Chapter 1: An Introduction to the Climate Problem

http://lees.geo.msu.edu/courses/geo103/

1/21 & 1/26

1.1. What is Climate?
1.2. What is Climate Change?
1.3. A Coordinate System for the Earth
1.4. Why You Should Believe This Book
Terms
Problems

1.1. What is Climate?

Climate & Weather: AMS and WMO definitions

Climate: The slowly varying aspects of the atmosphere-hydrosphere-land surface system

Weather: The state of the atmosphere…as distinguished from climate, weather consists of short-term (minutes to days) variations in the atmosphere.

1.1. What is Climate?

Weather is actual state of atmosphere at particular time and location:

- At 10:53 AM on November 15, 2014, (air) temperature in College Station, TX, was 8 °C, humidity was 66%, winds were out of the southeast at 8 knots, barometric pressure was 1023 hPa, no precipitation (inch or mm).

- Temperature will be dropping this weekend when a cold front comes through the area.

- 1 knot = 1 nautical mile per hour (≈ 1.852 km/h)
- 1 nautical mile = 1,852 m = 1.1508 land miles
- 1 mile = 1.61 km
- 8 knots = 9.2 miles/hour = 14.8 km/h = 4.1 m/s

1.1. What is Climate?

Climate is statistical description of weather over period of time, usually month or more (decades):

- Descriptions often include one or more quantities such as temperature, pressure, humidity, precipitation, cloudiness, visibility, and wind.

- Distribution of daily maximum temperatures in September at Ellington Field, southeast of Houston, TX (**Fig. 1.1**).

1.1. What is Climate?

In 1970s (blue), most likely daily maximum temperature was 31 °C, occurring ~18% of days (blue dot).

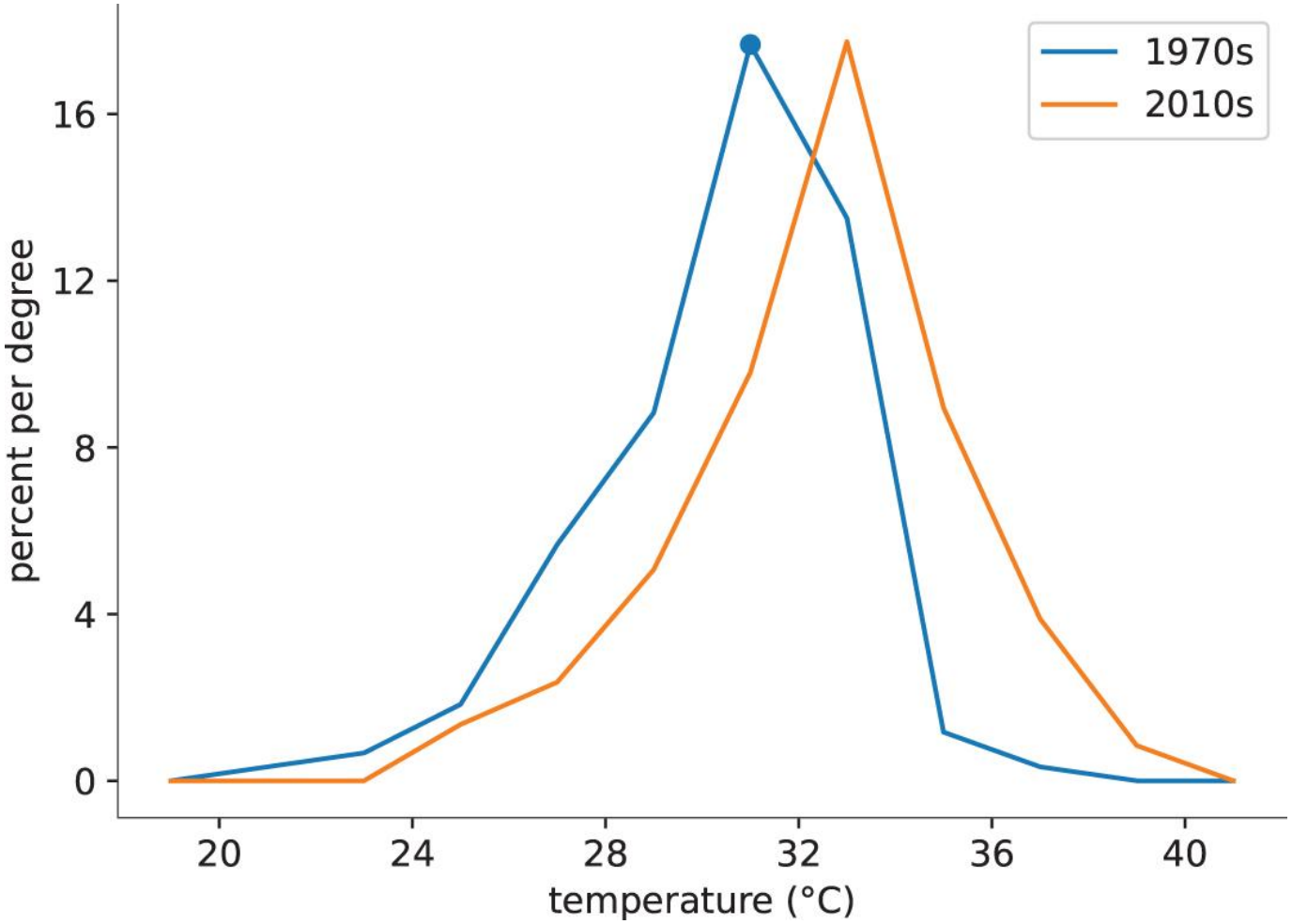


Fig. 1.1: Frequency of occurrence of daily high temperature in September at Ellington Field, near Houston, TX, for two time periods: 1970-1979 (blue) & 2010-2019 (orange).

1.1. What is Climate?

In 2010s (orange), most likely daily maximum temperature was 33 °C, occurring ~18% of days.

