Agronomy 406
World Climates

March 6, 2018

Climate of Iowa.

Climate and agriculture.

Team 1 Climate News on Thursday, March 8.

Reading: UN Food and Agriculture Organization summaries for maize, wheat, soybean and sugarcane.

The Climate of Iowa

Physical geography of Iowa

Area is about 145,000 square km (56,000 sq mi)

- Extent is about 300 km north-south and 500 km east-west.

Latitude ranges 40.6 - 43.3 ^{o}N

- Ames is 42 ^{o}N, about the same as Rome and Boston.
- **Where is Iowa in terms of the 3-cell model?**

Elevation changes are small.

- Gradual rise from east to west: about 400 m elevation increase in 500 km distance. (How many feet in how many miles?)
- Terrain is mostly flat or rolling hills.

General climate characteristics

Midlatitude cool continental (Koeppen Dfa or Dfb)

- This climate type is also found in southeastern Europe and southwestern Russia.

Typical frost-free season at Ames is mid-April through mid-October.

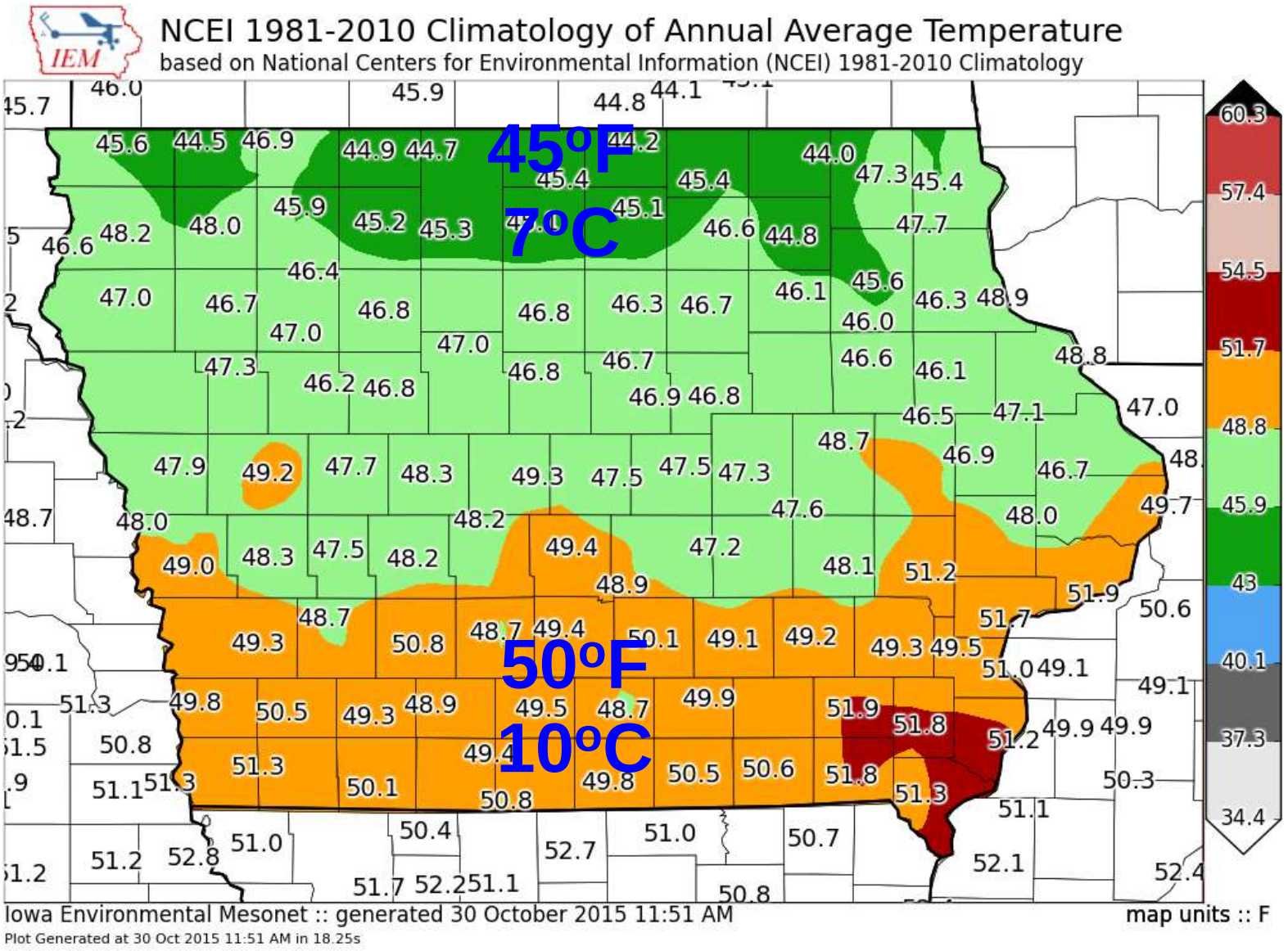
Statewide average annual precipitation is about 910 mm (36 inches).

Average temperature and rainfall varies across the state:

