USDA Midwest Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

Climate Change Issues for STEM and Tribes

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Topics

- A brief Background of USDA Climate Hubs
  - The need, mission
  - More on the Midwest Climate Hub
- Climate Change and Agriculture
  - Climate information
  - Tools
  - Outlooks
- Resources of the USDA Midwest Climate Hub
  - Website
  - For more Information

National Climate Assessment

- Intergovernmental Panel on Climate Change
- https://www.ipcc.ch

- Climate Science Report
- https://science2017.globalchange.gov/
- National Climate Assessment
- https://nca2018.globalchange.gov/
- Chapters (of interest)
  - Water
  - Land Cover and Use
  - Ag and Rural Communities
  - Built Environment Urban Systems and Cities

Changing Climate Impact on Agriculture

UNDERSTANDING CLIMATE CHANGES

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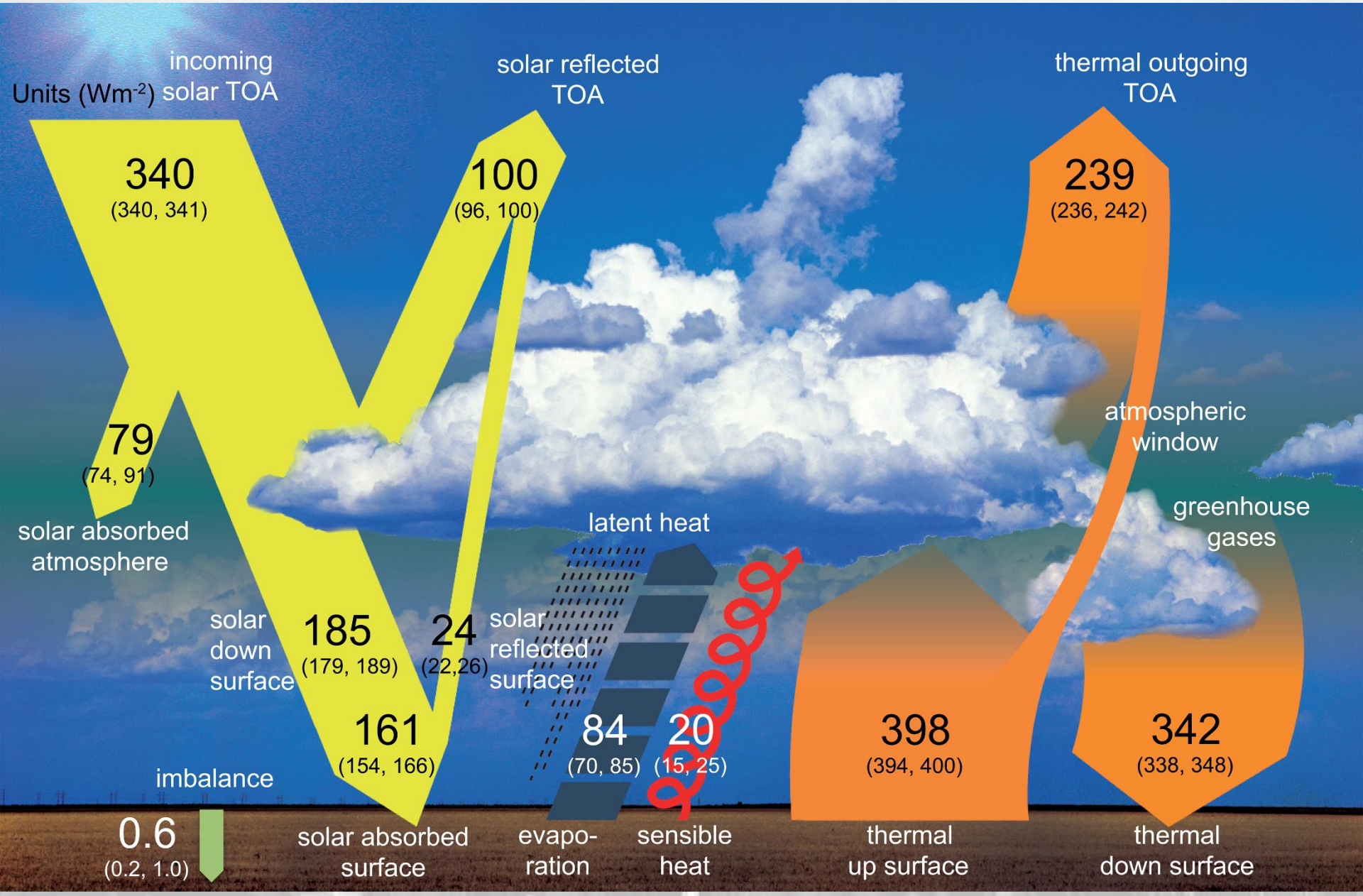
A little bit about the Atmosphere



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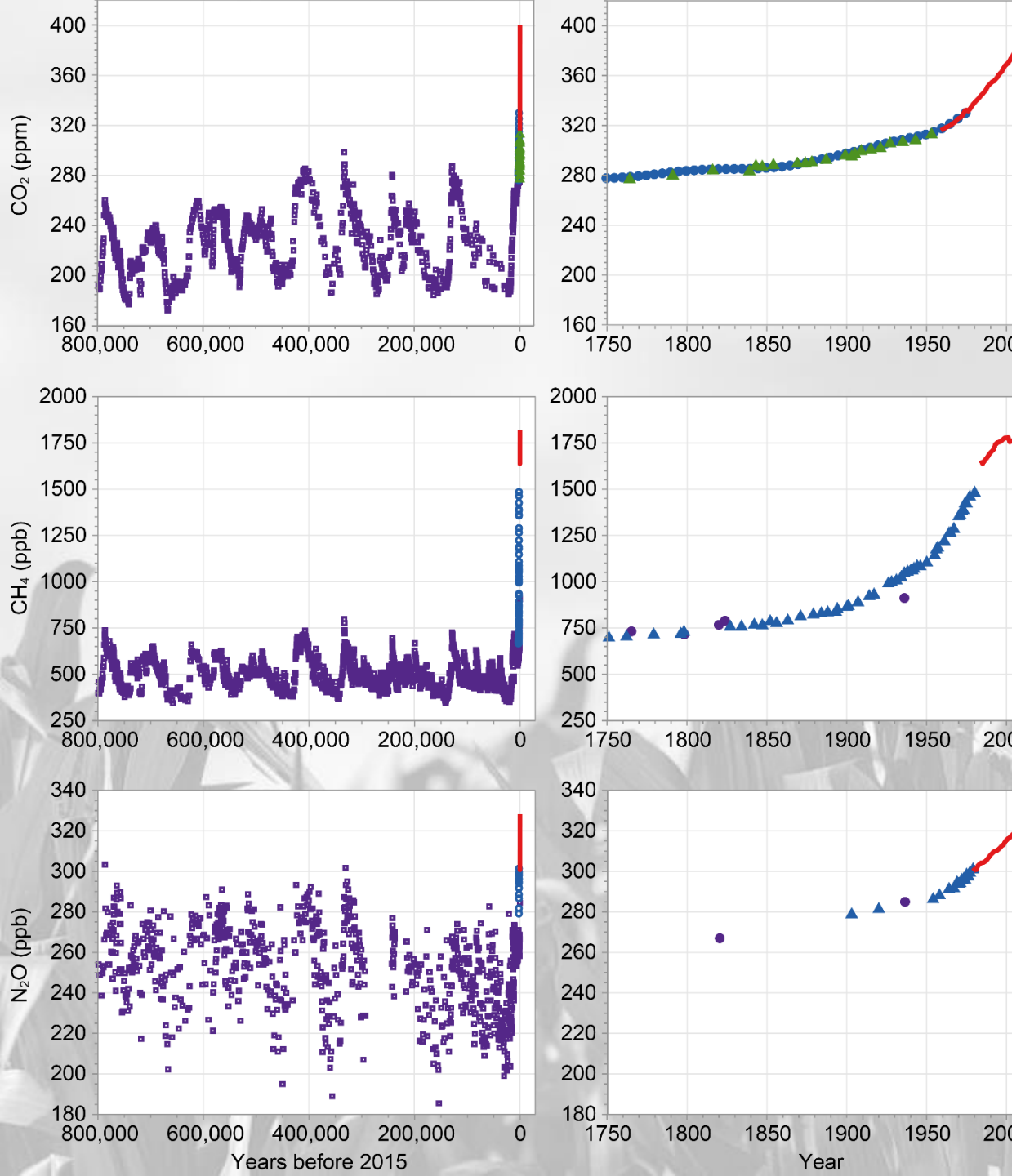
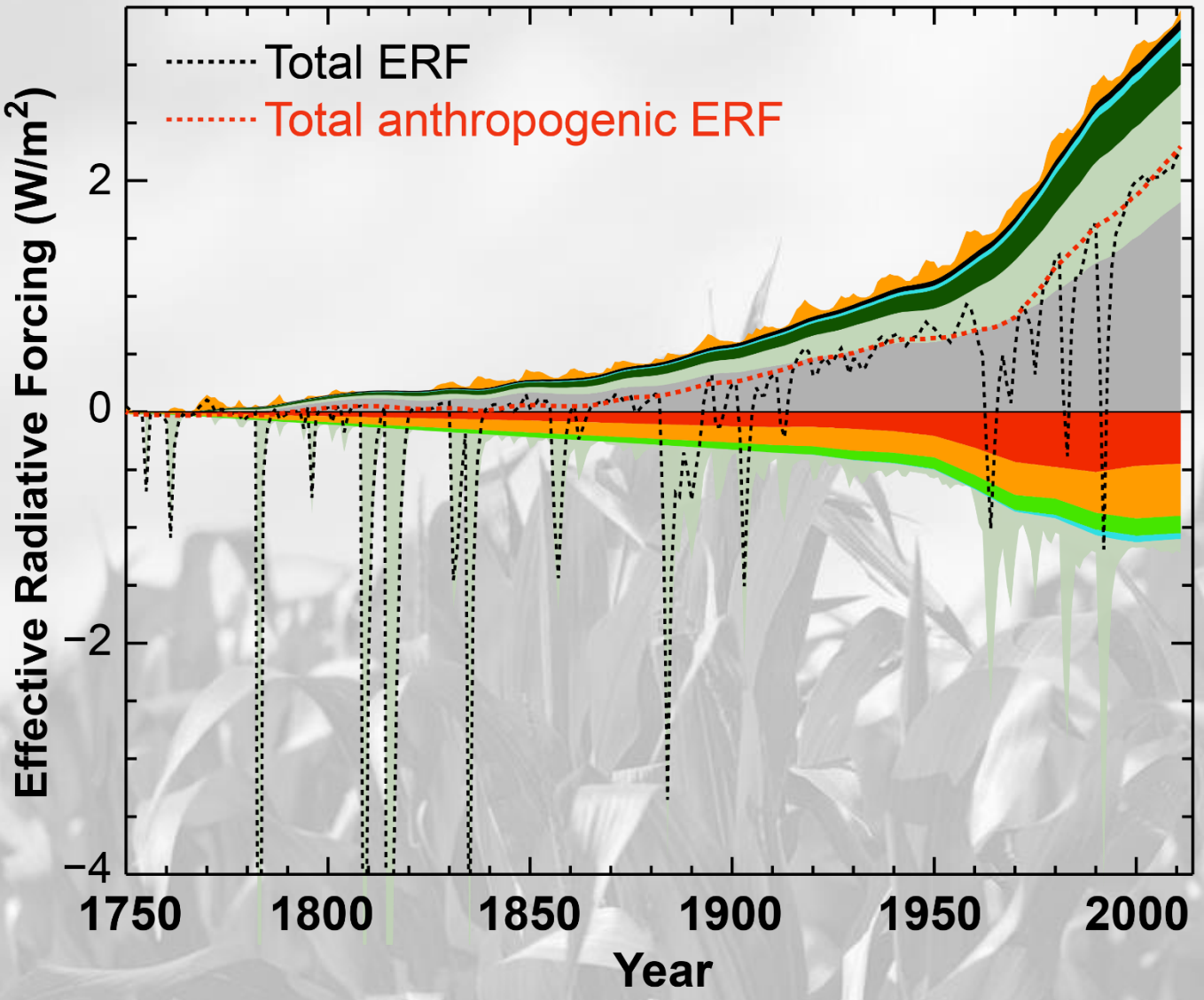


A little bit about the Atmosphere

Time Evolution of Forcings



Solar

Black carbon on snow and contrails

Stratospheric water

Tropospheric ozone

Other WMGHG

Carbon dioxide

Aerosol-radiation int.