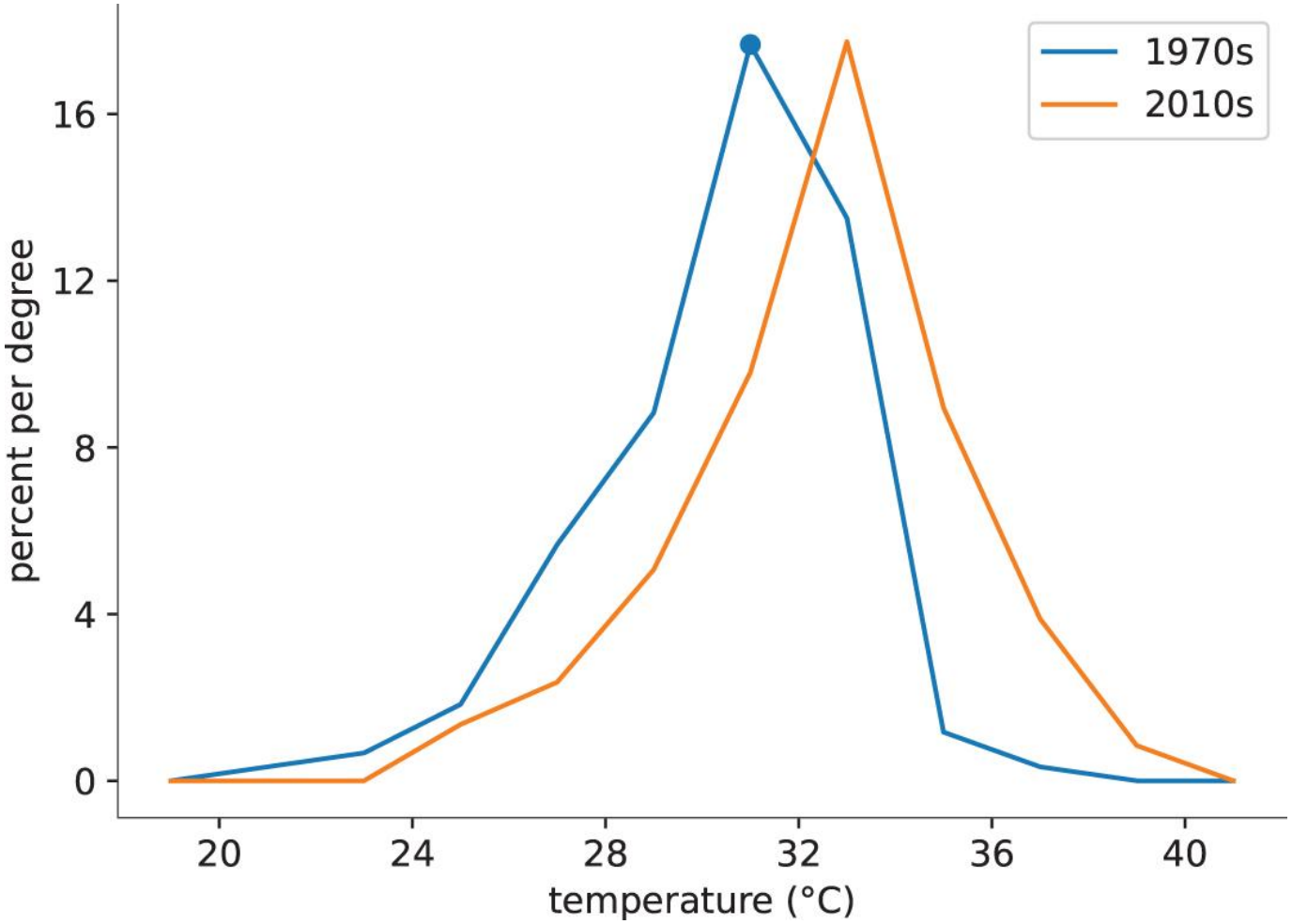
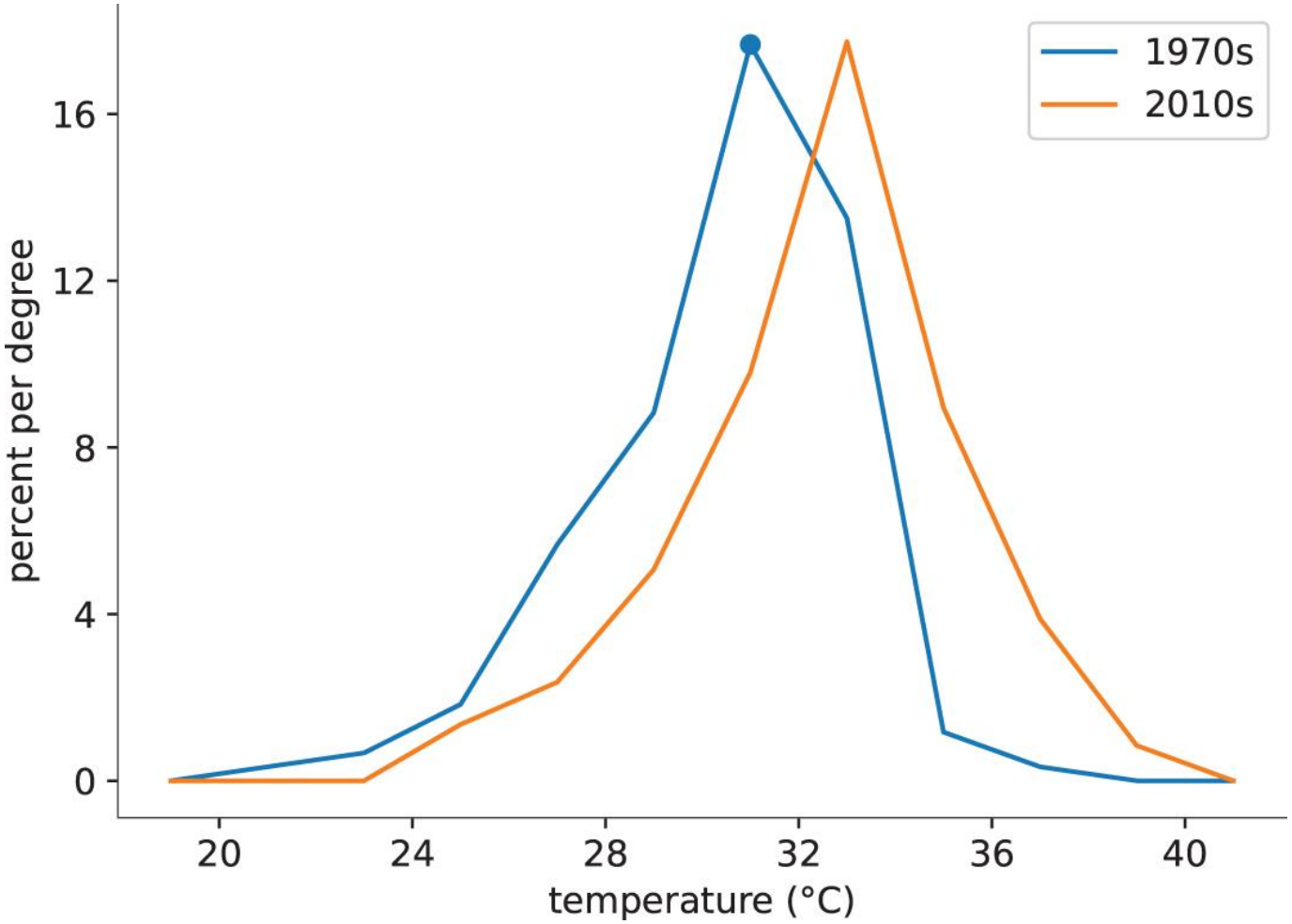