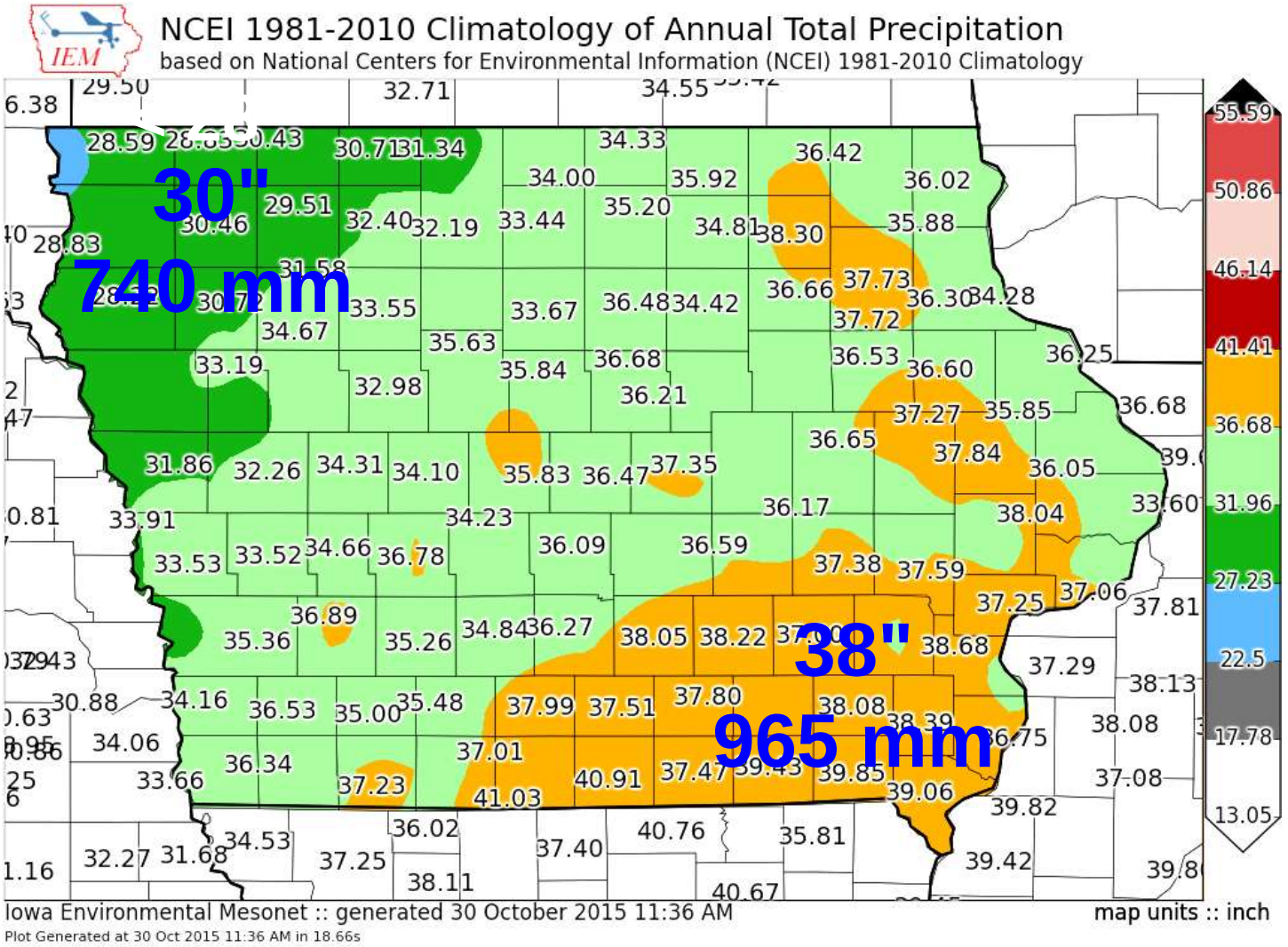
Temperature decreases from south to north.

Rainfall decreases from southeast to northwest.

Average yearly temperature for most recent climate normal period



Average yearly precipitation
(rain plus liquid equivalent of snow)



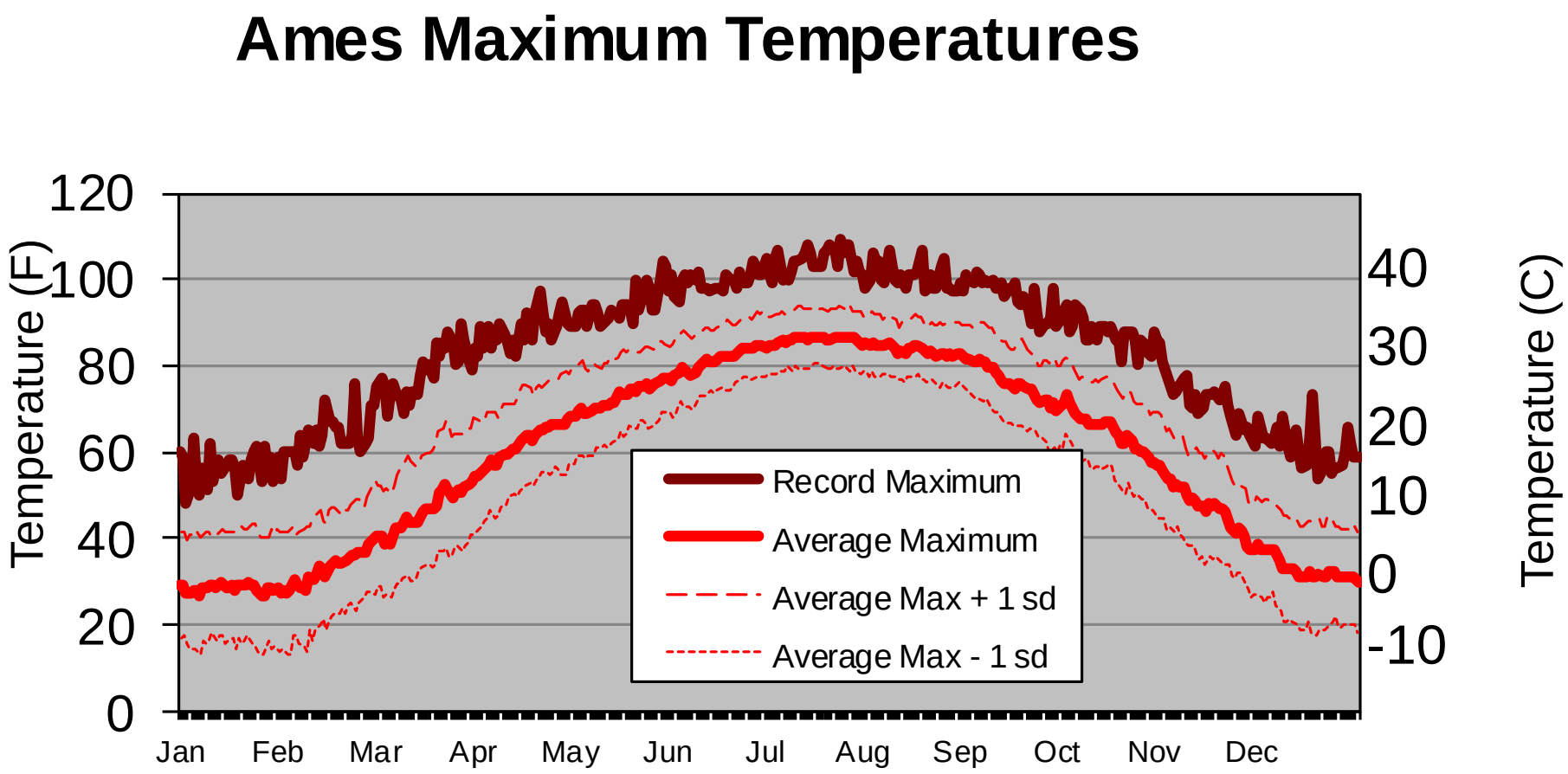
Continentality

Iowa has a **continental** climate:

