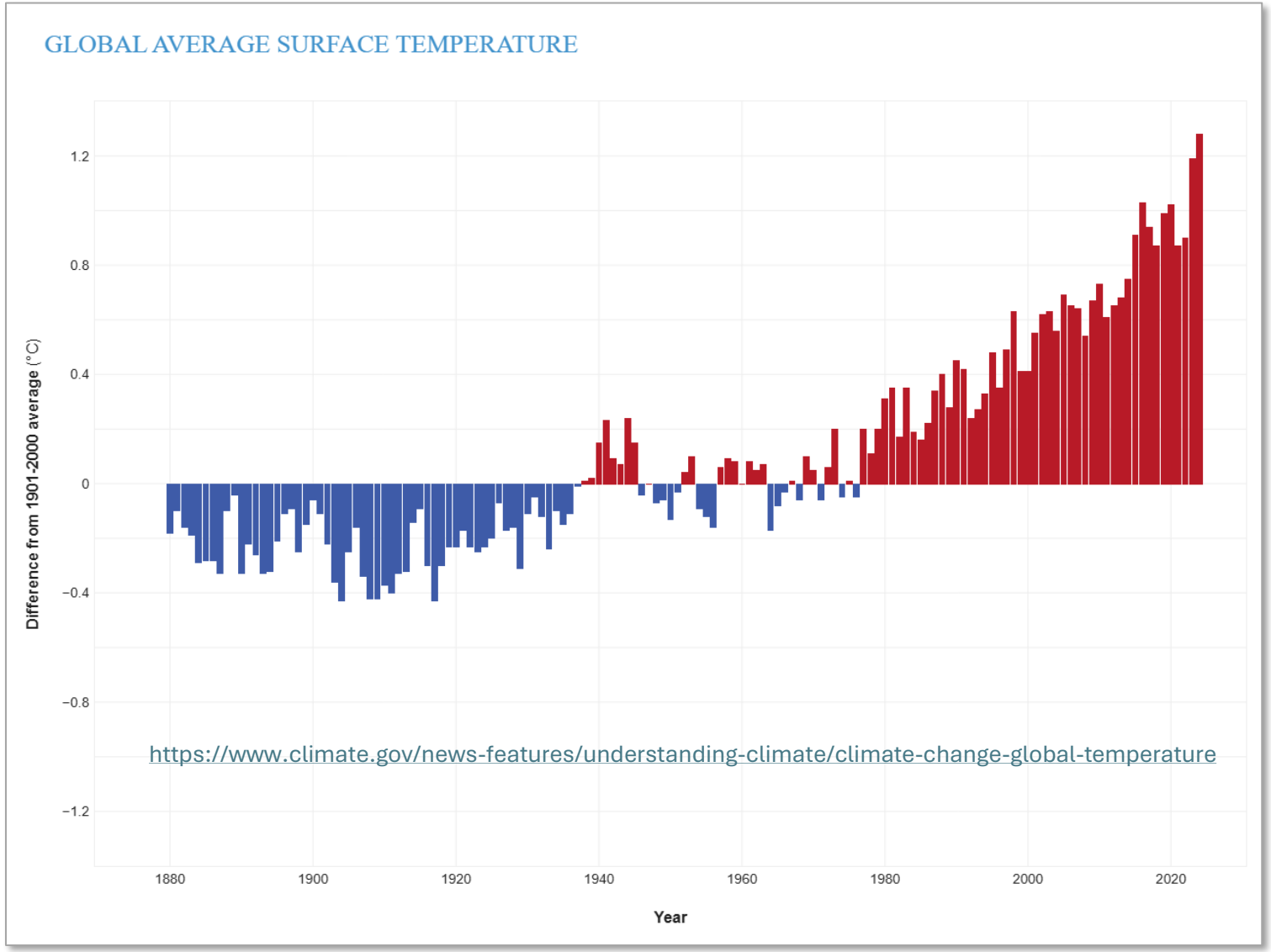


Fig. 6. Diurnal changes in (a) air temperature; (b), soil temperature in the clearcut, edge (south-facing) and old-growth Douglas-fir forest. *Chen et al. 1993*