Fig. 1.1: Frequency of occurrence of daily high temperature in September at Ellington Field, near Houston, TX, for two time periods: 1970-1979 (blue) & 2010-2019 (orange).

1.1. What is Climate?

Distributions provide range of probable conditions over these two time periods.



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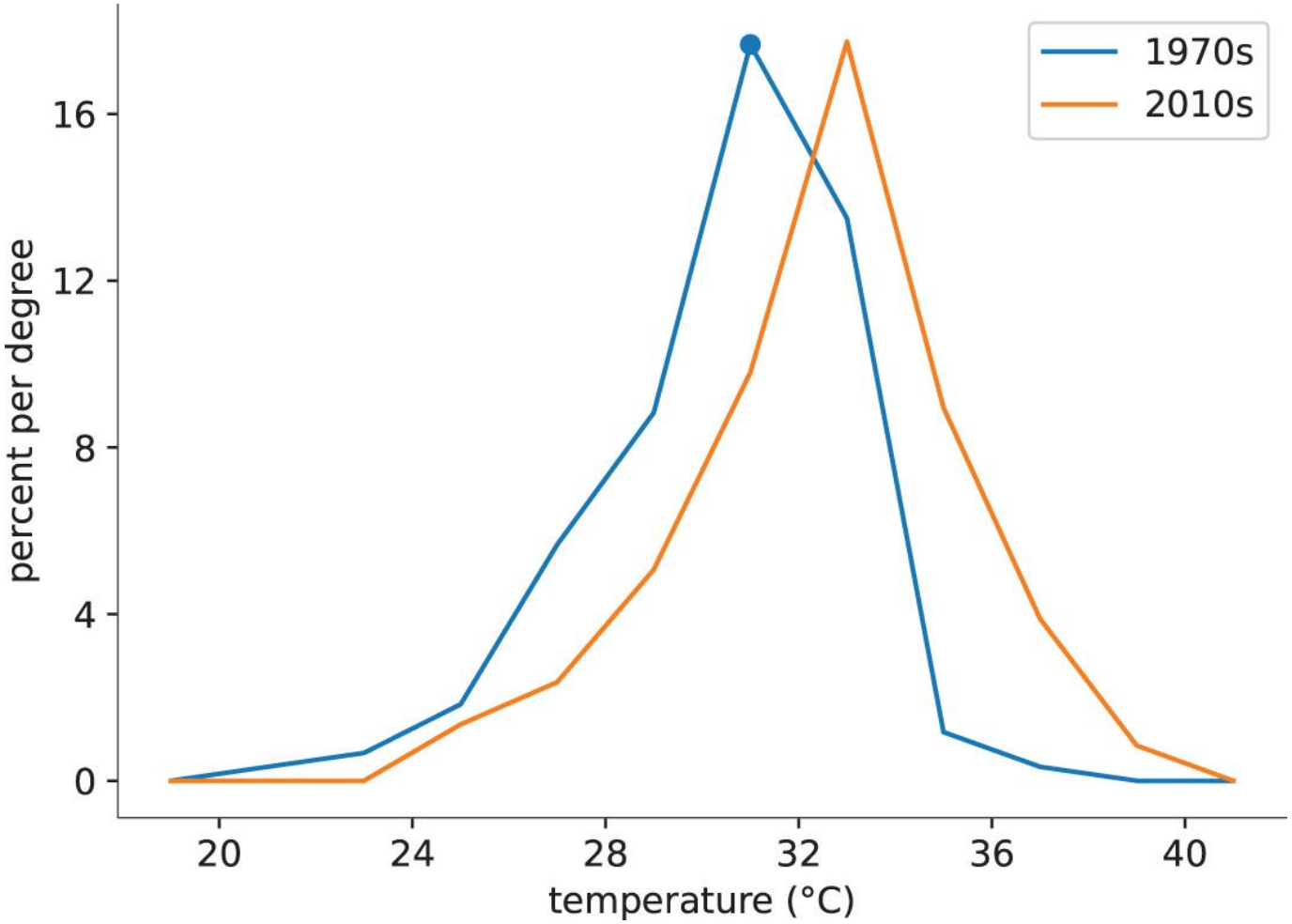
1.1. What is Climate?

Distributions do not provide information about actual daily maximum temperature for any specific date.



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1.1. What is Climate?

Question: If temperature (T) changes by 2 °C increase (ΔT_C), by how much does T change in °F (ΔT_F)?

Note: this is not temperature conversion, but rather temperature change conversion!

- *In this case, do not use, F = C x 9/5 + 32, but:*

- $\Delta T_F = \Delta T_C \times 9/5$
- $\Delta T_F = 2 \times 9/5$
- $\Delta T_F =$ ***3.6 °F***

What about 4 °C increase in T?

1.1. What is Climate?

Why care about weather and climate?

- Weather important for making short-term decisions.