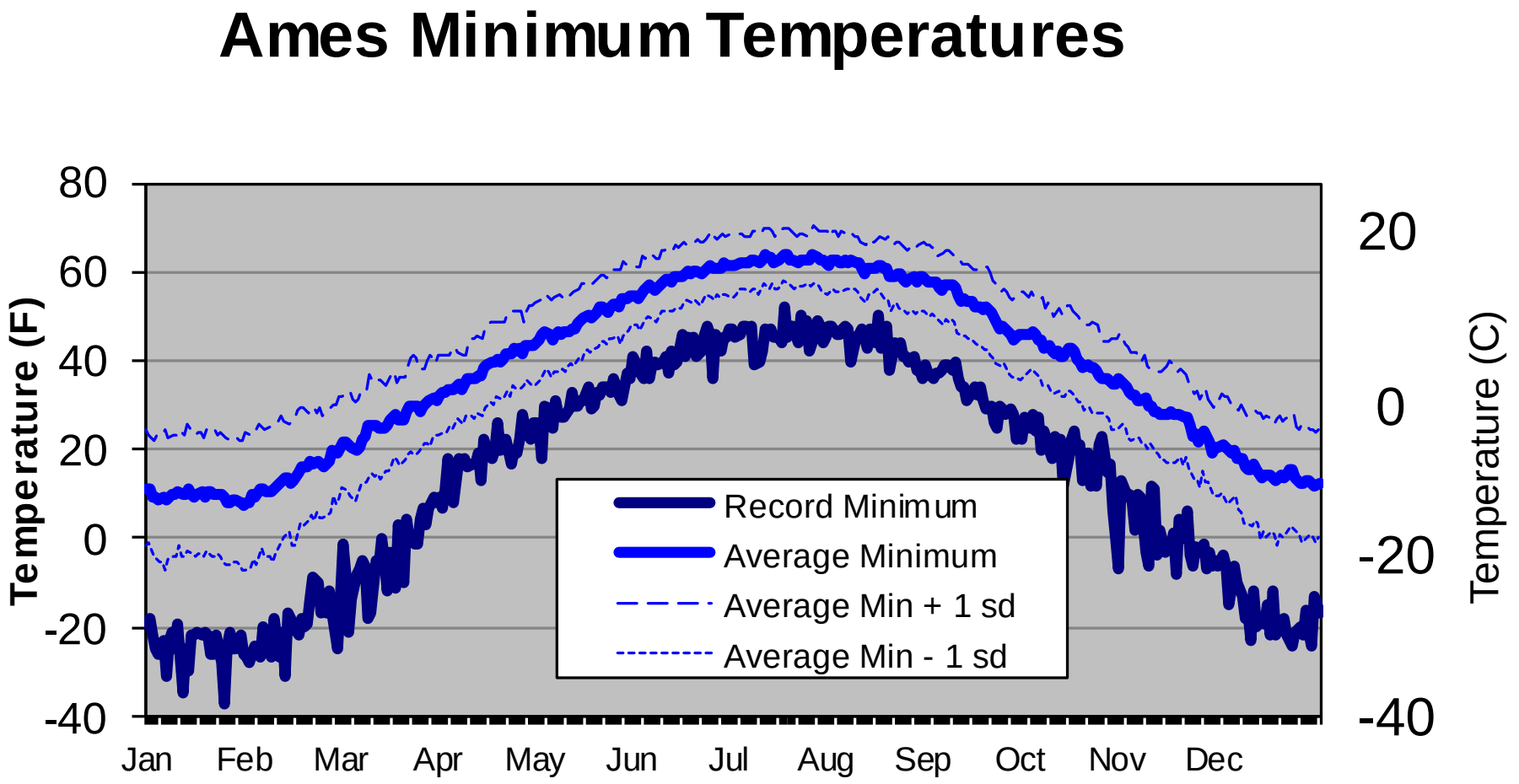
Far from oceans (1300 km to Gulf of Mexico, 1600 km to Atlantic Ocean).

This allows **large annual temperature swings** with cold winters and hot summers.

In continental climates, temperature usually follows the solar cycle



Minimum temperatures also follow the solar cycle



Quantifying continentality

Probably most common is the **Conrad index:**

$$k = \frac{1.7A}{\sin(\varphi + 10)} - 14$$

A = annual temperature range (Celsius)

= (average temperature of the warmest month) – (average temperature of the coldest month)