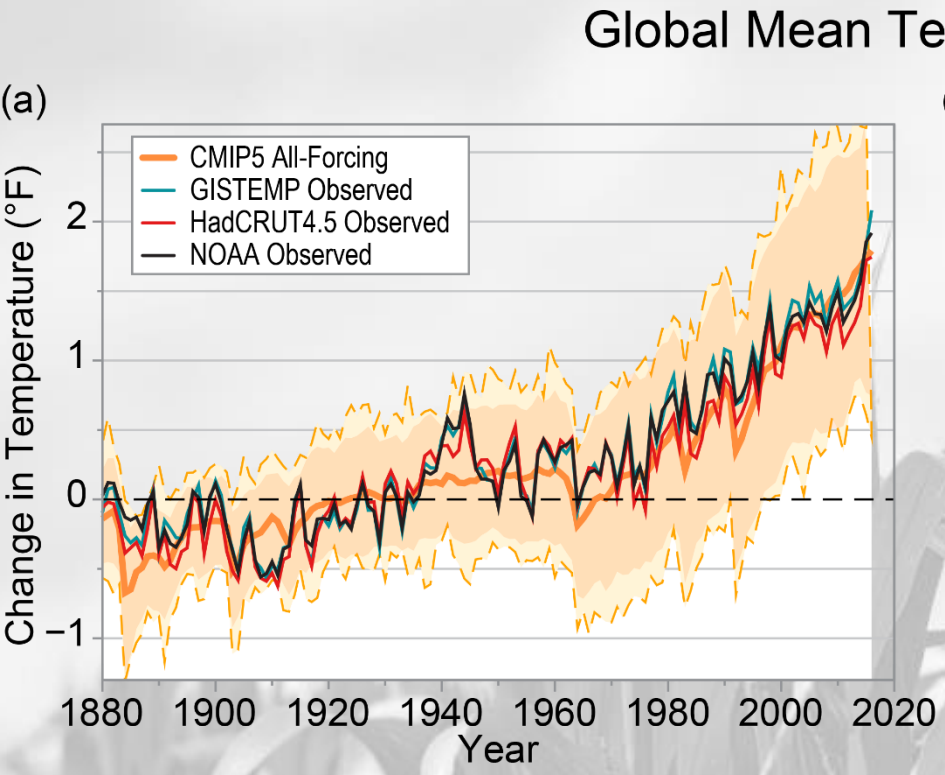
Aerosol-cloud int.