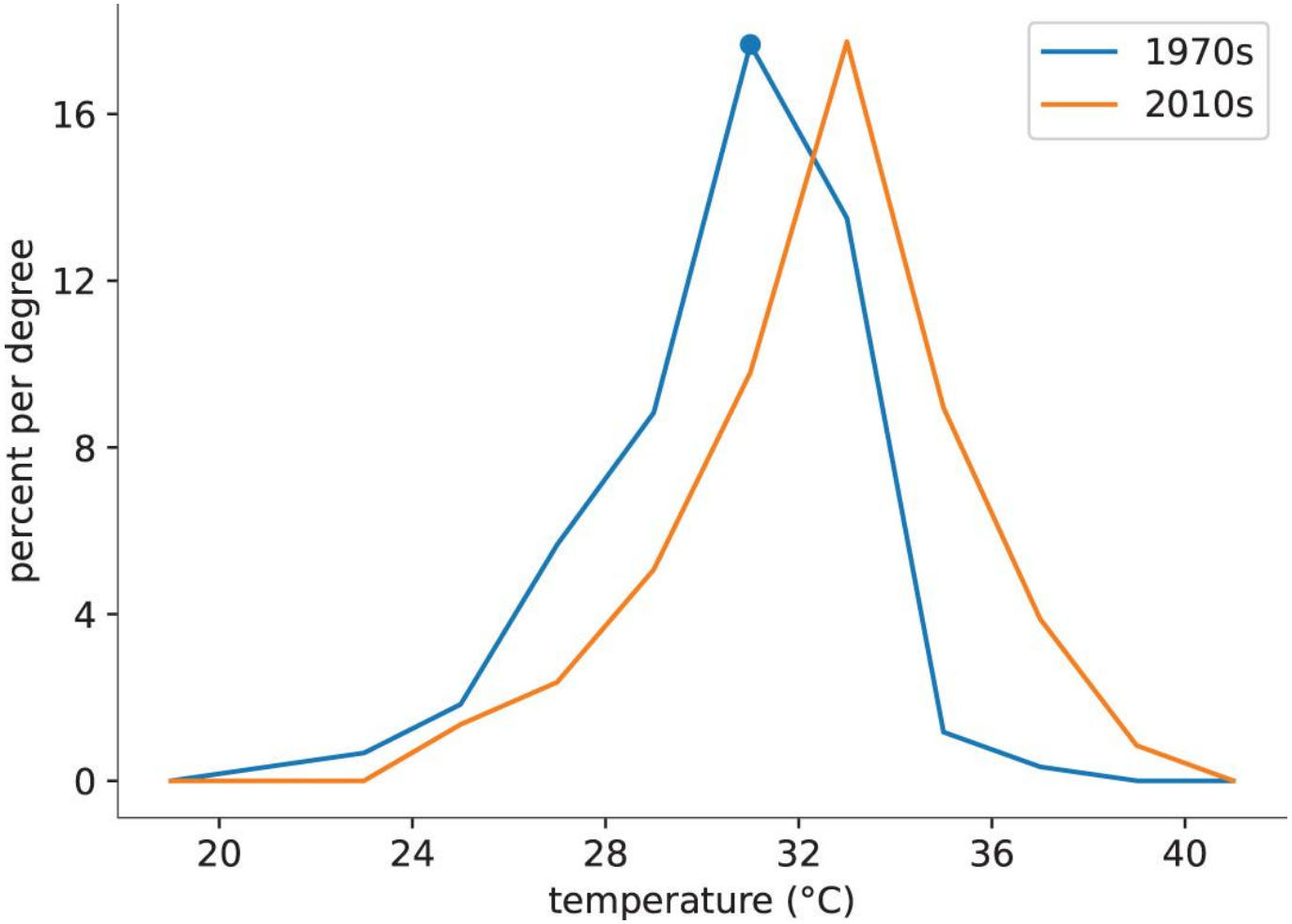
  Should you take an umbrella to class? Or Should you bike/walk instead of drive? Are schools closed because of heavy snow and road conditions?

- Climate important for making long-term decisions.

  Imagine you want to buy a home in a place that frequently enjoys pleasant weather. Lansing vs Phoenix or San Francisco?

1.1. What is Climate?

Temperature distributions can be used to determine home heating or air-conditioning needs.



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1.1. What is Climate?

Why care about weather and climate?

Weather and climate both important for making military decisions, such as the D-Day invasion:

- ✓ Climate assisted in choosing the location/season of invasion (i.e., Normandy).
- ✓ Weather assisted in choosing specific day/time of invasion (i.e., June 6, 1944).
- ✓ Advances in weather balloons, radar, and satellites propelled by military and aviation.
- ✓ Current Ukraine-Russia War during the winter months

1.1. What is Climate?

Temperature is variable most often associated with climate and directly affects well-being of Earth inhabitants.

- Average (mean) temperature gets much attention, but extremes matter:
  - ✓ High (maximum) temperature
  - ✓ Low (minimum) temperature
  - ✓ Range (max-min)
- Heat-related mortality during heat waves is leading cause of weather-related death in U.S.

1.1. What is Climate?

Precipitation rivals temperature in importance to humans, since life without fresh water is impossible:

- Total annual precipitation important for any region, but distribution of precipitation throughout year also matters:

  ✓ Some locations have wet/dry seasons.

- Temperature determines whether precipitation in form of rain or snow, and rates of snow melt:

  ✓ Snowpack important fresh water source.

1.1. What is Climate?

What part of climate matters will vary from person to person:

- Farmer, ski resort owner, resident in Florida vs Michigan.

  We all rely on stability of our climate for our continuing existence.

Irrigation schedule in farmlands!

Precipitation, temperature (drought), and soil moisture (%)

1.2. What is Climate Change?

Seasonal cycle is most familiar example of climate change.

However, concern in climate change conversation is long-term climate change.

American Meteorological Society (AMS) defines **CLIMATE CHANGE**:

Any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer.

1.2. What is Climate Change?

We might be interested in comparing present day to one century ago.

We might be interested in comparing present day to projection one century into future.

- If statistics change, we can say climate has changed, quantified by its magnitude, direction, and frequency.

1.2. What is Climate Change?

Peak of distribution in 2010s (orange) is ~1.5 °C warmer than 1970s (blue).

Temperatures that rarely occurred in 1970s (blue) occurred frequently in 2010s (orange).