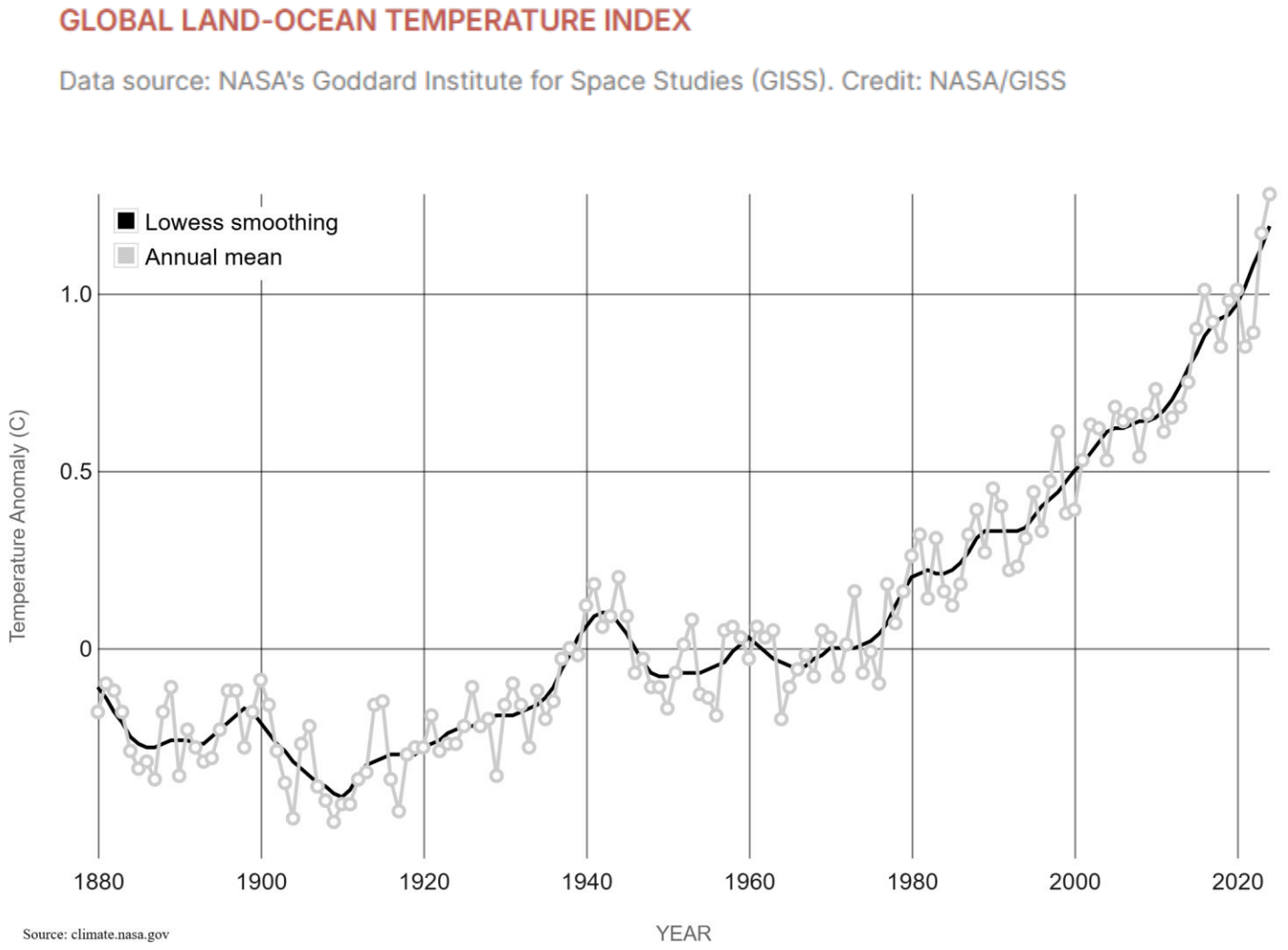
What Is Climate Change?

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.

(https://www.un.org/en/climatechange/what-is-climate-change)



Temperature anomalies: Overall, Earth was ~2.65 °F (~1.47 °C) warmer in 2024 than in the late 19th-century (1850-1900) preindustrial average.