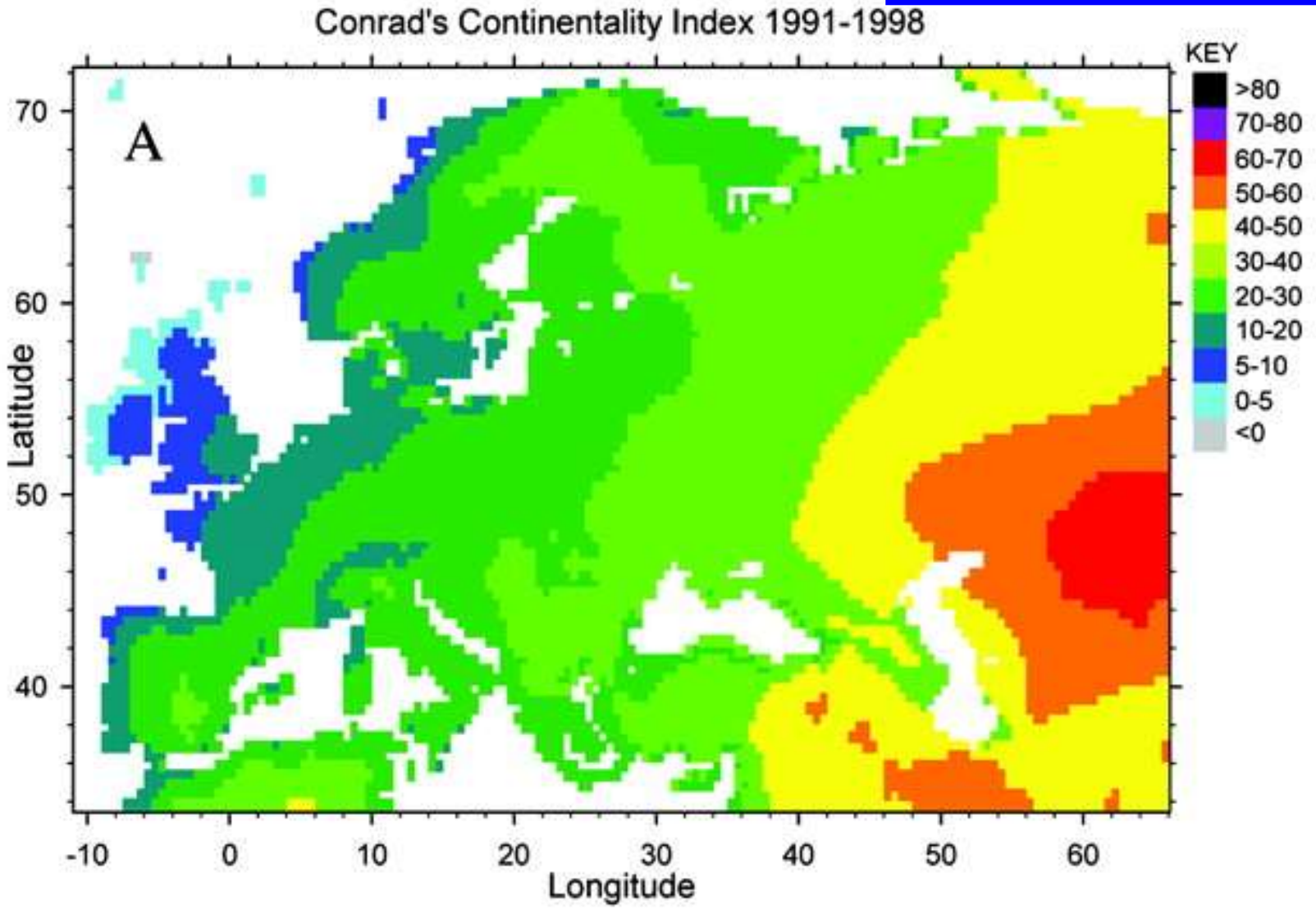
ϕ = latitude (degrees north: index in this form works only for the Northern Hemisphere)

Questions for teams:

- **What is the Conrad index for Ames?**
- **Ames continentality is similar to where in Europe?**

Continentality in Europe

Ames has continentality similar to what place(s) on this map?



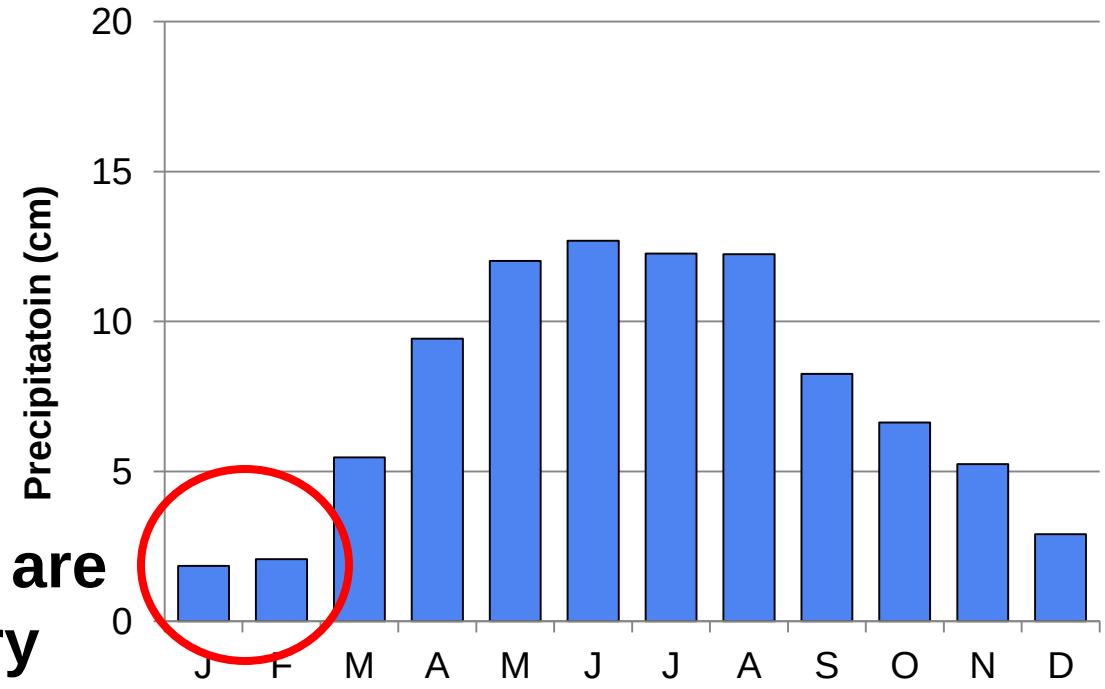
from Crawford et al. (2003) Ann Bot. doi: 10.1093/aob/mcf185

Average monthly precipitation in Ames

Wettest month is June

Driest month is January

Average annual total is 36 inches (91 cm) for the current normal period (1981-2010).