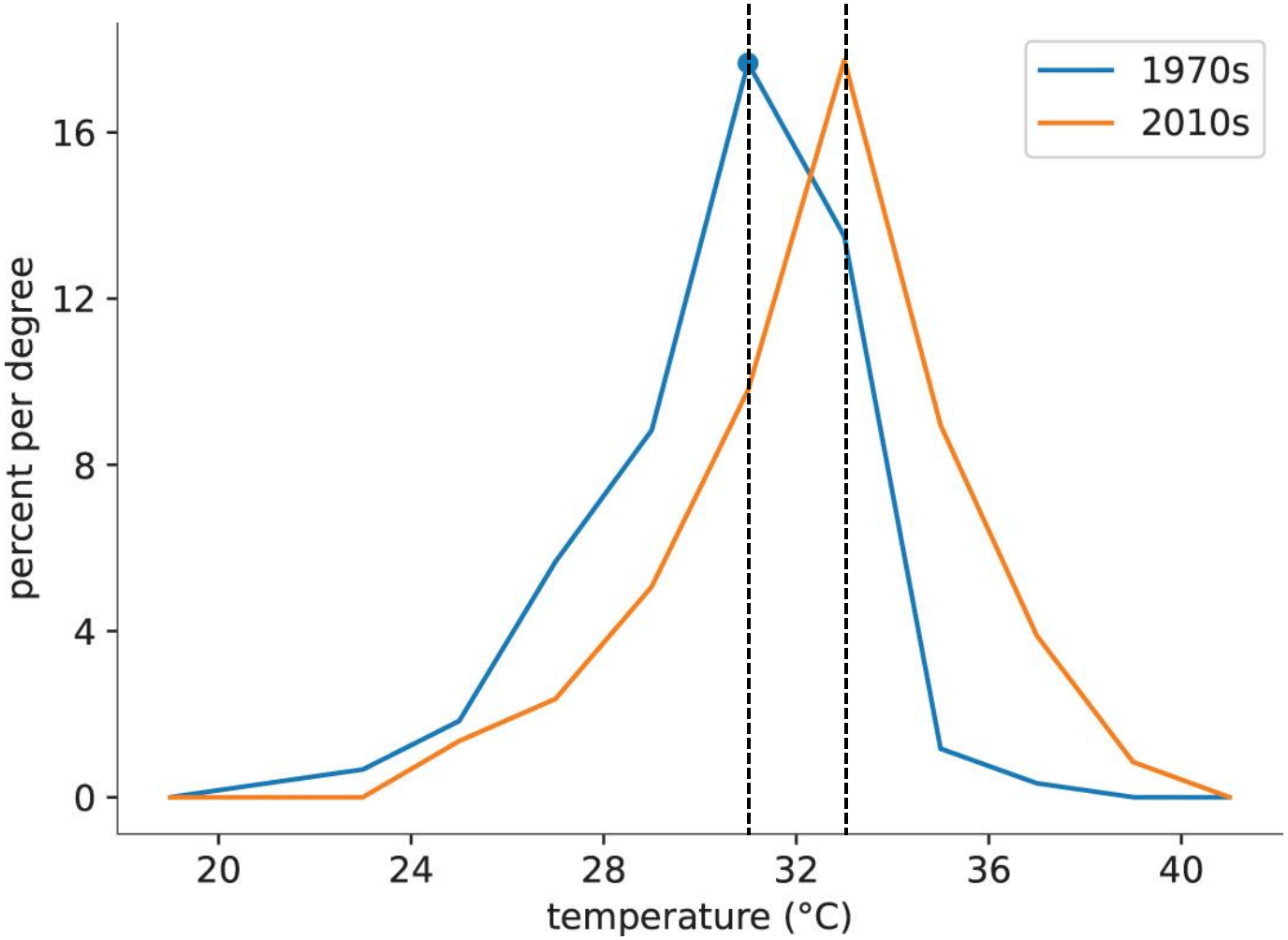
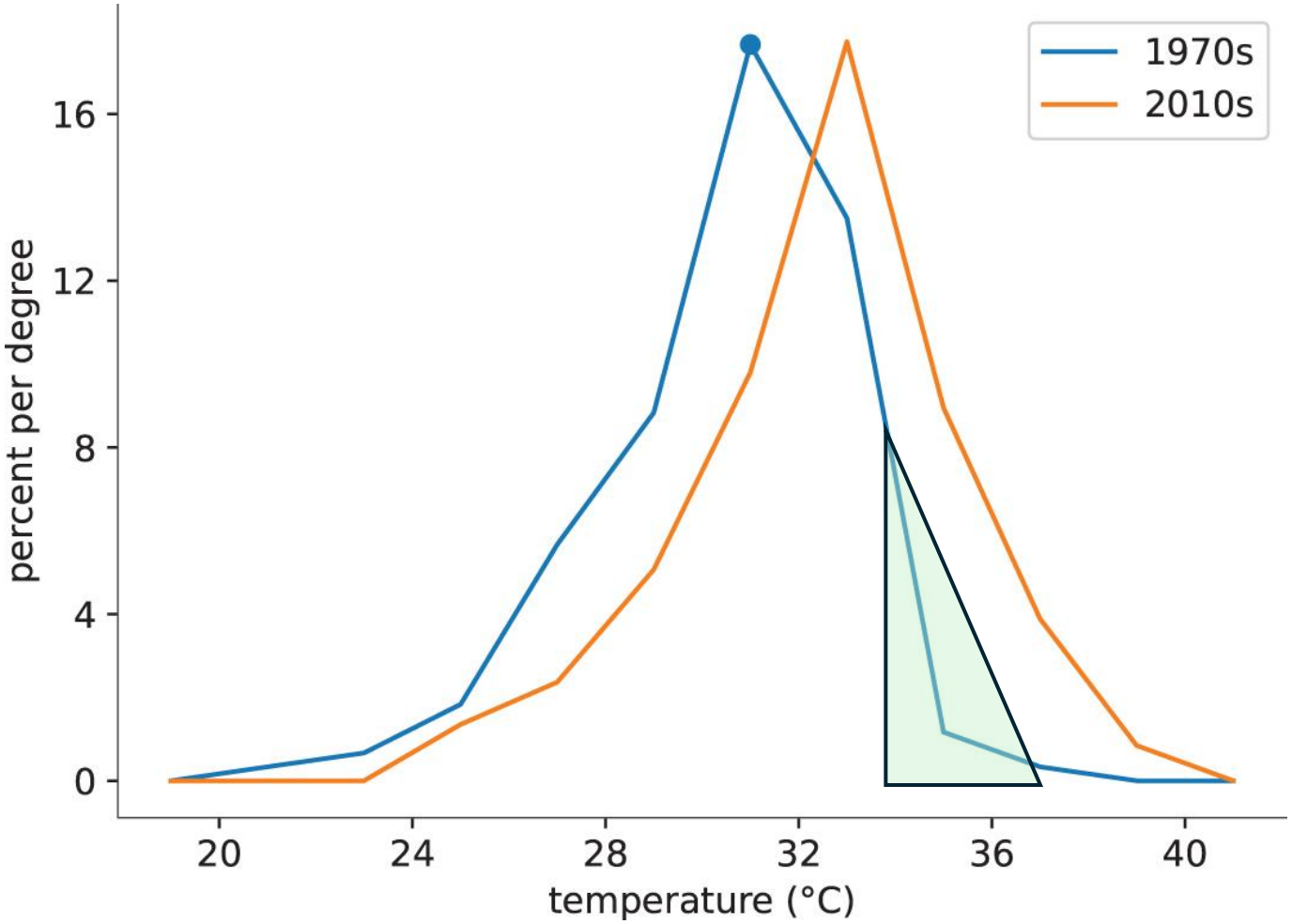