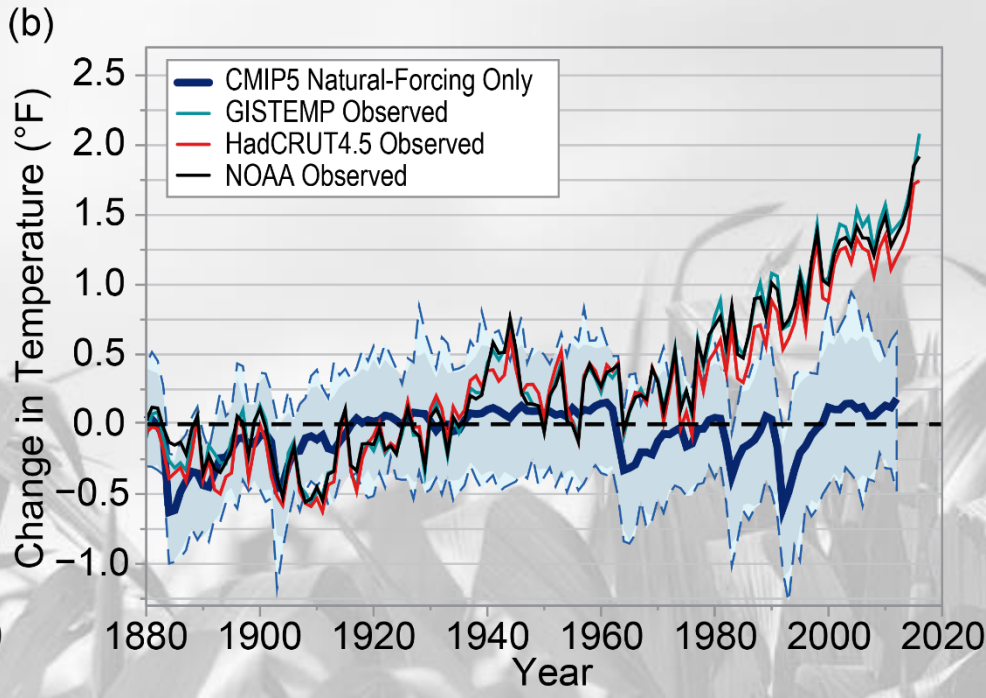
Land use

Stratospheric ozone

Volcanic

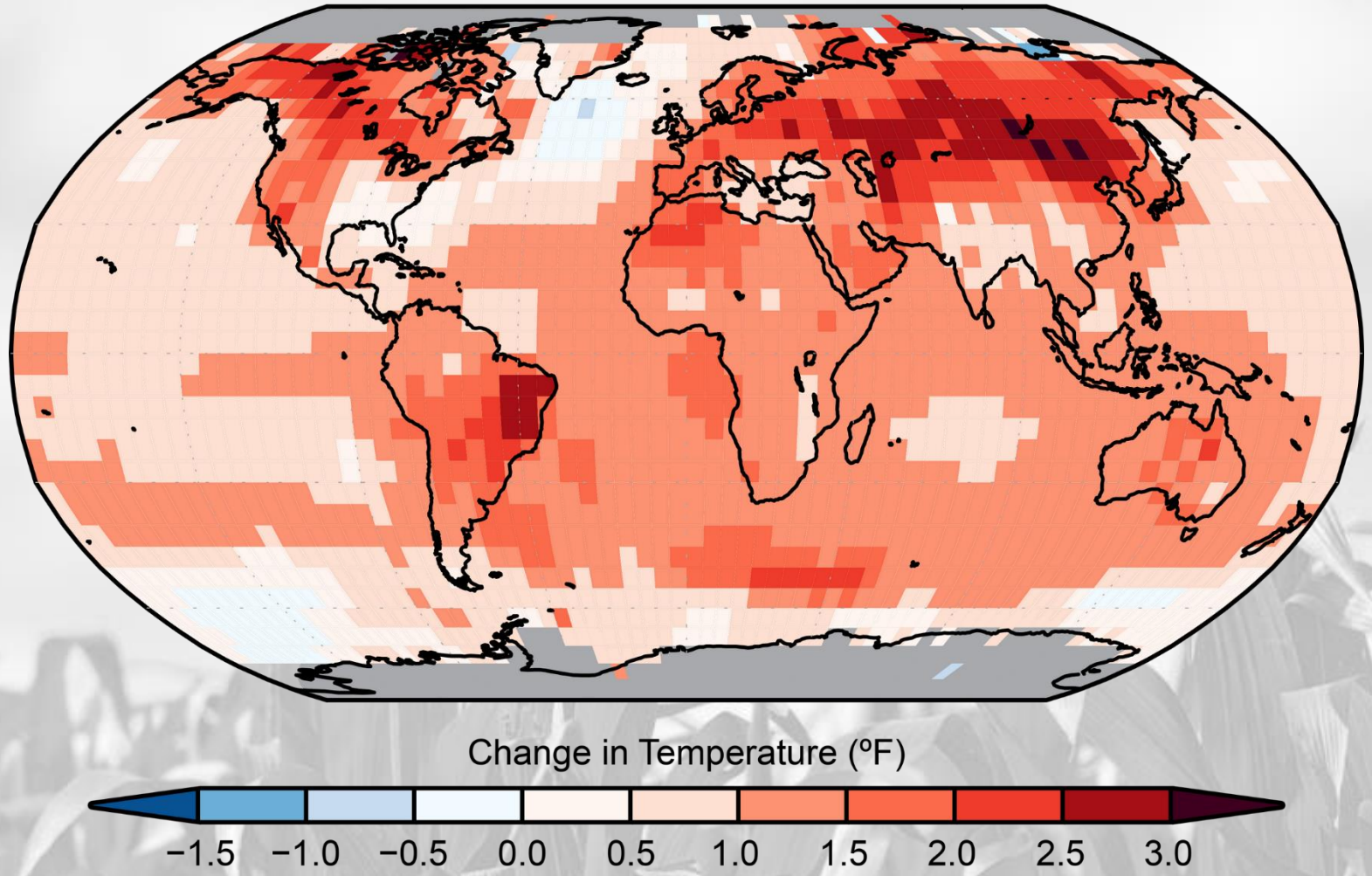
A little bit about the Atmosphere





https://science2017.globalchange.gov/chapter/1/

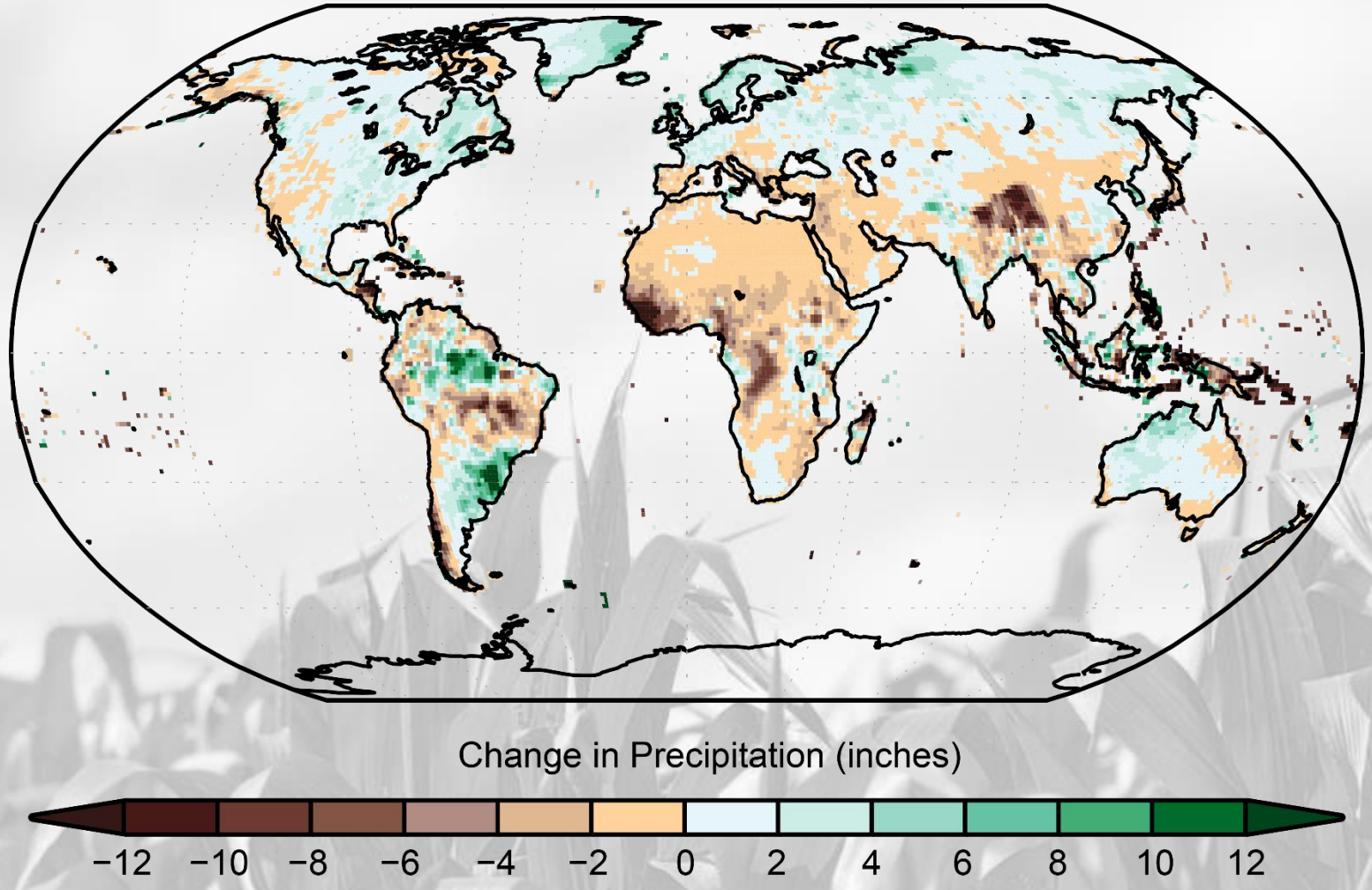
Surface Temperature Change



Surface temperature change (in °F) for the period 1986–2015 relative to 1901–1960 from the NOAA National Centers for Environmental Information's (NCEI) surface temperature product. For visual clarity, statistical significance is not depicted on this map. Changes are generally significant (at the 90% level) over most land and ocean areas. Changes are not significant in parts of the North Atlantic Ocean, the South Pacific Ocean, and the southeastern United States. There is insufficient data in the Arctic Ocean and Antarctica for computing long-term changes (those sections are shown in gray because no trend can be derived). The relatively coarse resolution (5.0° × 5.0°) of these maps does not capture the finer details associated with mountains, coastlines, and other small-scale effects (see Ch. 6: Temperature Changes for a focus on the United States). (Figure source: updated from Vose et al. 2012).

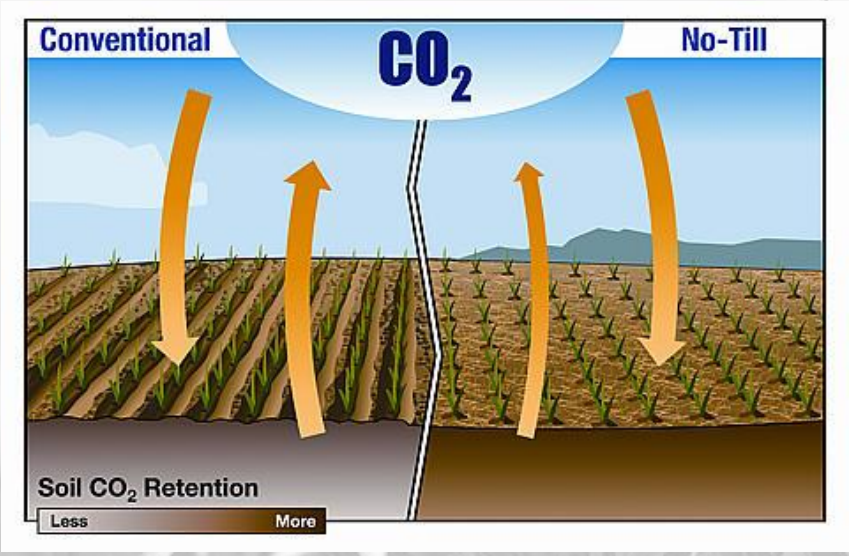
https://science2017.globalchange.gov/chapter/1/

Annually-averaged Precipitation Trends



Surface annually averaged precipitation change (in inches) for the period 1986–2015 relative to 1901–1960. The data is from long-term stations, so precipitation changes over the ocean and Antarctica cannot be evaluated. The trends are not considered to be statistically significant because of a lack of data coverage early in the record. The relatively coarse resolution (0.5° × 0.5°) of these maps does not capture the finer details associated with mountains, coastlines, and other small-scale effects. (Figure source: NOAA NCEI and CICS-NC).

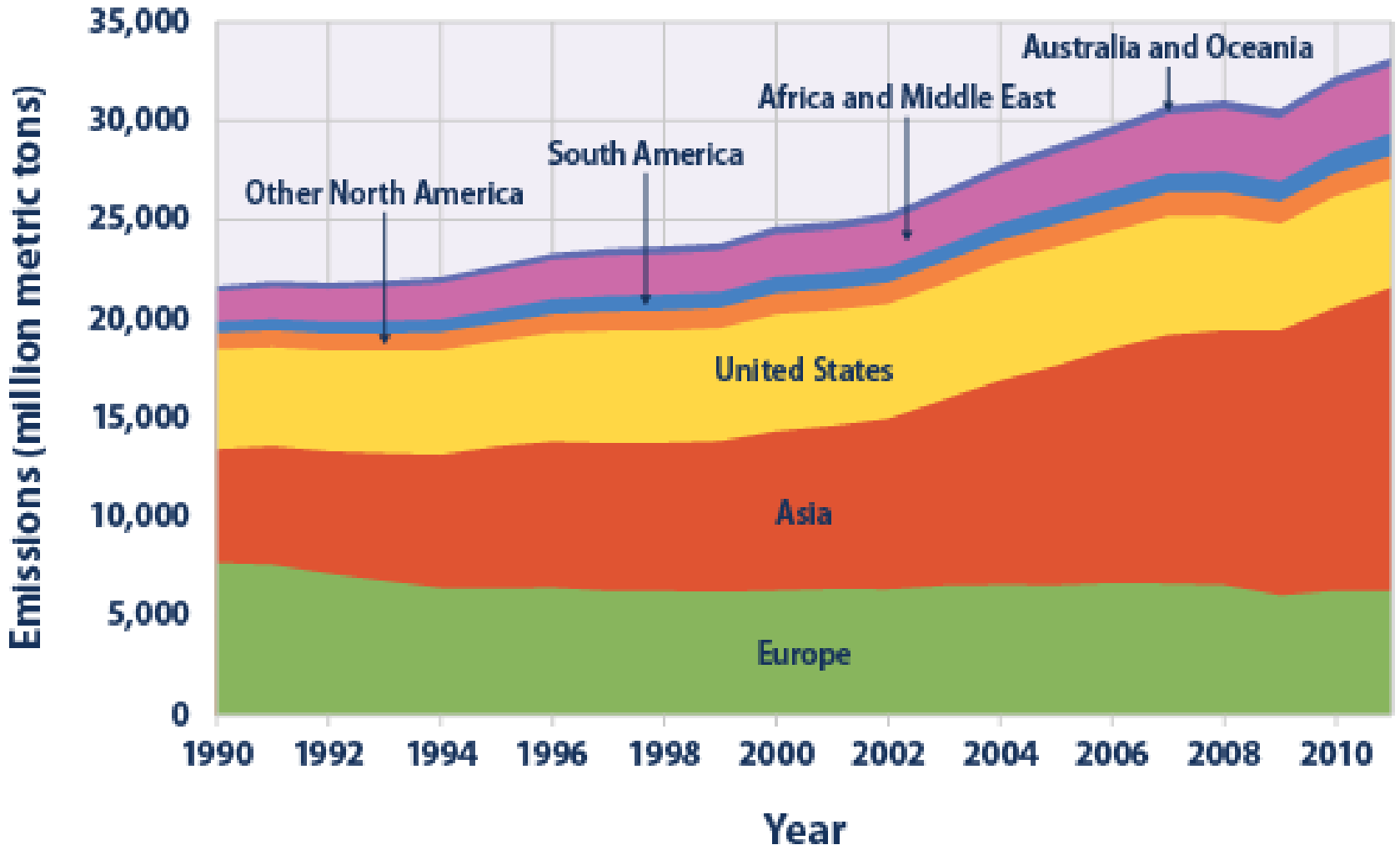
Global Warming



- **Agriculture contributes to global warming:**
  - CO_2 released from plant decomposition
    - CO_2 = 80% greenhouse gases
    - No-till Ag releases less CO_2
  - Methane released from rice paddies
    - Methane: 23 x warming impact of CO_2
  - Nitrous Oxide (NO) released from fertilizer use
    - NO: 296 x warming impact of CO_2

http://picturethis.pnl.gov/PictureT.nsf/All/6GPMKU?opendocument

Figure 3. Global Carbon Dioxide Emissions by Region, 1990–2011



http://tomchance.org/wp-content/uploads/2015/03/global-ghg-emissions-figure3-2014.png