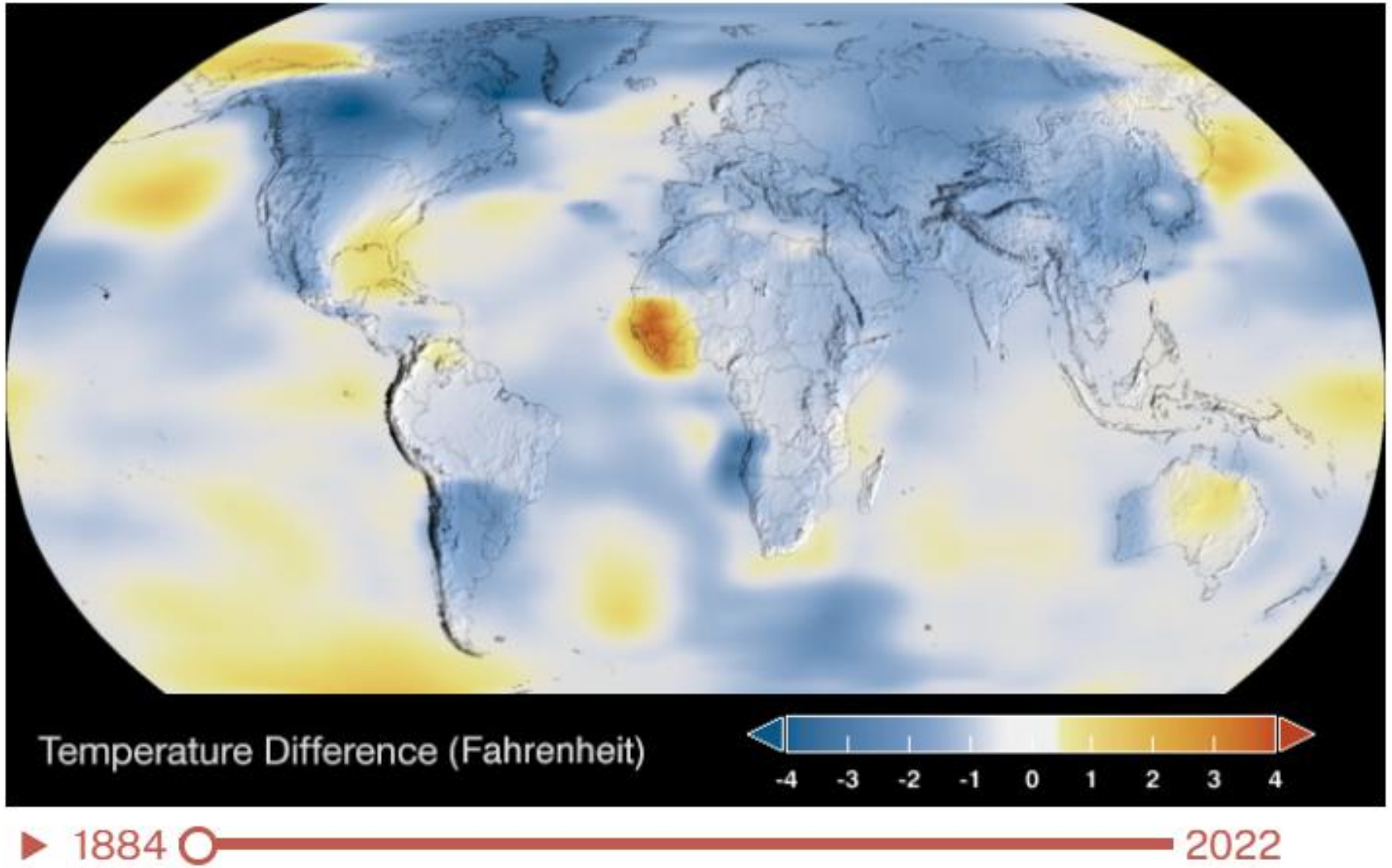


https://climate.nasa.gov/vital-signs/global-temperature/?intent=121

The spatial changes in interannual temperature anomalies are highly variable!