Fig. 1.1: Frequency of occurrence of daily high temperature in September at Ellington Field, near Houston, TX, for two time periods: 1970-1979 (blue) & 2010-2019 (orange).

1.2. What is Climate Change?

In 1970s (blue), maximum temperature >34 °C occurred on ~12% of days:

Area = (B x H)/2
Area = (3 x 8)/2
Area = 24/2
Area = ~12%



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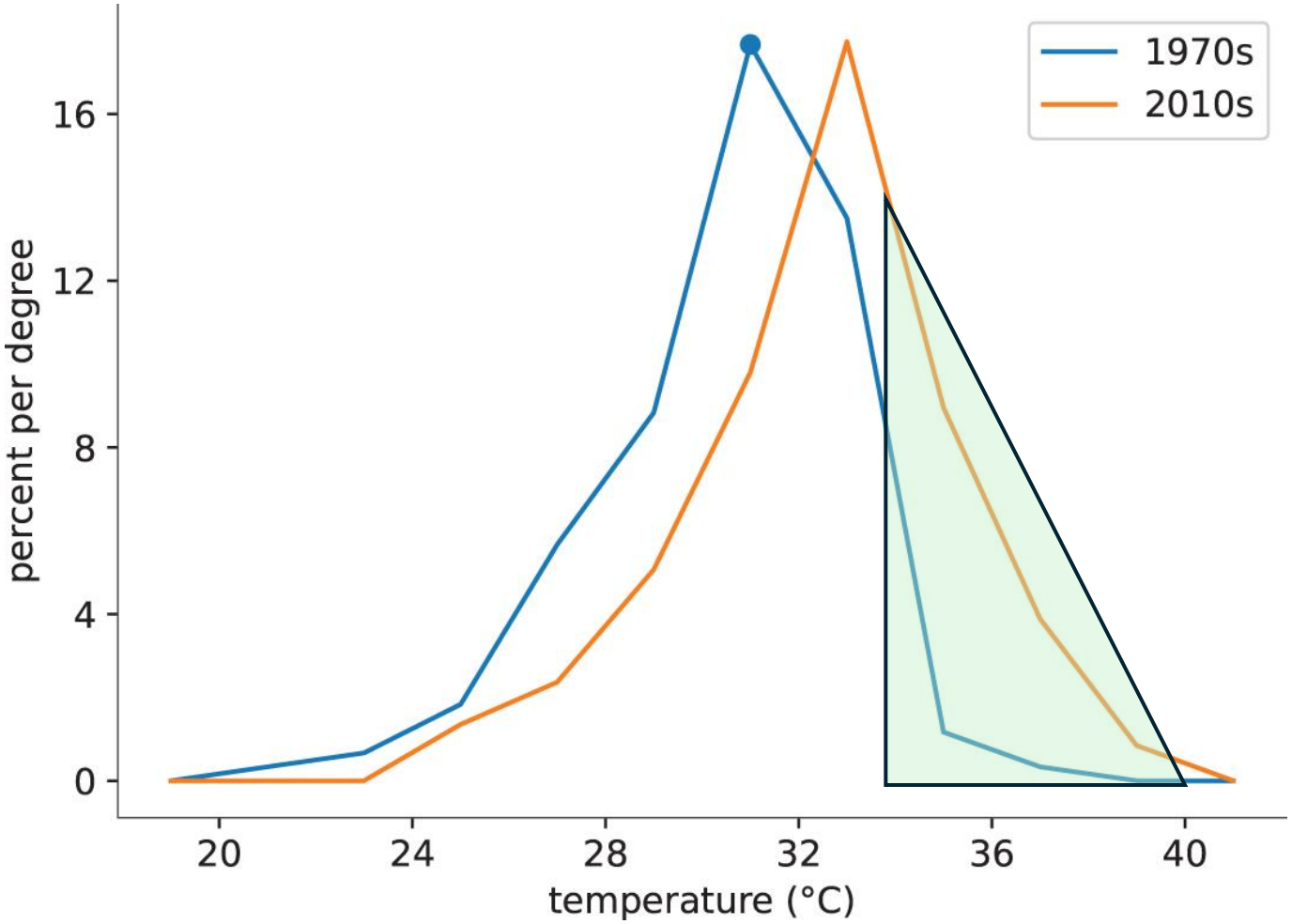
1.2. What is Climate Change?

In 2010s (orange), maximum temperature >34 °C occurred on ~36% of days:

Area = (B x H)/2
Area = (6 x 12)/2
Area = 72/2
Area = ~36%



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Terms & Units so far!