Changing Climate Impact on Agriculture

US CLIMATE CHANGES

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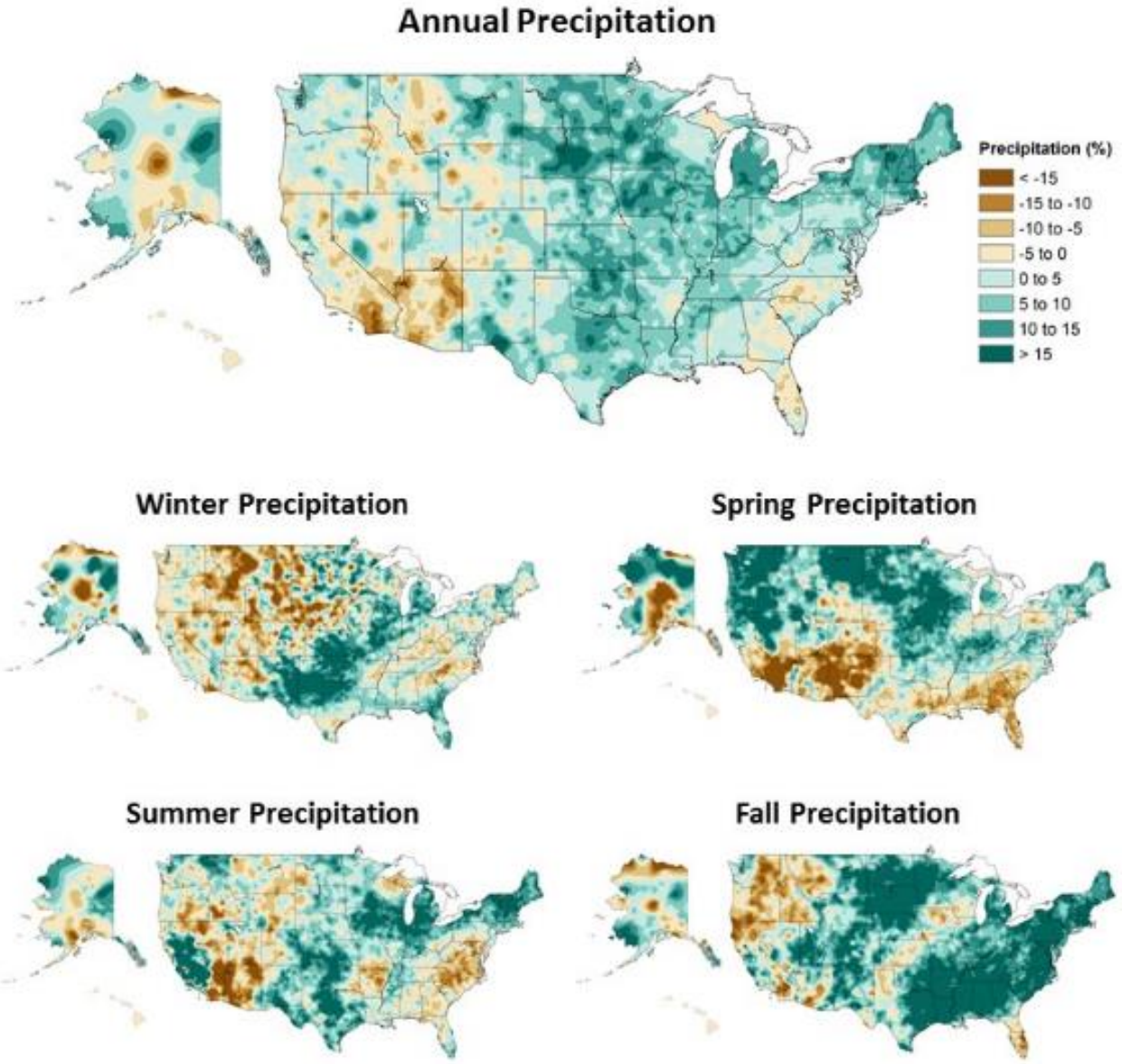
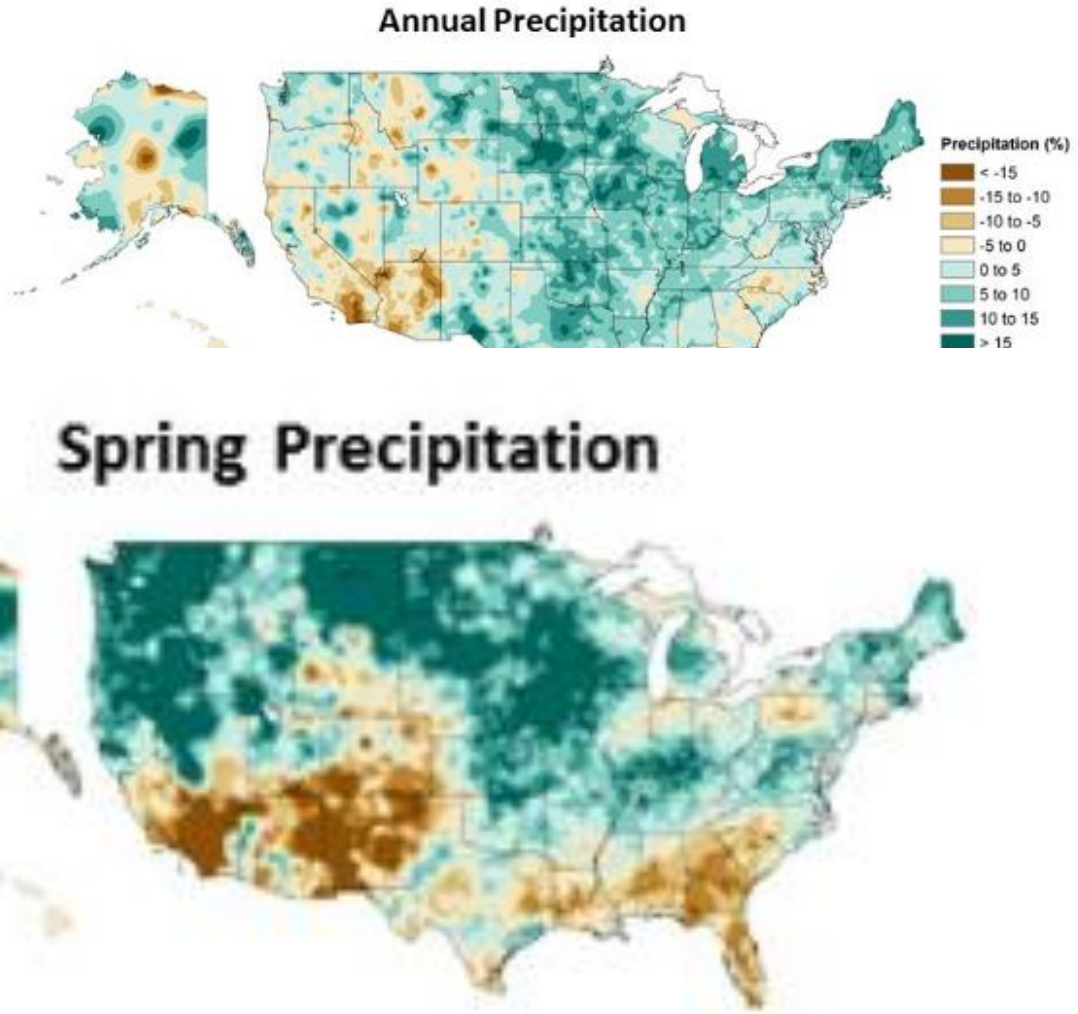


Figure 7.1: Annual and seasonal changes in precipitation over the United States. Changes are the average for present-day (1986–2015) minus the average for the first half of the last century (1901–1960 for the contiguous United States, 1925–1960 for Alaska and Hawai'i) divided by the average for the first half of the century. (Figure source: [top panel] adapted from Peterson et al. 2013,[78] © American Meteorological Society. Used with permission; [bottom four panels] NOAA NCEI, data source: nCLIMDiv].



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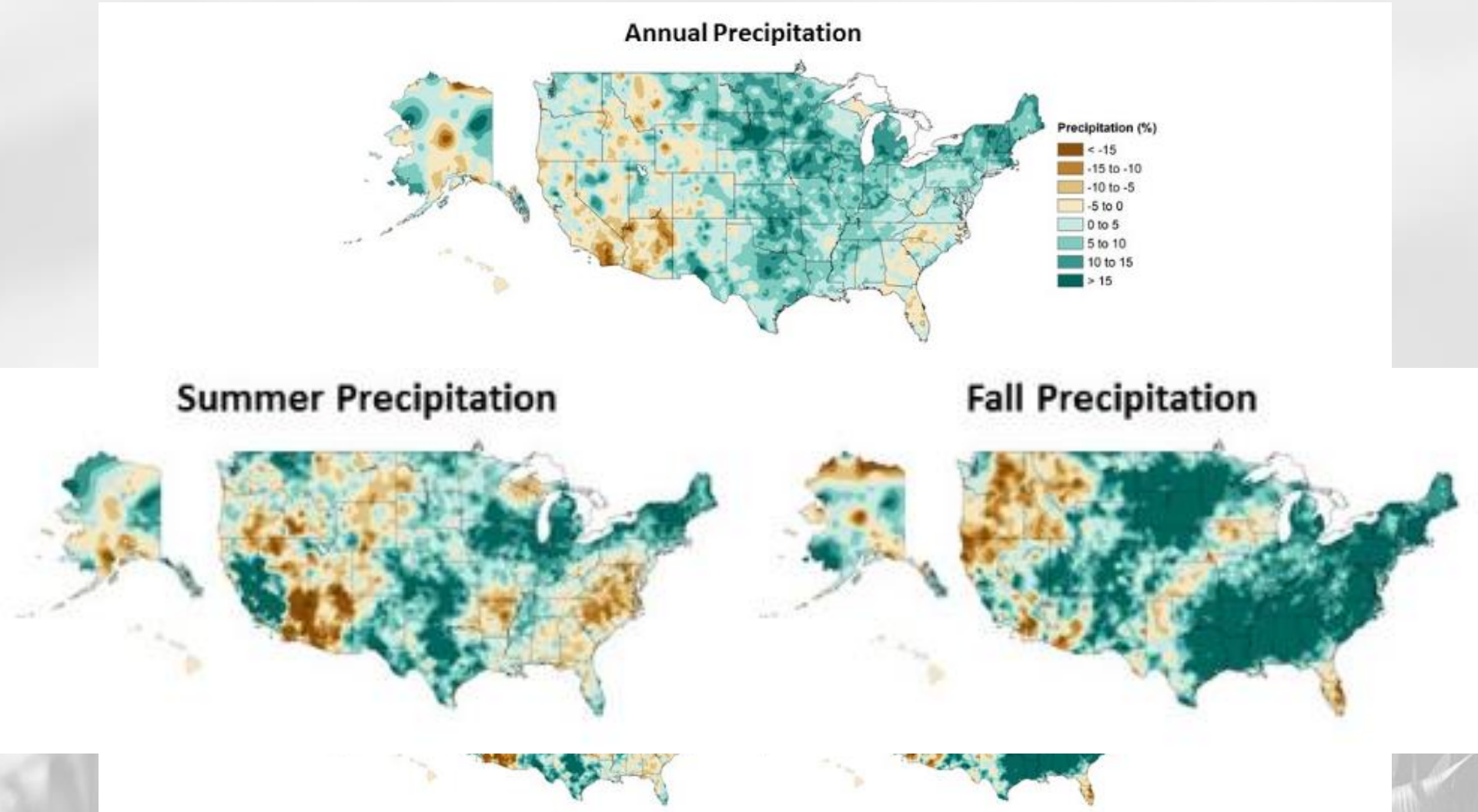