winters are fairly dry

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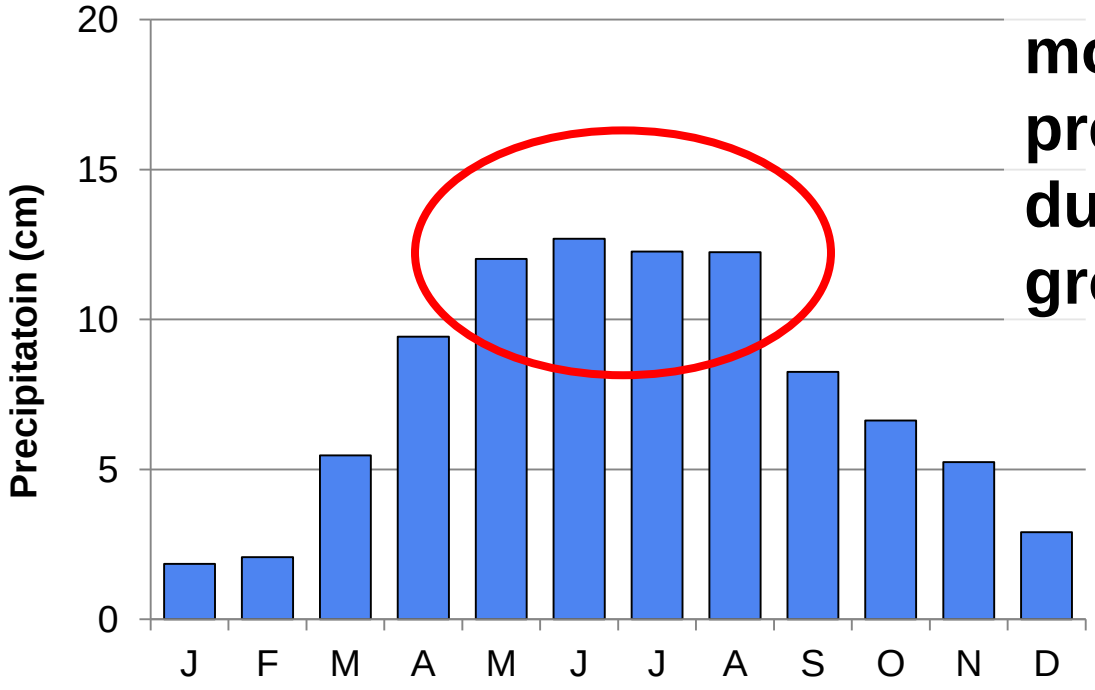
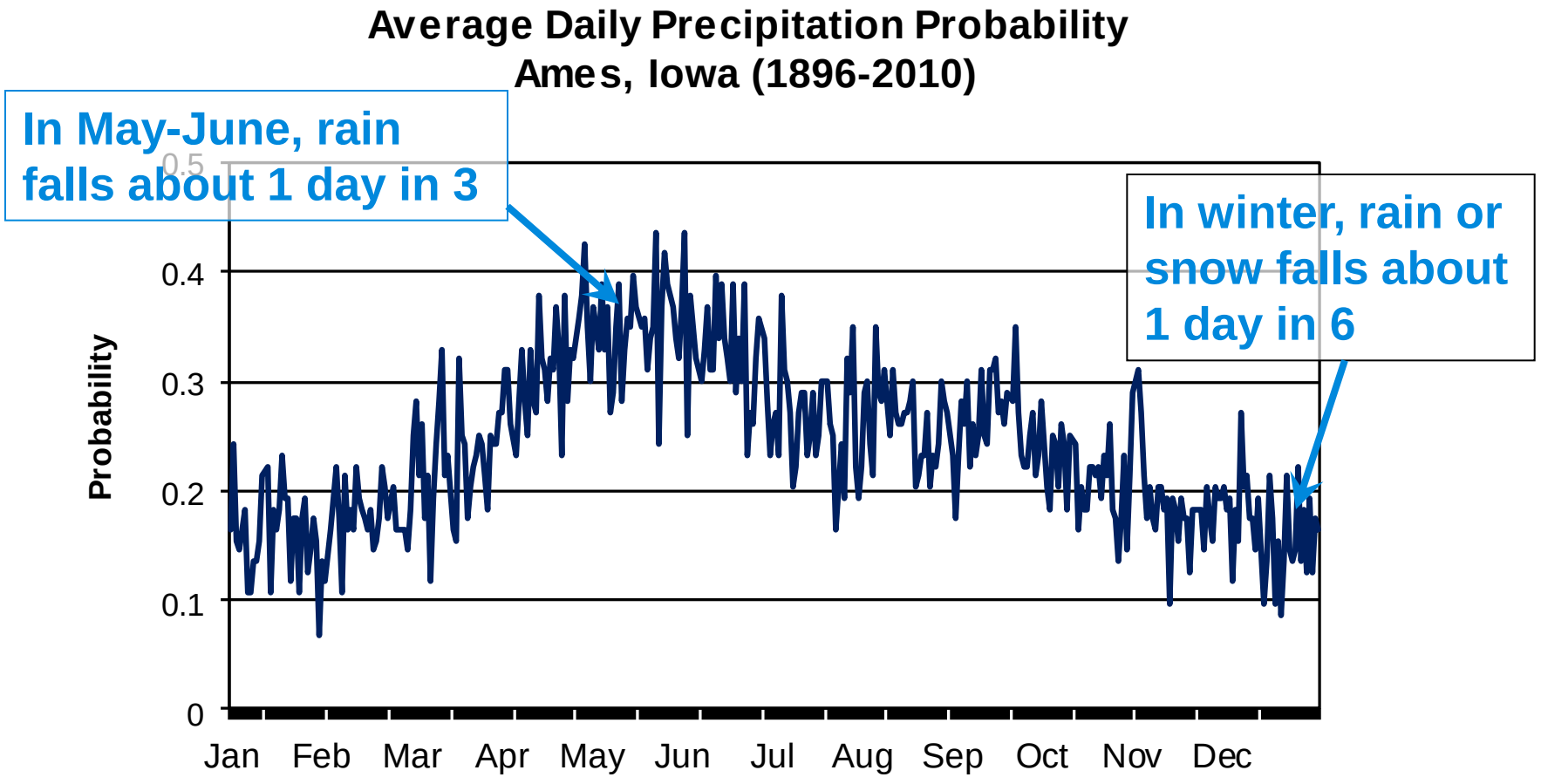


most of our precipitation falls during the growing season

Precipitation is most frequent in late spring



Plant available soil moisture

Iowa soils can hold around 10-12 inches of crop available water in the top 5 feet of soil (25-30 cm in the top 1.5 m).

Variation in a “normal” year:

- **Early spring** soil is a little below holding capacity.
- **Rain in late spring fills the soil column** to capacity by mid-June.
- During summer, **plants draw down the moisture in the soil.**
- By September 1 most of the state has 4-5 inches of available subsoil moisture.

Snow

Average seasonal snowfall increases from south to north (25 to 43 inches, or 630 to 1100 mm).