TIME SERIES: 1884 TO 2022

Data source: NASA/GISS
Credit: NASA's Scientific Visualization Studio



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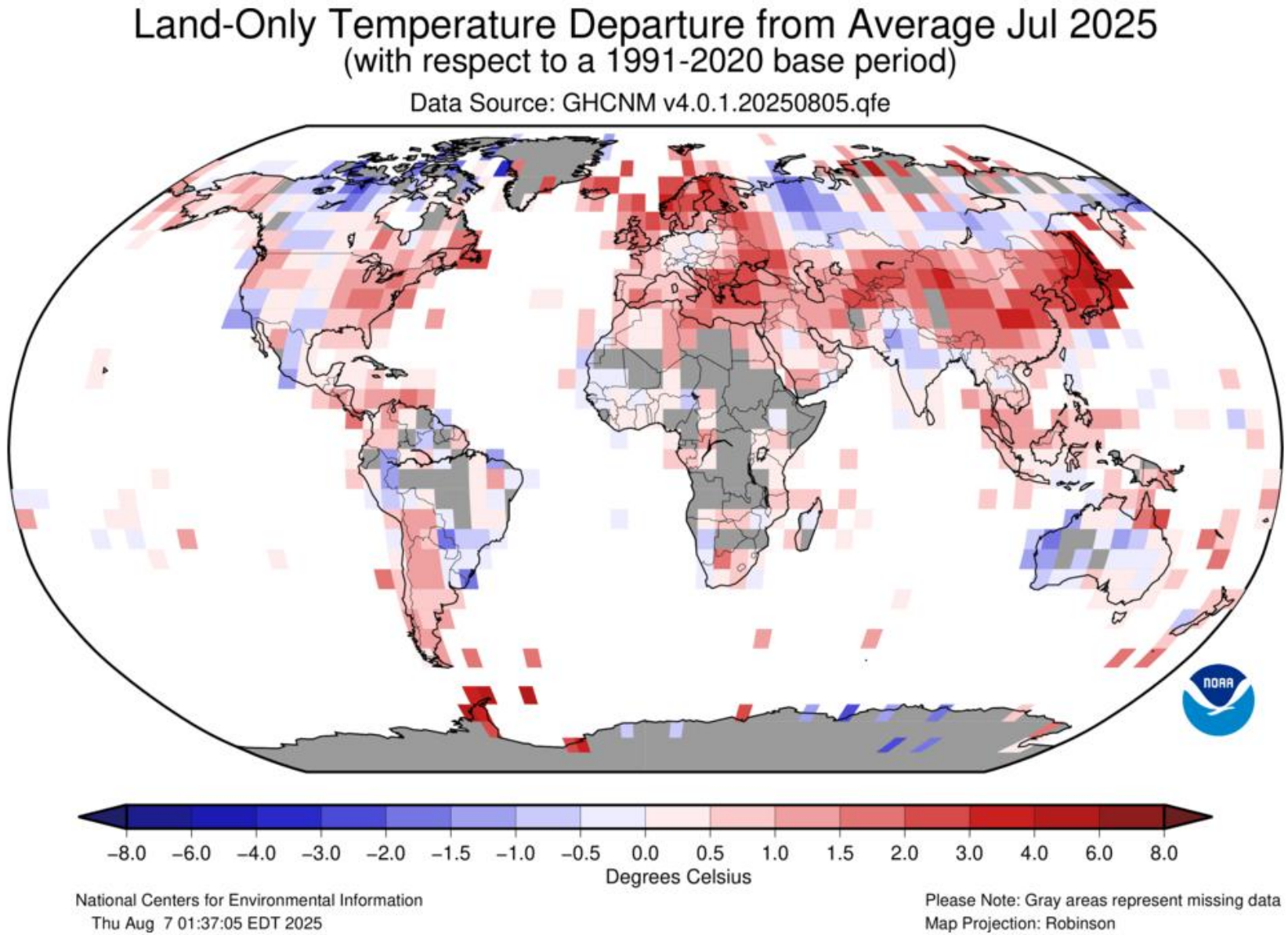
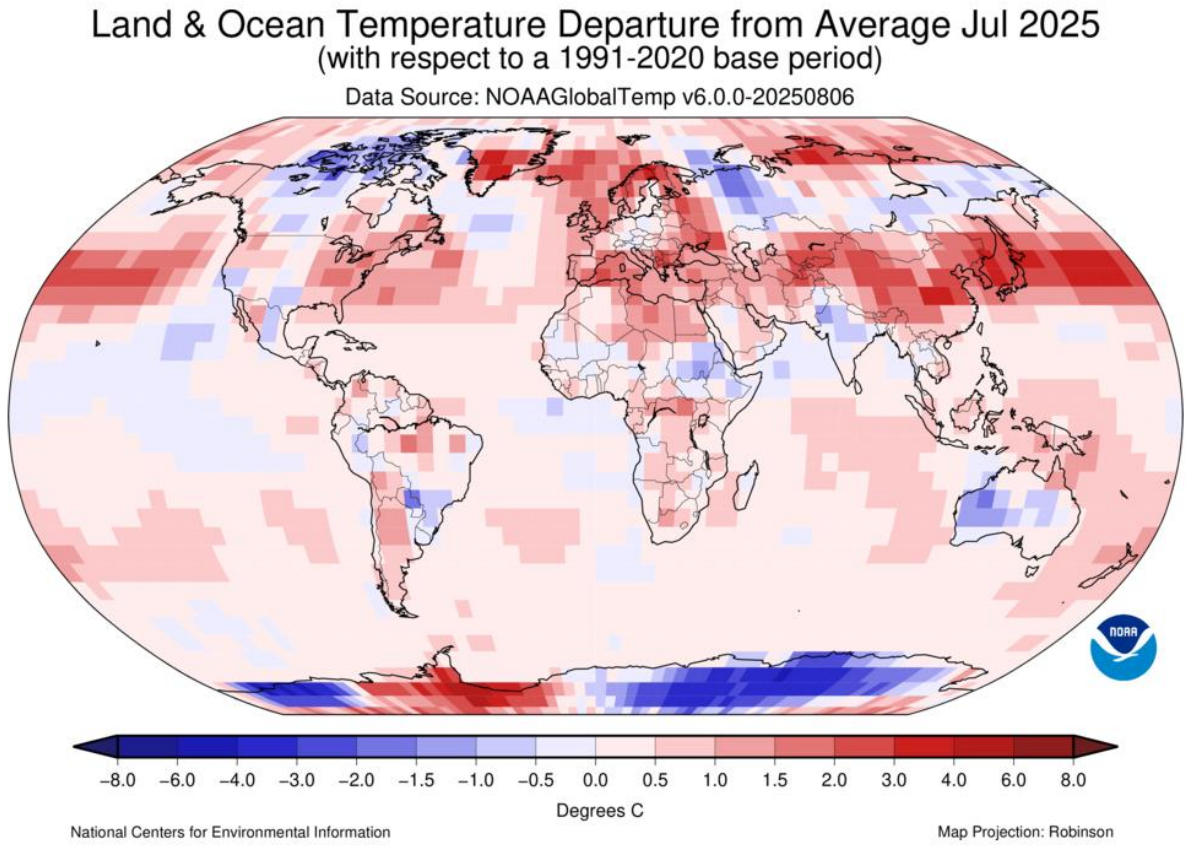
https://www.ncei.noaa.gov/access/monitoring/ghcn-gridded-products/