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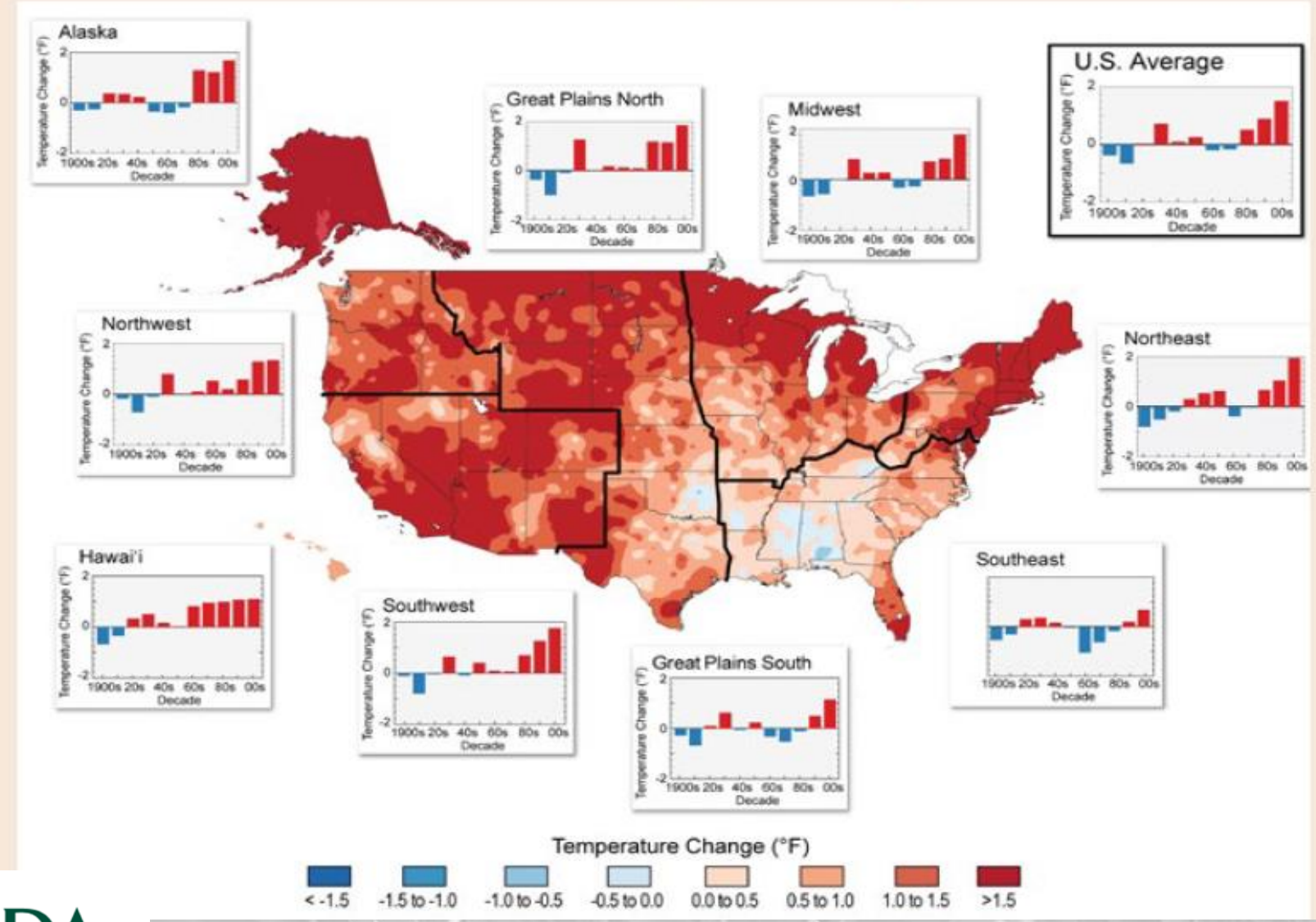
Issues from Precip Changes

- Variable across the corn belt
- Increasing precip intensity (especially off-season)
- More soil/nutrient loss potential
- Soil loss
  - Reducing tillage
  - Cover crops
- Nutrient loss
  - 4Rs
- Increased need for drainage

Observed U.S. Temperature Change



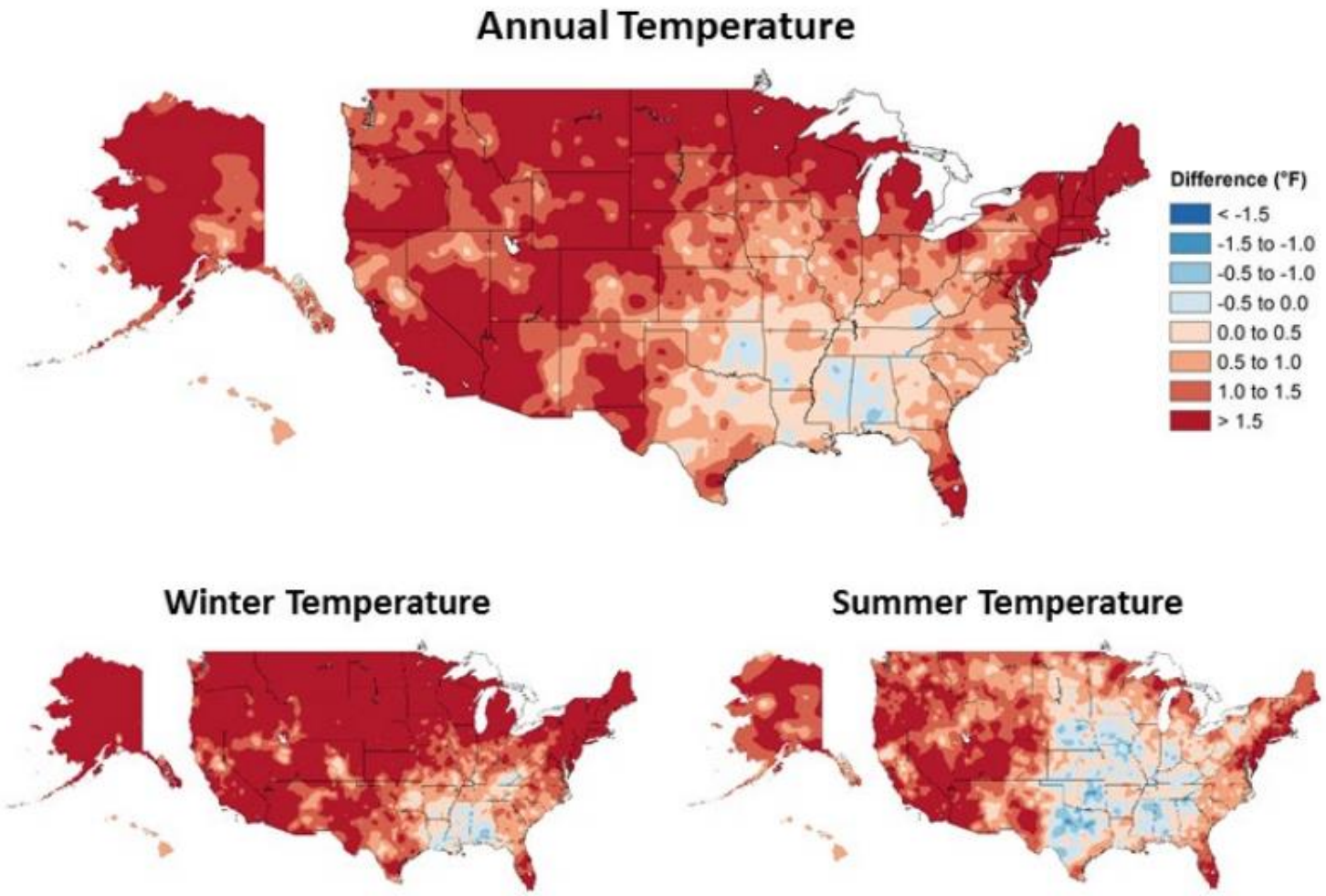
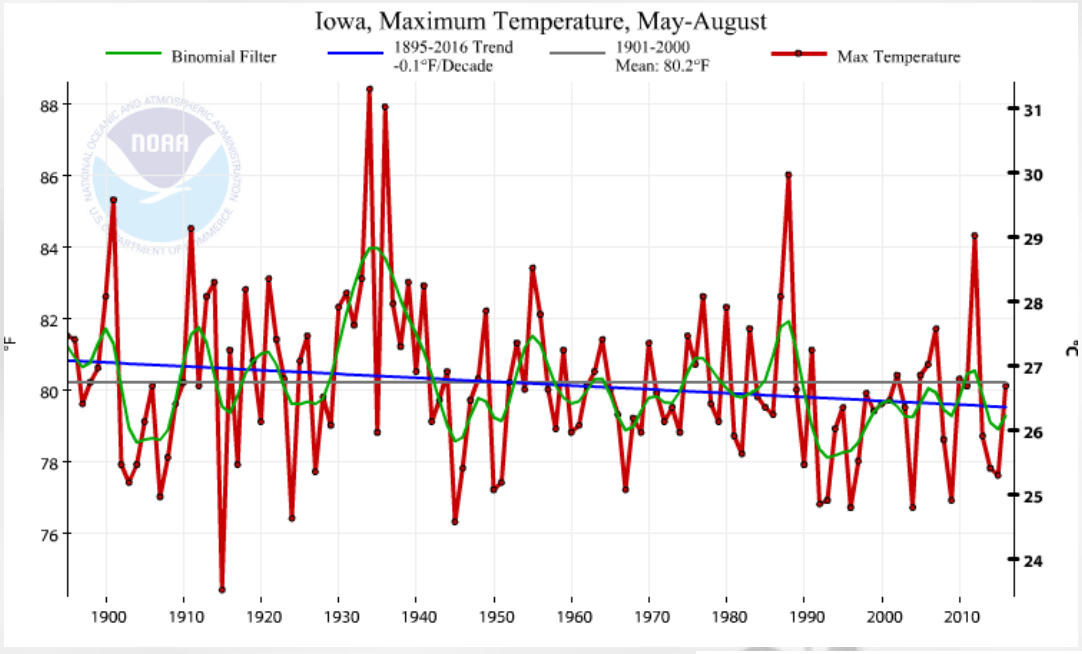
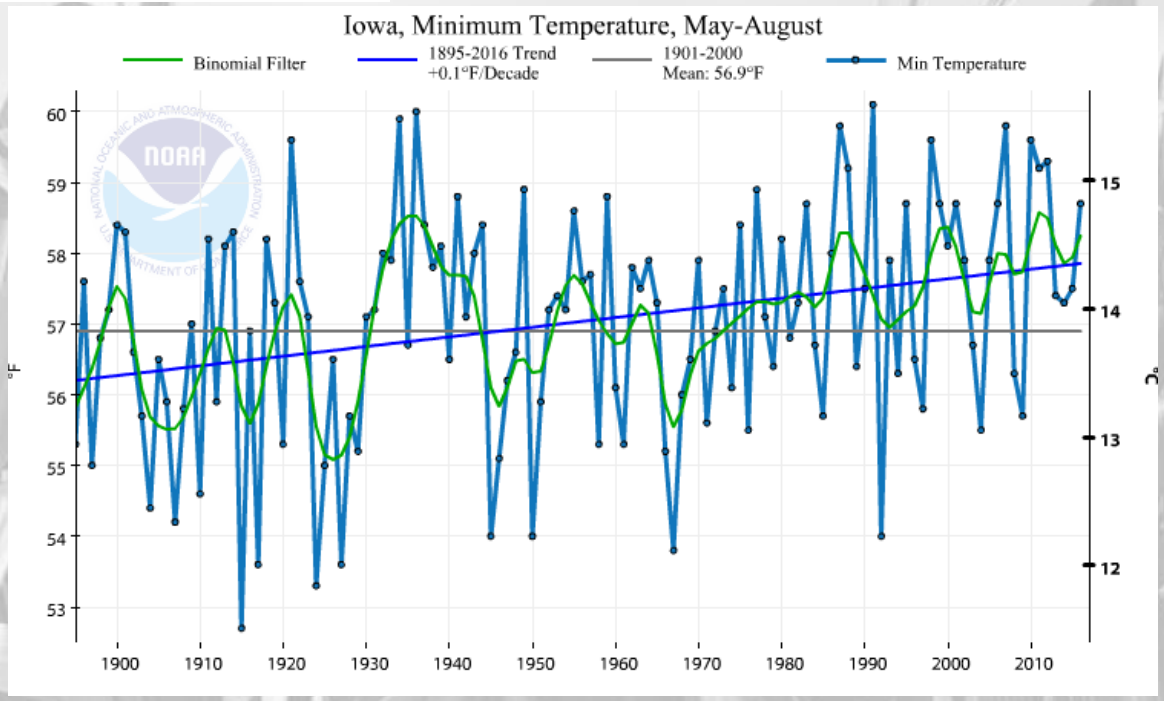