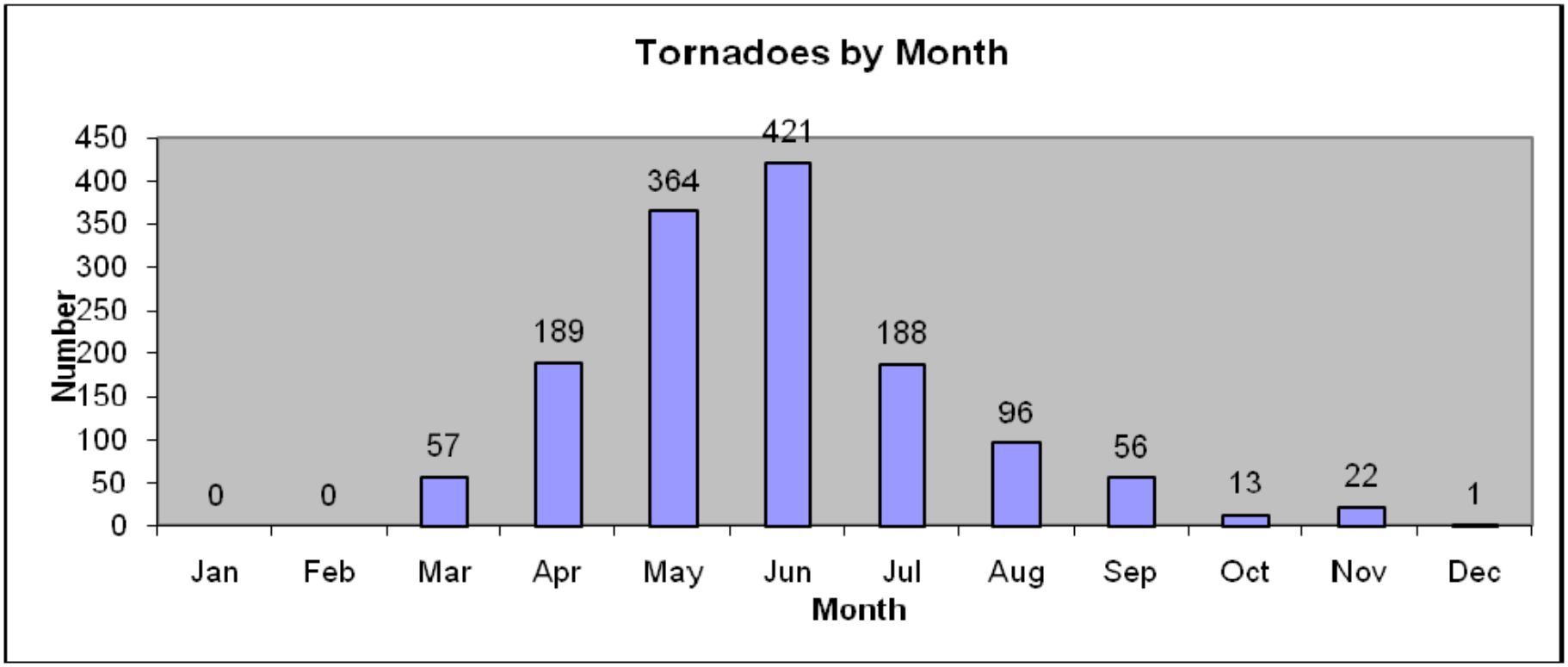
- Southern Iowa is warmer so moisture is less likely to fall as snow.

Snow season usually is late October to mid April.

- Sometimes snows as early as late September or as late as early May.


Home of the Cyclones

Iowa tornados are most common in late spring but have occurred in almost all months



Craig Cogil, NWS Des Moines

8 September 2005
EF1 tornado

Other weather hazards

- Lightning
- Floods
  - **Spring flooding is common, sometimes worsened by ice jams.**
- Drought
  - **Extended severe drought in 1930s, shorter severe droughts in 1988, 2012.**
- Hail
  - **Ice at least 0.5 cm diameter (2.5 cm for "severe")**
  - **About 70 damaging hailstorms per year.**
  - **Destroys 1 to 5% of crop value in a typical year.**

Sources of weather and climate data

Daily observations and forecasts are available from the National Weather Service:

http://www.crh.noaa.gov/dmx

Current and historical data are available through the Iowa Environmental Mesonet

http://mesonet.agron.iastate.edu

Climate and agriculture

Relation of agriculture to climate has been recognized since ancient times:

Ancient Egyptians had three seasons: flooding (Akhet), growing (Peret), and harvesting (Shemu).

"Then I shall give you rains in their season, so that the land will yield its produce and the trees of the field will bear their fruit."