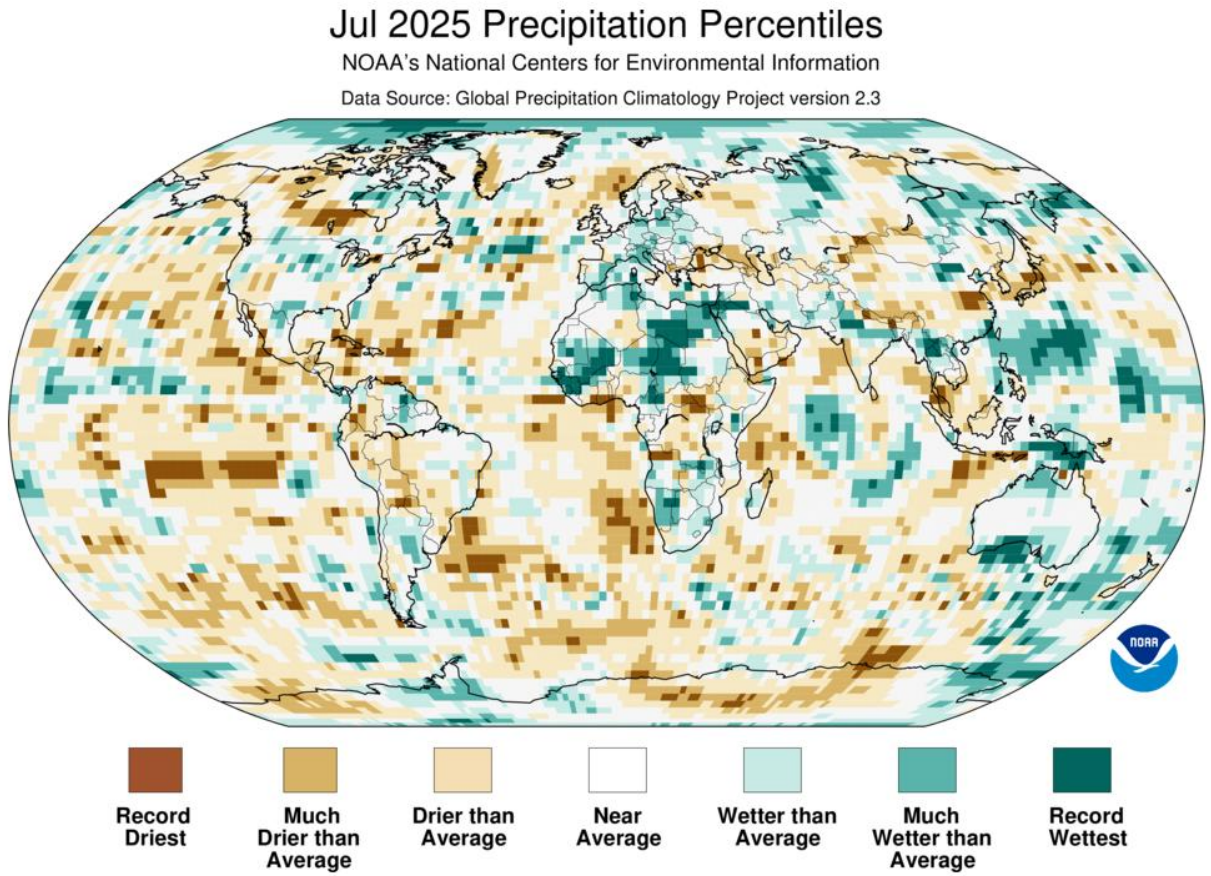


https://www.ncei.noaa.gov/access/monitoring/ghcn-gridded-products/temperature

Global Land and Ocean July 