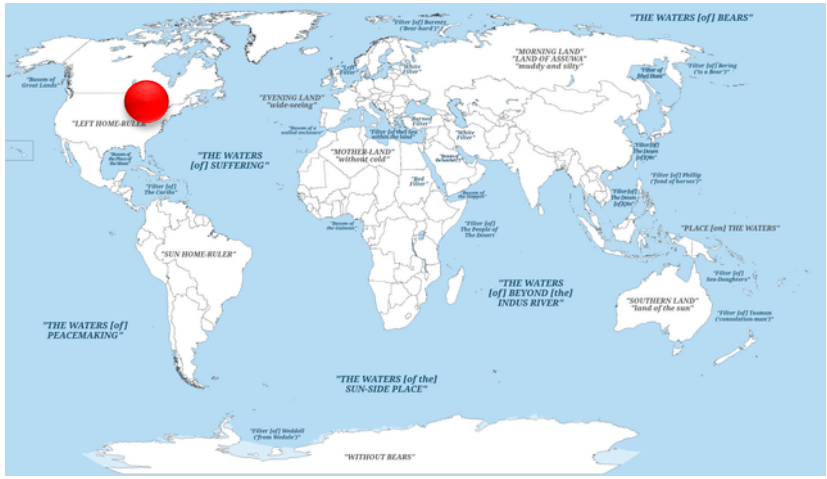
Climate
Weather
Temperature (°F, °C, K)
Precipitation (inch, mm)
Soil moisture (%)
Wind (knot, miles/h, km/h, m/s)
Atmospheric pressure (hPa, kPa)
Amount of energy (Joule, J)
Energy use (Watt, W)
Energy flux (W/m^2)
Metrics (max, min, mean, range, frequency, cumulative value, anomalies, rate of change, etc.)

Units & conversions

1 kPa = **10 hPa (**hectopascals)
1 hPa = **0.1 kPa**

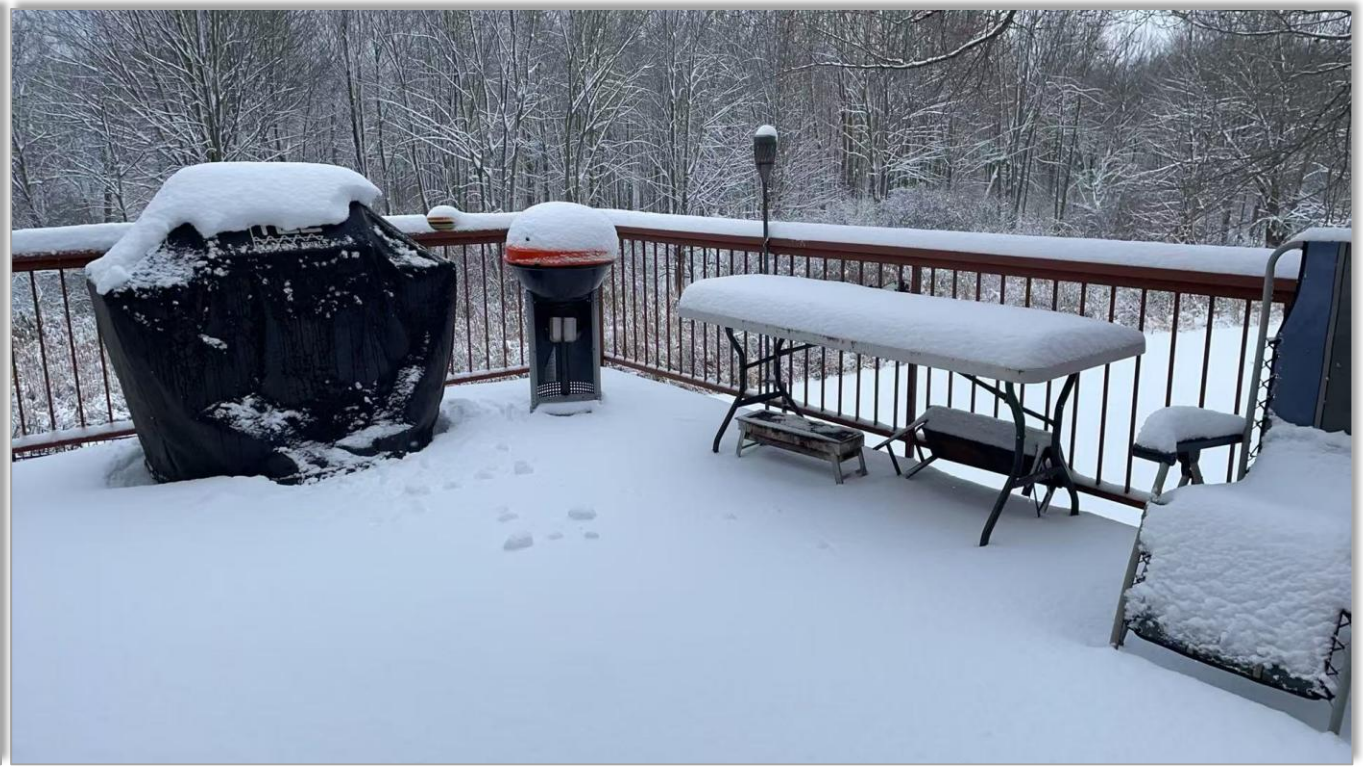
- Standard atmospheric pressure (at sea level) = 1013 hPa = 101 kPa
- Typical ranges: ~980 – 1050 hPa
- Higher elevation: lower pressure (e.g., ~700 hPa at ~3 km)

Climate in Lansing

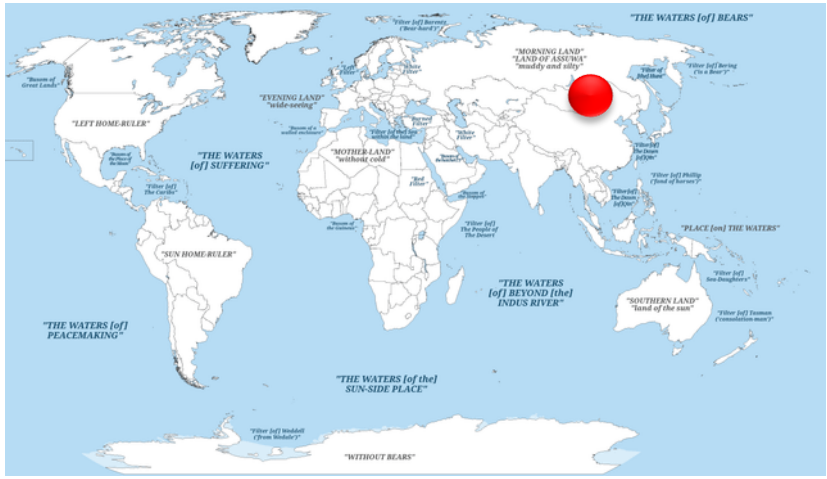


Summer: warm & wet/dry

Winter: cold & dry



Climate in Mongolia



Summer: hot & dry

Winter: cold & dry

Study questions for Ch1.1 – 1.2, previous lectures

2
3
4
5
8
9

First quiz on Jan 28 (Wed before the lecture)