Leviticus 26:4, ca. 500-400 BC from much older oral traditions

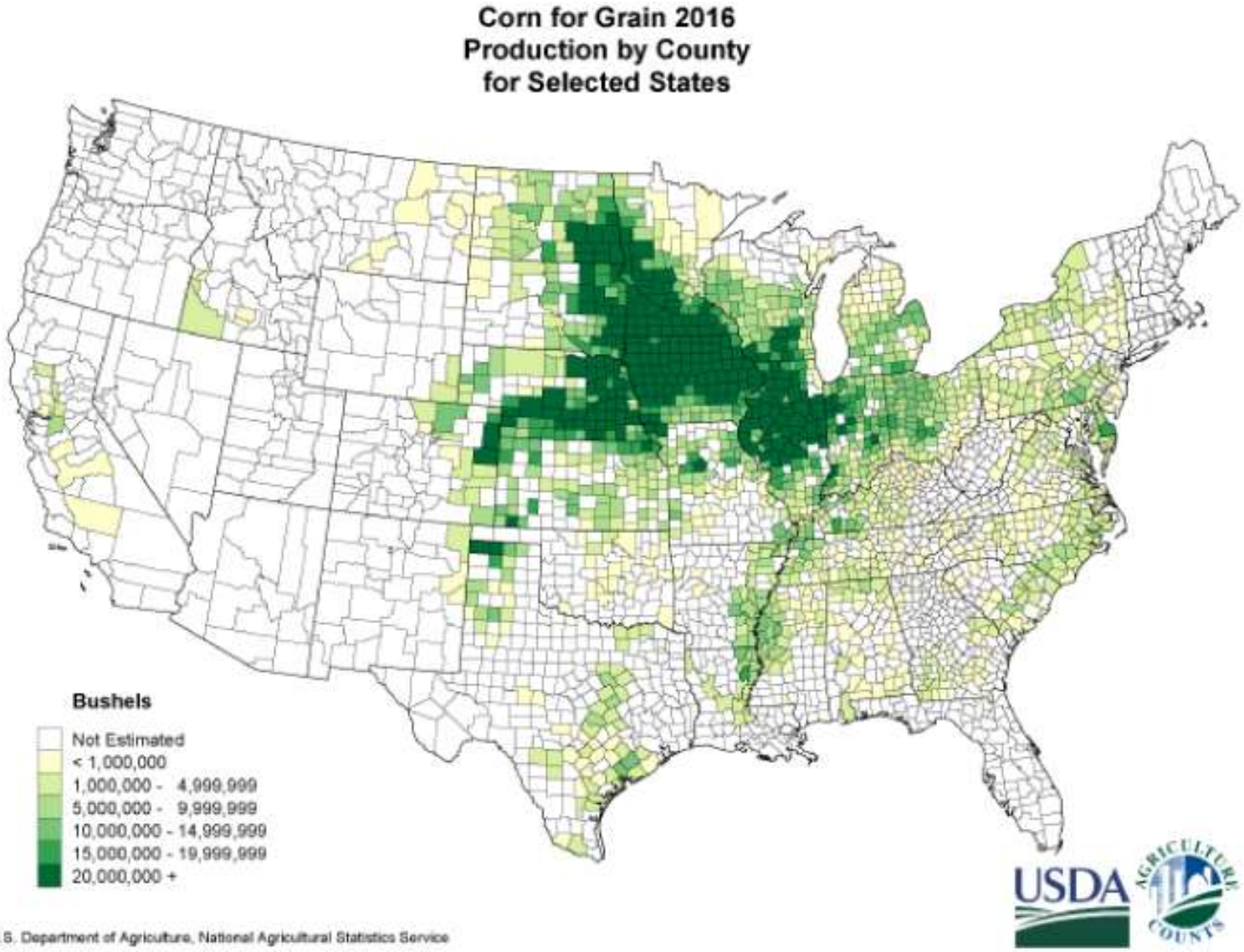
Modern scientific study of the relation between climate and agriculture began in the early 1800s.

Major crops in the U.S.
excluding animal products

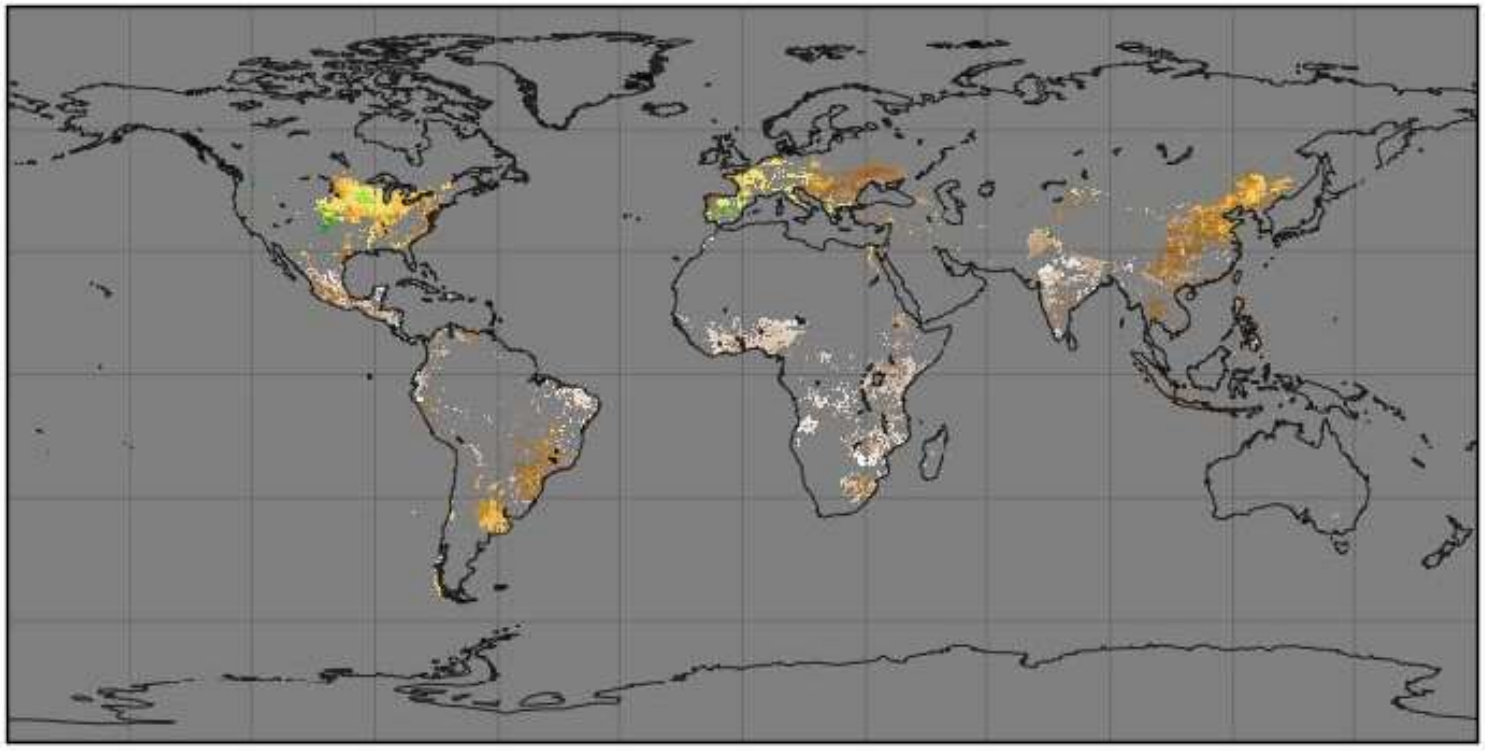
Crop	Production (millions of metric tons)	Photosynthesis type
Maize (corn)	353.7	C4
Soybeans	91.4	C3
Wheat	91.3	C3
Sugar beet [1]	58.0	C3
Sugar cane [1]	29.7	C4
Potatoes	27.9	C3
Tomatoes	12.6	C3
Sorghum	9.9	C4
Rice	8.6	C3

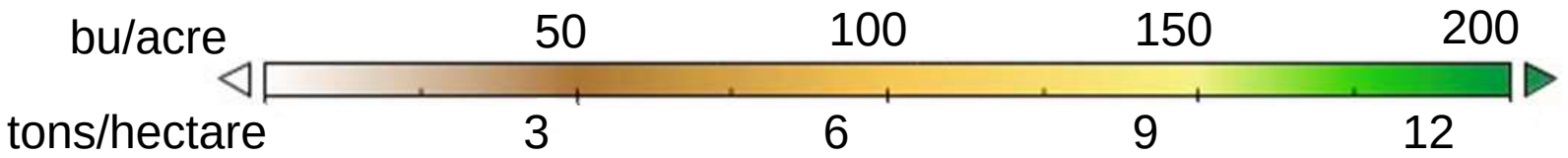
[1] Combined production of refined sugar is about 7.4 million metric tons

Corn production in the U.S.