Figure 6.1. Observed changes in annual, winter, and summer temperature (°F). Changes are the difference between rage for present-day (1986–2016) and the average for the first half of the last century (1901–1960 for the con- United States, 1925–1960 for Alaska and Hawai'i). Estimates are derived from the nClimDiv dataset.[1,2] (Figure NOAA/NCEI).





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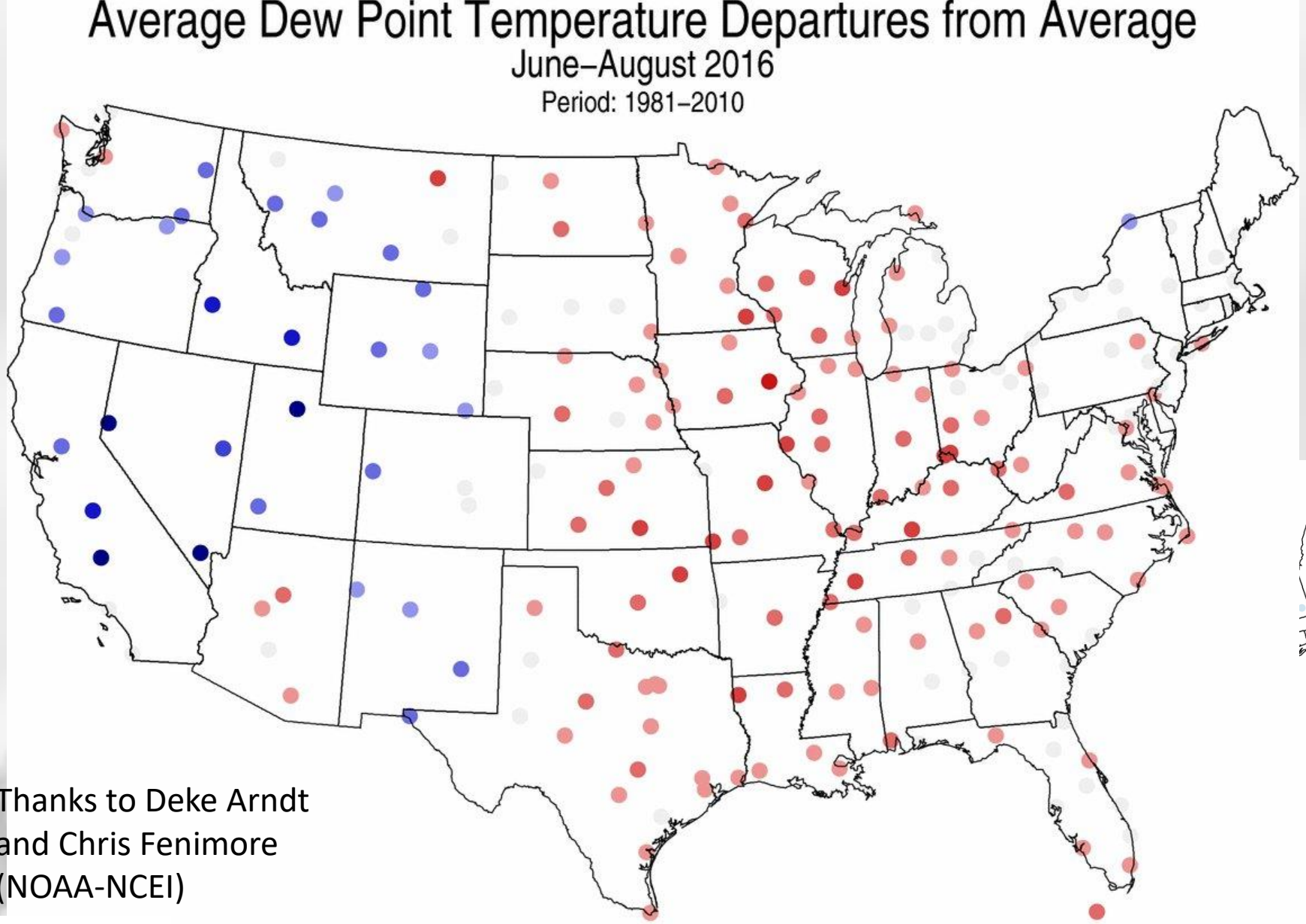
ncdc.noaa.gov/cag



Thanks to Deke Arndt and Chris Fenimore (NOAA-NCEI)

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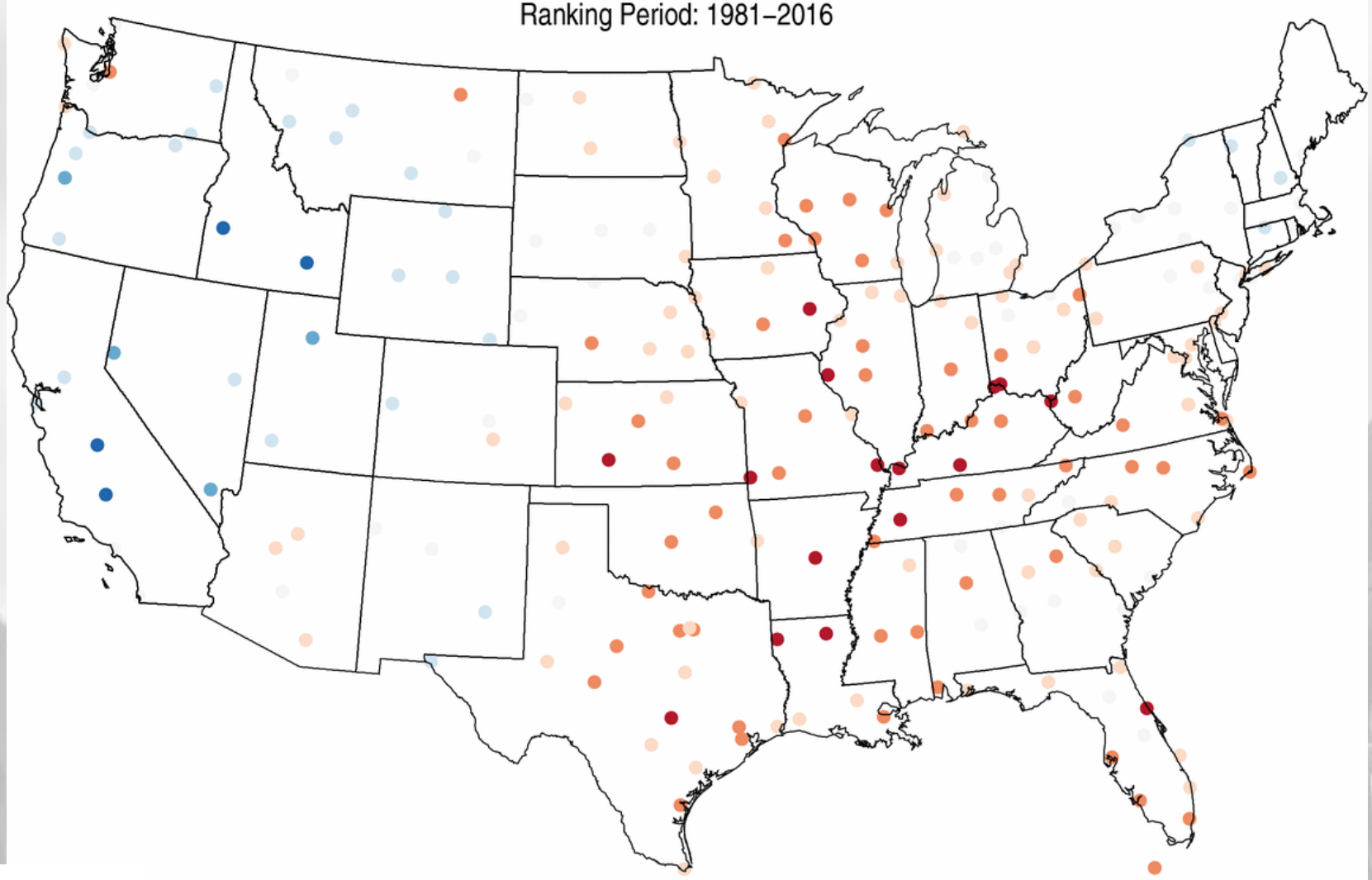
urface Daily (ISD)

Average Dew Point Temperature Percentiles

June–August 2016

Ranking Period: 1981–2016



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Record Low*

Much Below Normal

Below Normal

Near Normal

Above Normal

Much Above Normal

Record High*

es Ties
ed Surface Daily (ISD)

National Centers for Environmental Information

Warm Nights

- Added livestock/human stress
- Additional cooling needed (humans/livestock)
- Push GDD accumulation/phenological state

- Does help increase frost free season period

Increasing moisture in the atmosphere

- Complicated issues
  - Warmer nights/not as warm days
  - Changing disease potential
  - Adds to livestock stresses