2025 Average Temperature Anomalies & Precipitation

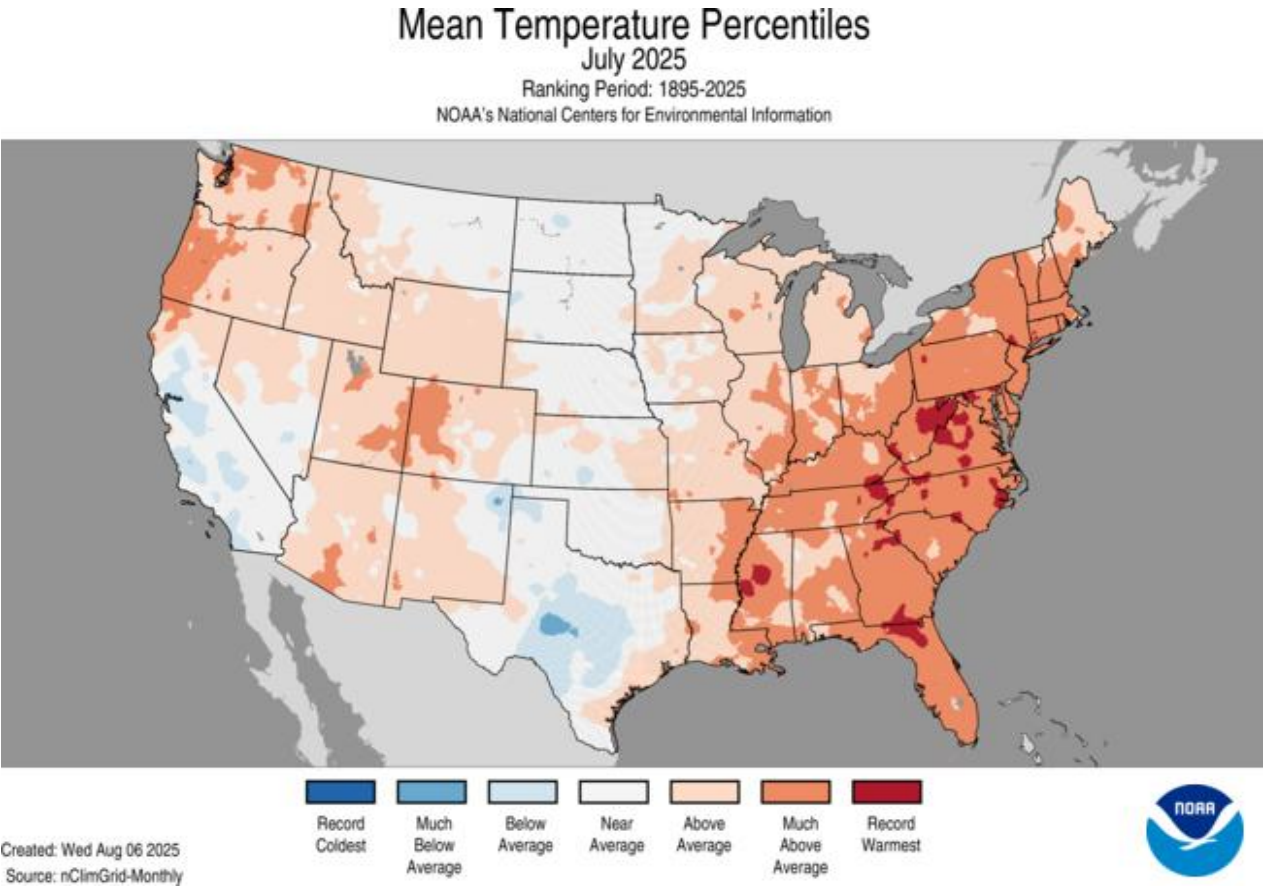
https://www.ncei.noaa.gov/access/monitoring/products/