Global corn growing regions and yields





100 bu /ac = 6.3 T/ha

Corn water use

A high-yielding crop will use around 20 to 30 inches (500 to 800 mm) of water during the season.

Water use depends on climate – higher end is for warm climates.

Water use around silking and pollination is about 0.3 inches (8 mm) per day.

Water stress around silking and pollination can greatly reduce yields.

Is all moisture that falls as precipitation available for use by the plant? Explain.

Relation to temperature: Corn growing degree days

Maturity	Days	Growing degree days
Early season	85-100	2100-2400
Mid season	101-130	2400-2800
Late season	131-145	2900-3200

What's a growing degree day?

data from https://www.extension.purdue.edu/extmedia/nch/nch-40.html

Growing Degree Days (GDD)

sometimes called "heat units" or other names

Concept of "thermal time":

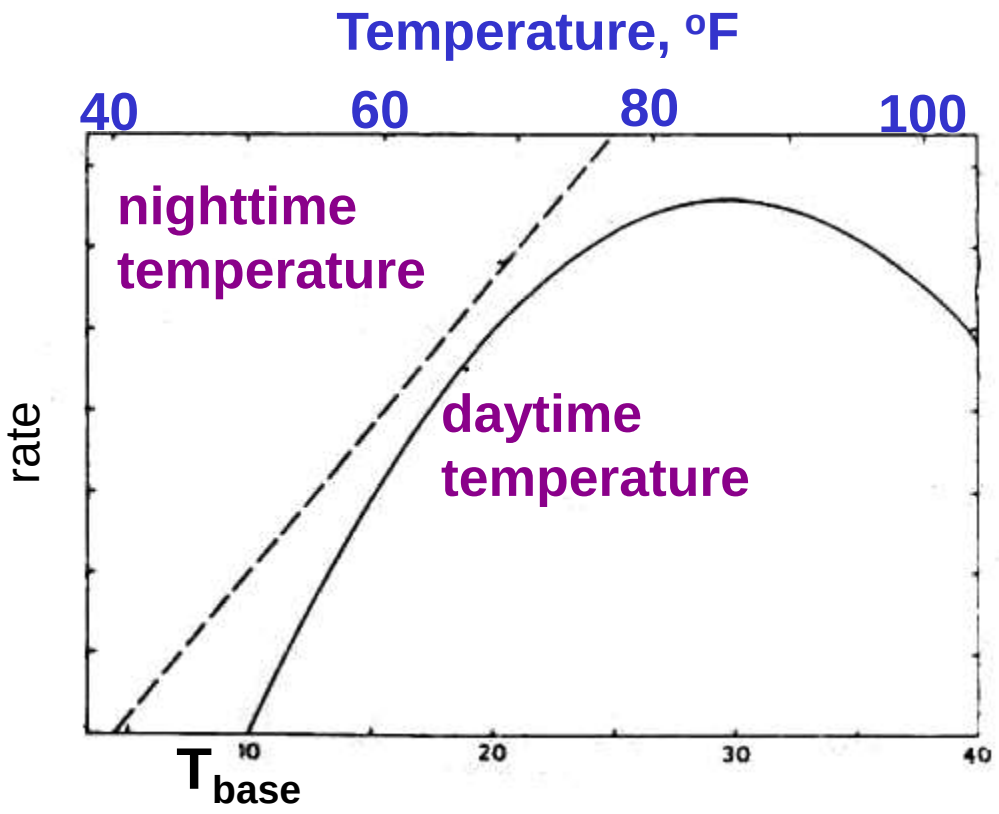
- Rates of chemical reactions and other biophysical processes often depend on temperature.
- Many organisms have a minimum temperature for development, and develop more rapidly as temperature increases.

Applies to many kinds of organisms that **do not regulate their own temperature:**

- plants, insects, etc.

Relates to development but not necessarily yield.

Corn development and temperature



For most crops there is a **base temperature** T_{base} below which development is slow or zero.

There is also often an upper temperature limit, above which development decreases.

Calculating Growing Degree Days (GDD)

For each day,

$$\mathbf{G = (T_{average} - T_{base})}$$

$T_{average} = (T_{max} + T_{min})/2$

T_{base} depends on type of organism

G cannot be negative. If $T_{min} < T_{base}$, set T_{min} to T_{base} (also for T_{max}).

Temperature also has an upper limit: if T_{max} exceeds this, set T_{max} to the upper limit (86°F for corn).

Sum G for each day following the start of growing season to get **growing degree days.**

Example: Last Wednesday, T_{max} was 52°F and T_{min} was 31°F. What was G for the day? Assume T_{base} = 50°F and upper limit 86°F.

Calculating Growing Degree Days (GDD)

Growing degree days for each day are **accumulated** over the season, starting with the day after planting date (or other relevant date for the application).

Example: Assume a planting date of April 19.

Date	Tmin (ºF)	Tmax (ºF)	G	GDD
Apr 20	42	62	6	**6**
Apr 21	44	64	7	**13**
Apr 22	38	48	0	**13**
Apr 23	46	58	4	**17**

Degree days can be used to predict development stage

Typical 2700 GDD hybrid

Development stage	GDD (50°F base)
Planting	0
Two leaves fully emerged	200
Six leaves fully emerged (growing point above soil)	476
Eight leaves fully emerged (tassel begins to develop)	610
Silks emerging, pollen shedding	1400
Kernels denting	2190
Maturity	2700