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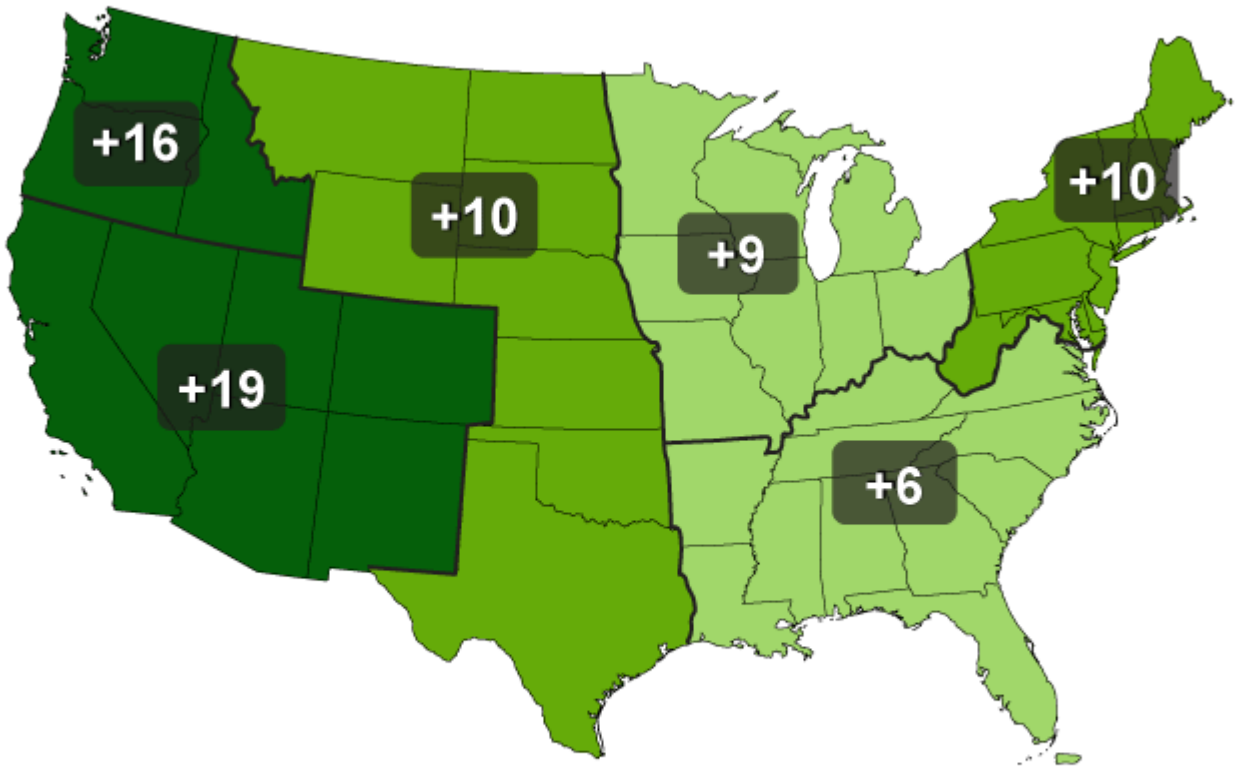
Observed Increase in Frost-Free Season Length



The frost-free season length, defined as the period between the last occurrence of 32°F in the spring and the first occurrence of 32°F in the fall, has increased in each U.S. region during 1991-2012 relative to 1901-1960. Increases in frost-free season length correspond to similar increases in growing season length. (Figure source: NOAA NCDC / CICS-NC).

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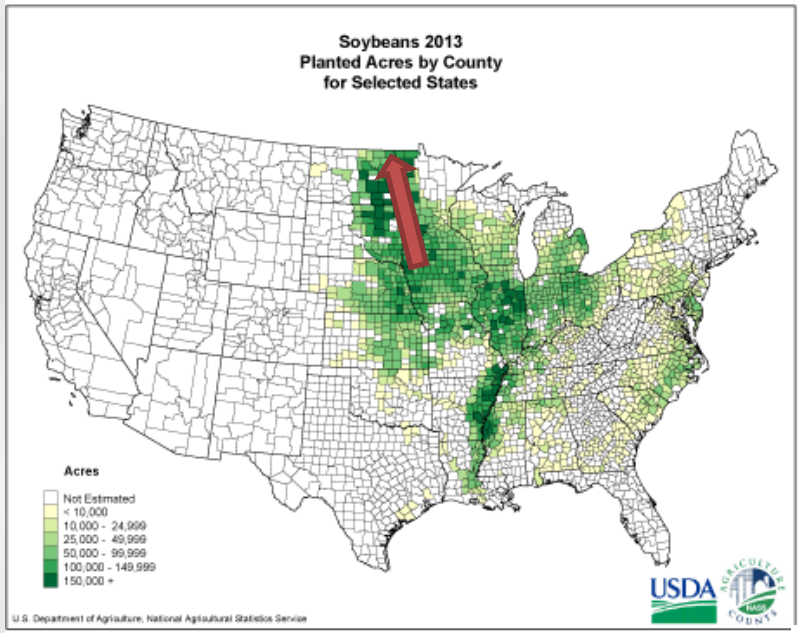
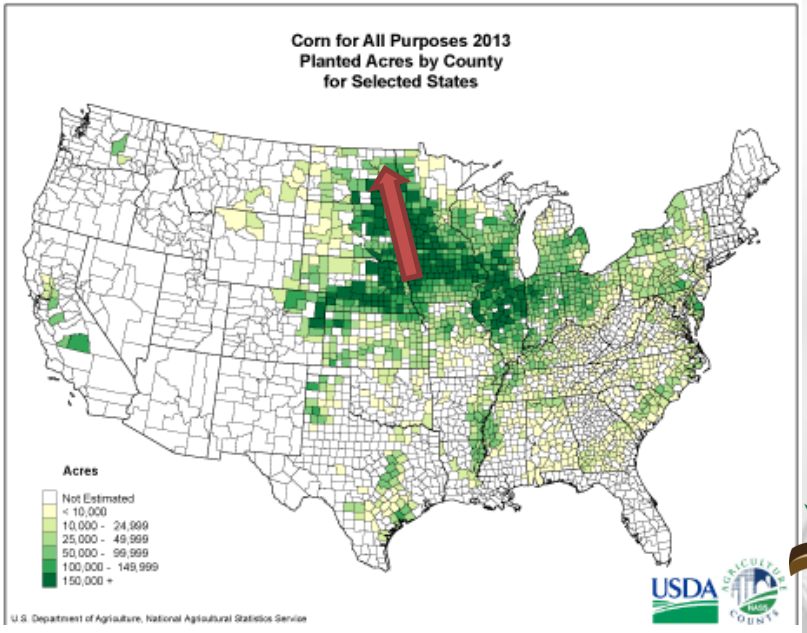
http://nca2014.globalchange.gov/

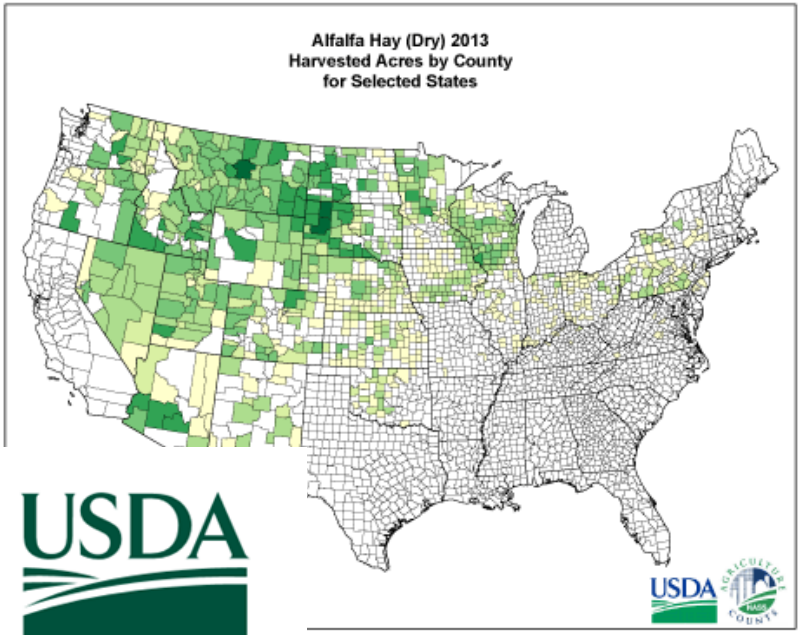
Frost Free Season Change

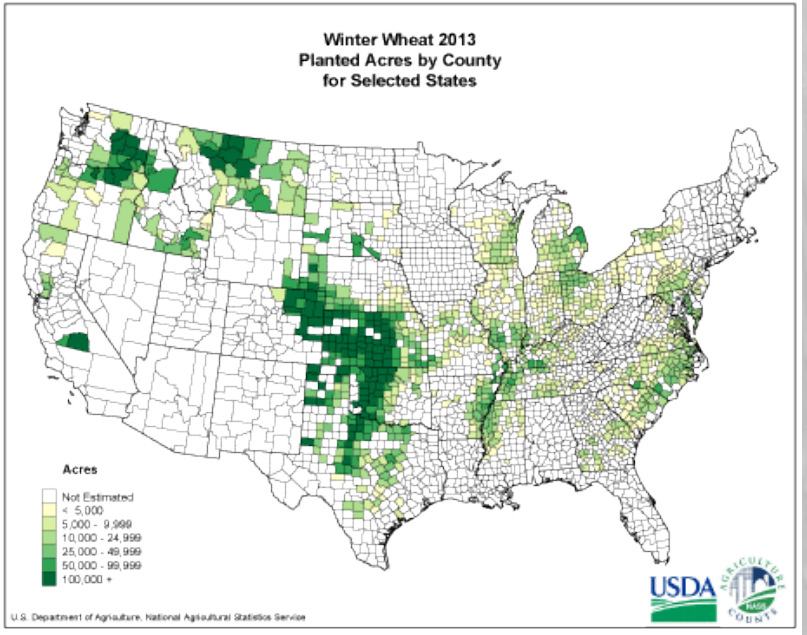
- Longer hybrid
- Earlier spring (confounded)
- Earlier planting not always possible/soil conditions
- Average dates change – not always a solid guarantee

Crop Production









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Changing Climate Impact on Agriculture