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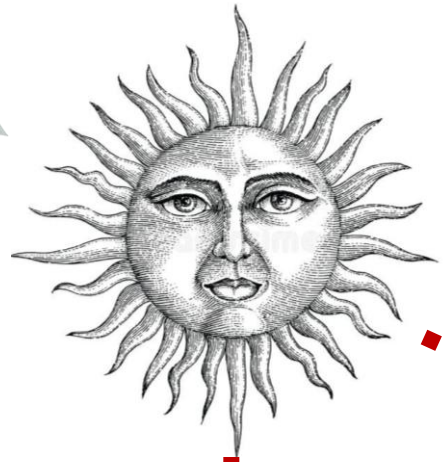
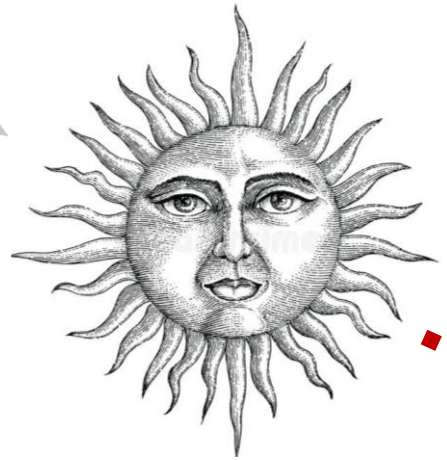


Amount of energy received per unit area is called solar constant (c) = 1361 W/m^2



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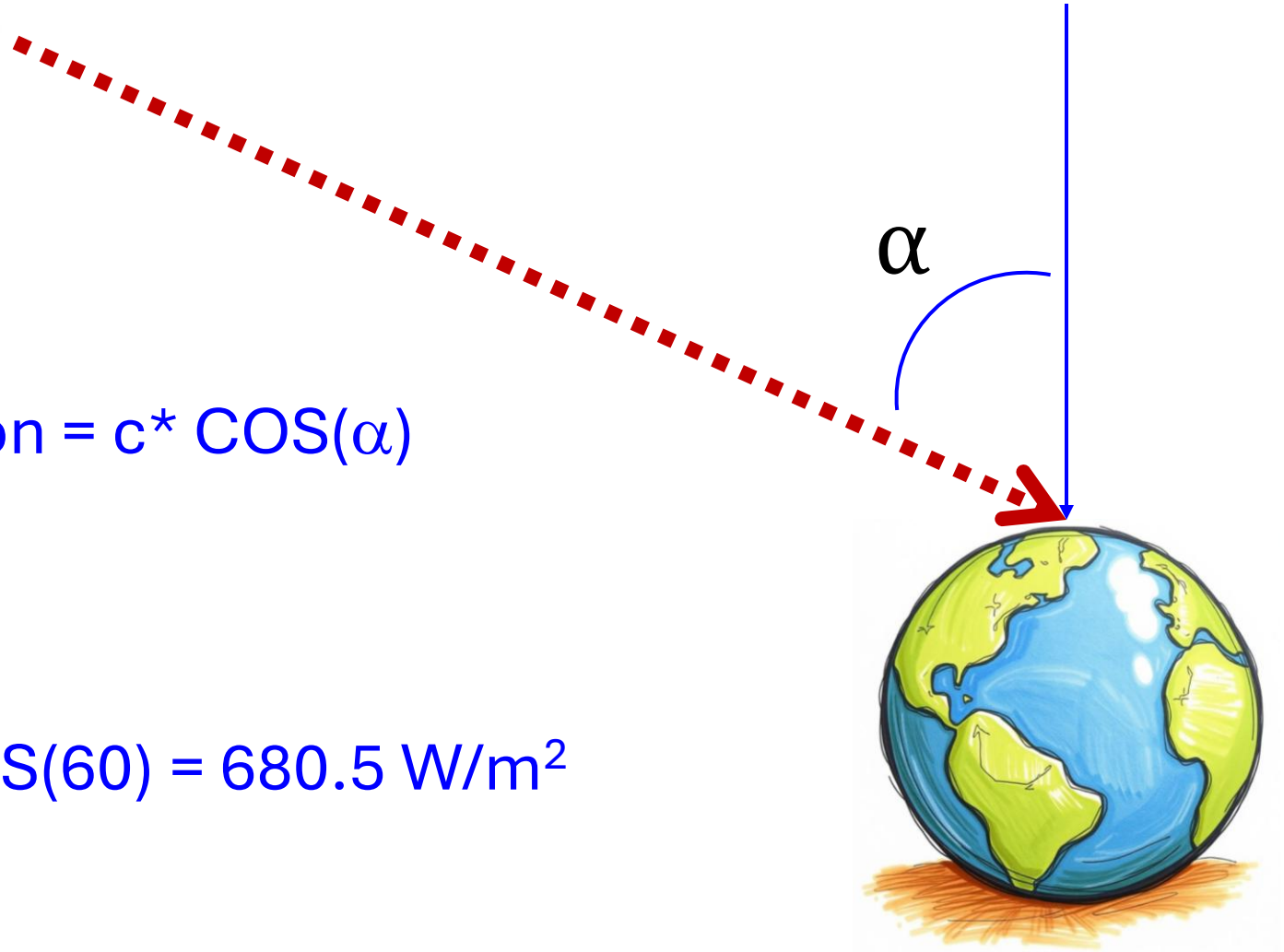

Actual radiation = c* COS(α)

α =60 degree

R_t = 1361*COS(60) = 680.5 W/m^2