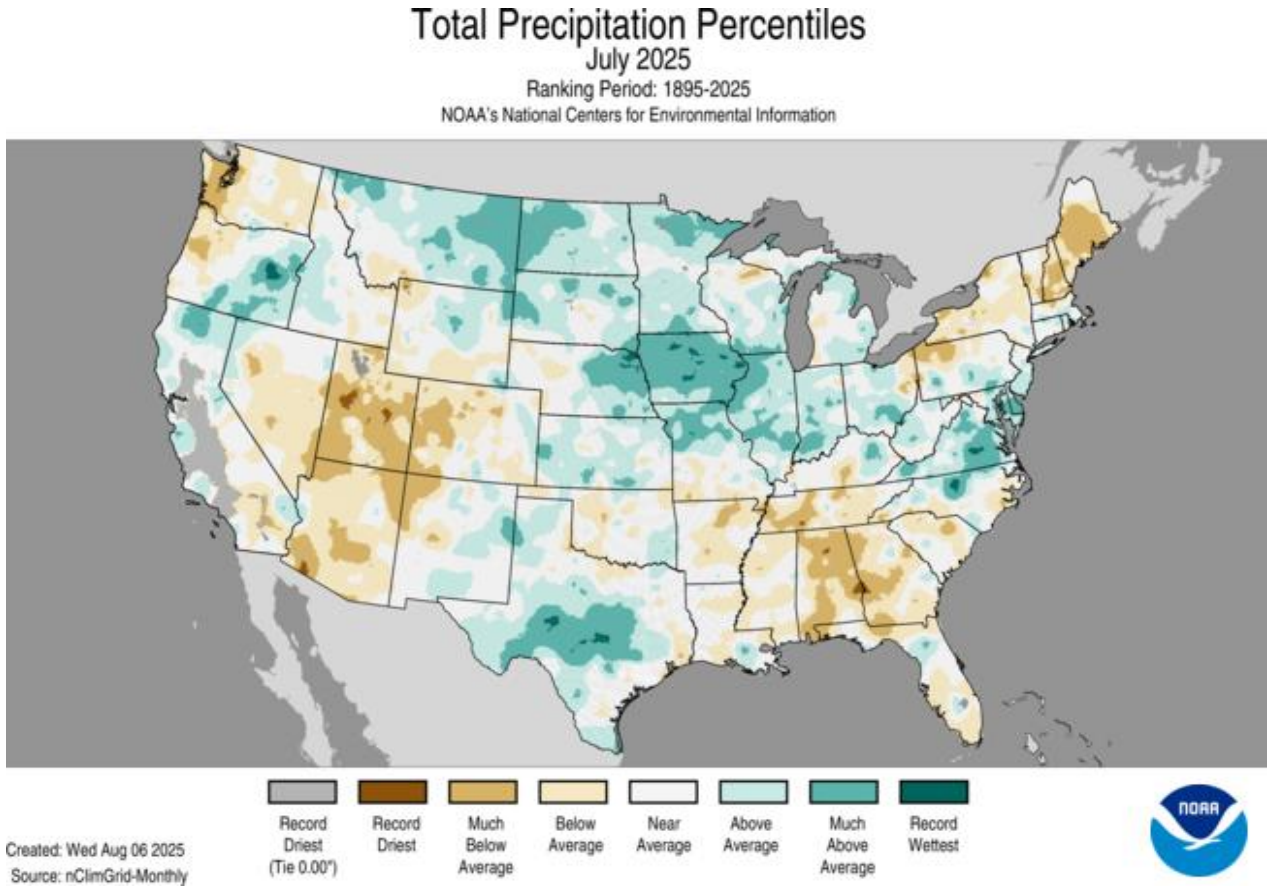




Land and Ocean July 2025 Average Temperature Anomalies & Precipitation of the contiguous United States

https://www.ncei.noaa.gov/access/monitoring/products/





Terminology (will continue on a weekly basis)

Climate is the average weather conditions for a particular location over a long period of time, ranging from months to thousands or millions of years. WMO uses a 30-year period to determine the average climate.

Microclimate is the climate near the surface (Geiger 1927)

Geiger 1927: Everything which does not belong to the macroclimate and which concerns the climate of a very small space is brought together under 'microclimate'.

WMO does not appear to offer a publicly available, standalone definition of 'microclimate'. But offers "Microscale" (< 100 m spatially; minutes to days temporally)

Terminology

Meteorology encompasses both weather and climate, as well as their interactions with the land and oceans, and the related distribution of water resources (WMO).

Micrometeorology is defined by the American Meteorological Society (AMS) as
"A part of meteorology that deals with observations and processes in the smallest scales of time and space, approximately smaller than 1 km and less than a day (i.e., local processes)… Micrometeorological processes are limited to shallow layers of frictional influence… The subject… is the bottom of the atmospheric boundary layer; exchange processes of energy, gases, etc., between the atmosphere and the surface… are important topics."

Boundary Layer Meteorology: "That part of the troposphere that is directly influenced by the presence of the earth's surface, and responds to surface forcings with a timescale of about an hour or less." (AMS).

Why is temperature increasing?

NASA Video: https://www.youtube.com/watch?v=bk6mCWfVtbw

Lecture 5. Solar radiation and Earth energy balance (by Scott Turner)

“Earth climate is fundamentally an energy balance that resolves energy inputs from solar radiation and ultimate loss of energy to the universe. These two streams of energy occur at very different bands of the electromagnetic spectrum, short-wave radiation from the sun, and long-wave radiation to the universe. Climate change boils down to understanding this energy balance.”

Next lecture

Sep 8: Physical Foundations for Global Climatic Changes

- Physical Laws
- Radiative processes & Albedo (a)
- Energy balance of the Earth

Reading

Chen, J., C. Lei, and P. Sciusco, 2021. Modeling Ecosystem Global Warming Potentials. In *Biophysical Models and Applications in Ecosystem Analysis* (pp. 11-18; 120-126). MSU Press.

Topic for term paper due!

Quiz 1

Midterm Exam: 100 points
Quizzes: 60 points
Term Paper: 140 points (100+40)
Attendance: 28 points
Total: **328** points