PROJECTED CLIMATE CHANGES

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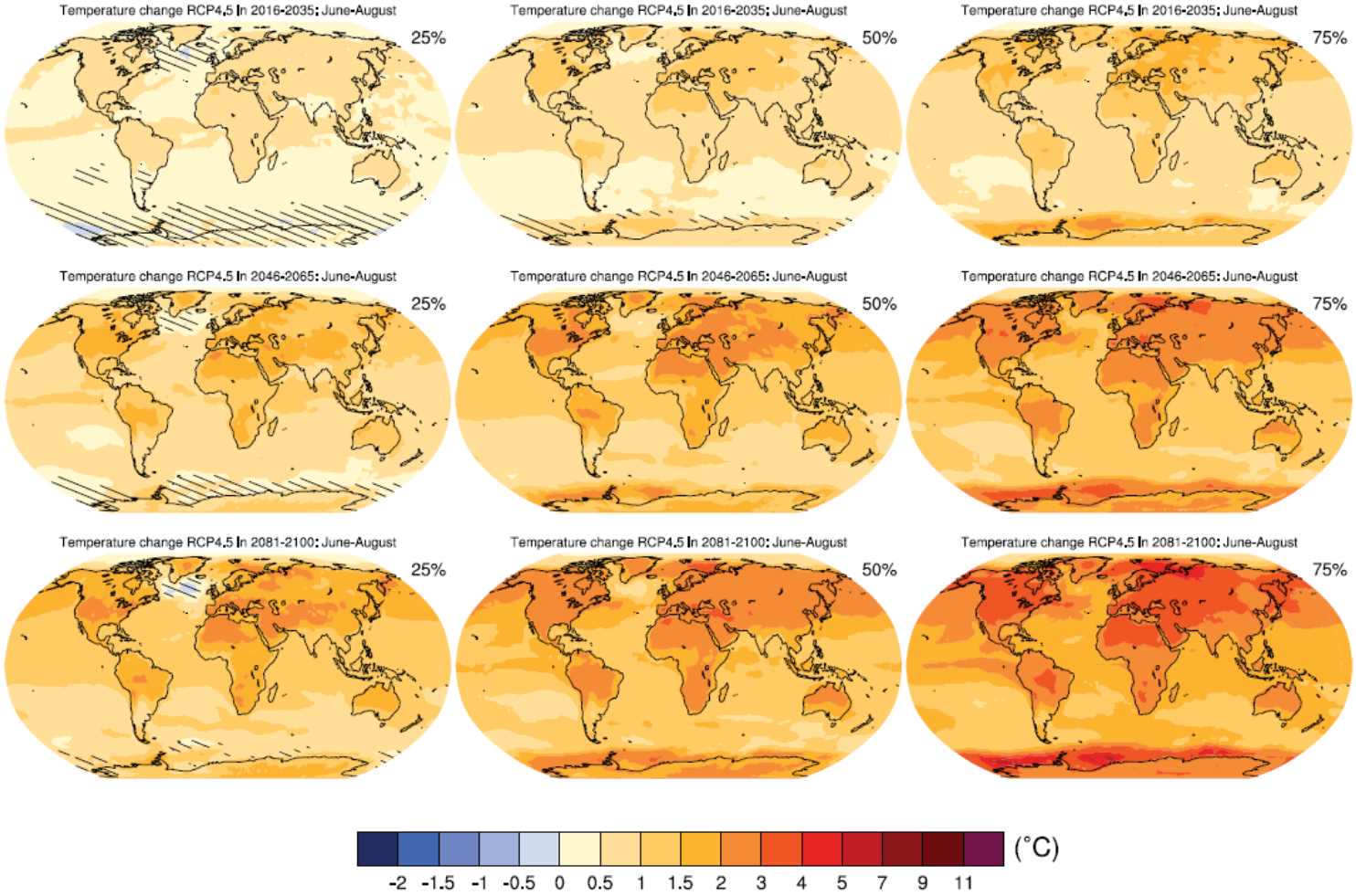
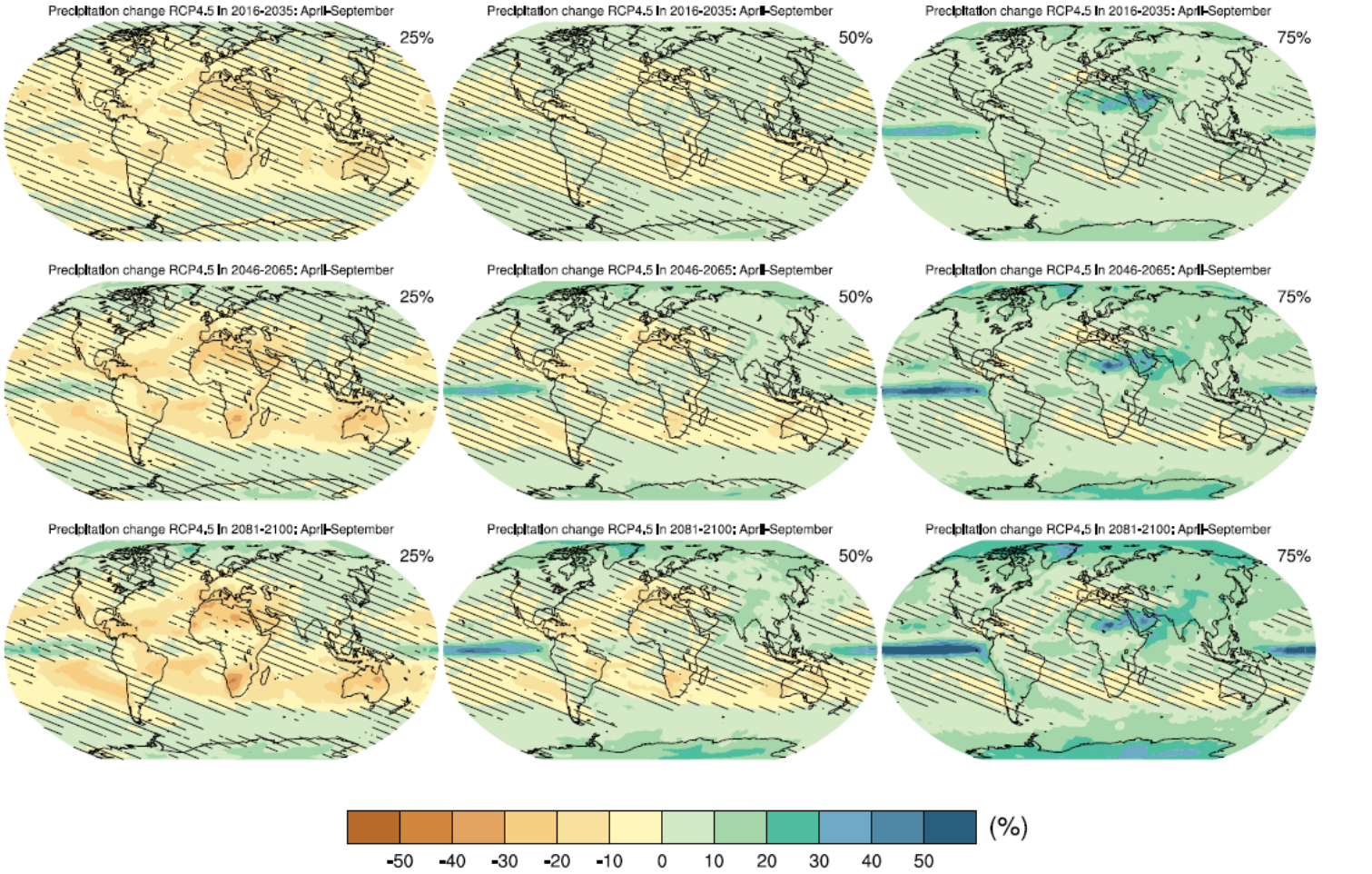


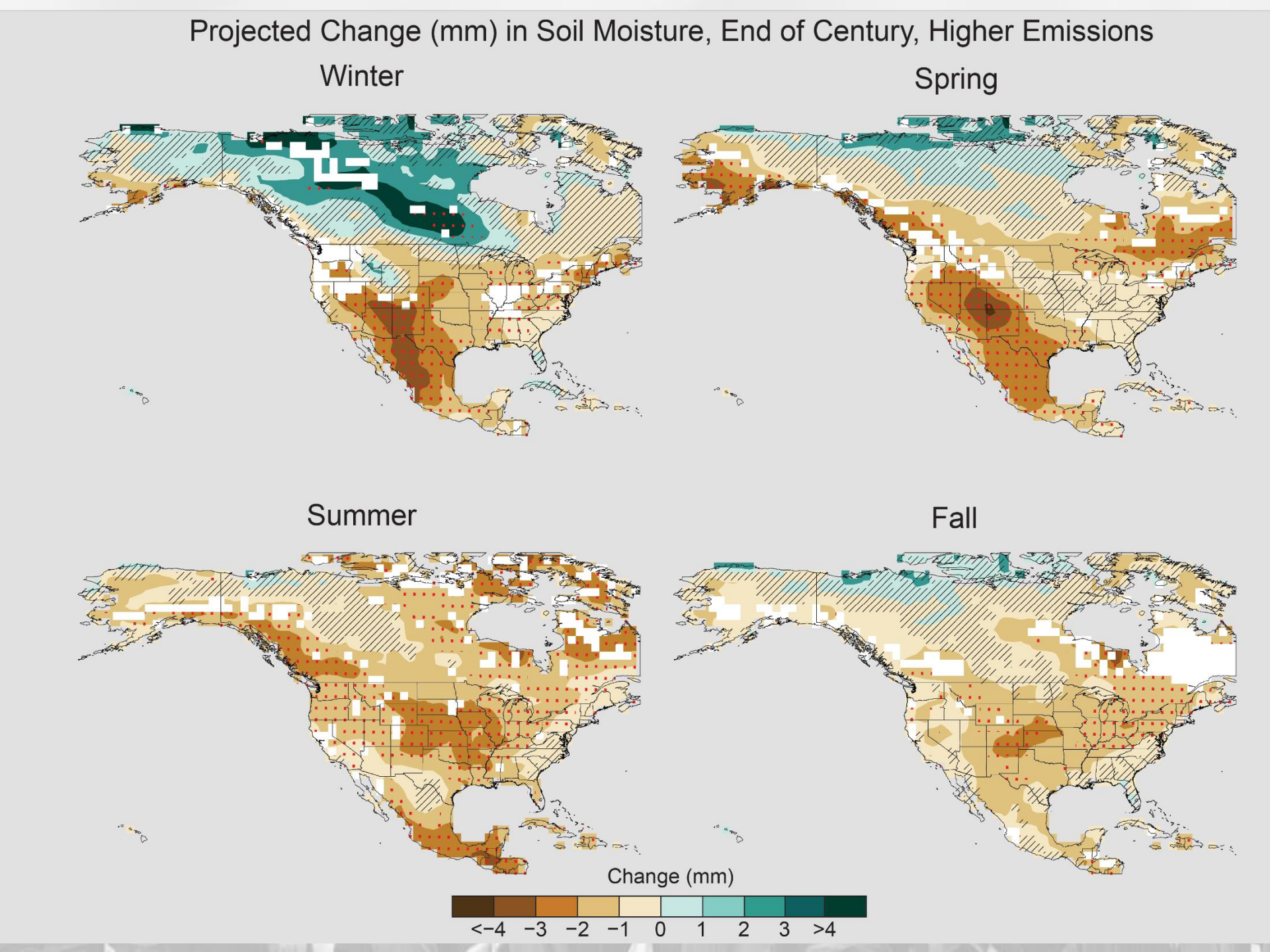
Annex I: Atlas of Global and Regional Climate Projections

www.ipcc.ch



Annex I: Atlas of Global and Regional Climate Projections

www.ipcc.ch


Projected Change (mm) in Soil Moisture, End of Century, Higher Emissions
Winter
Spring
Summer
Fall
Change (mm)
<−4 −3 −2 −1 0 1 2 3 >4

Questions

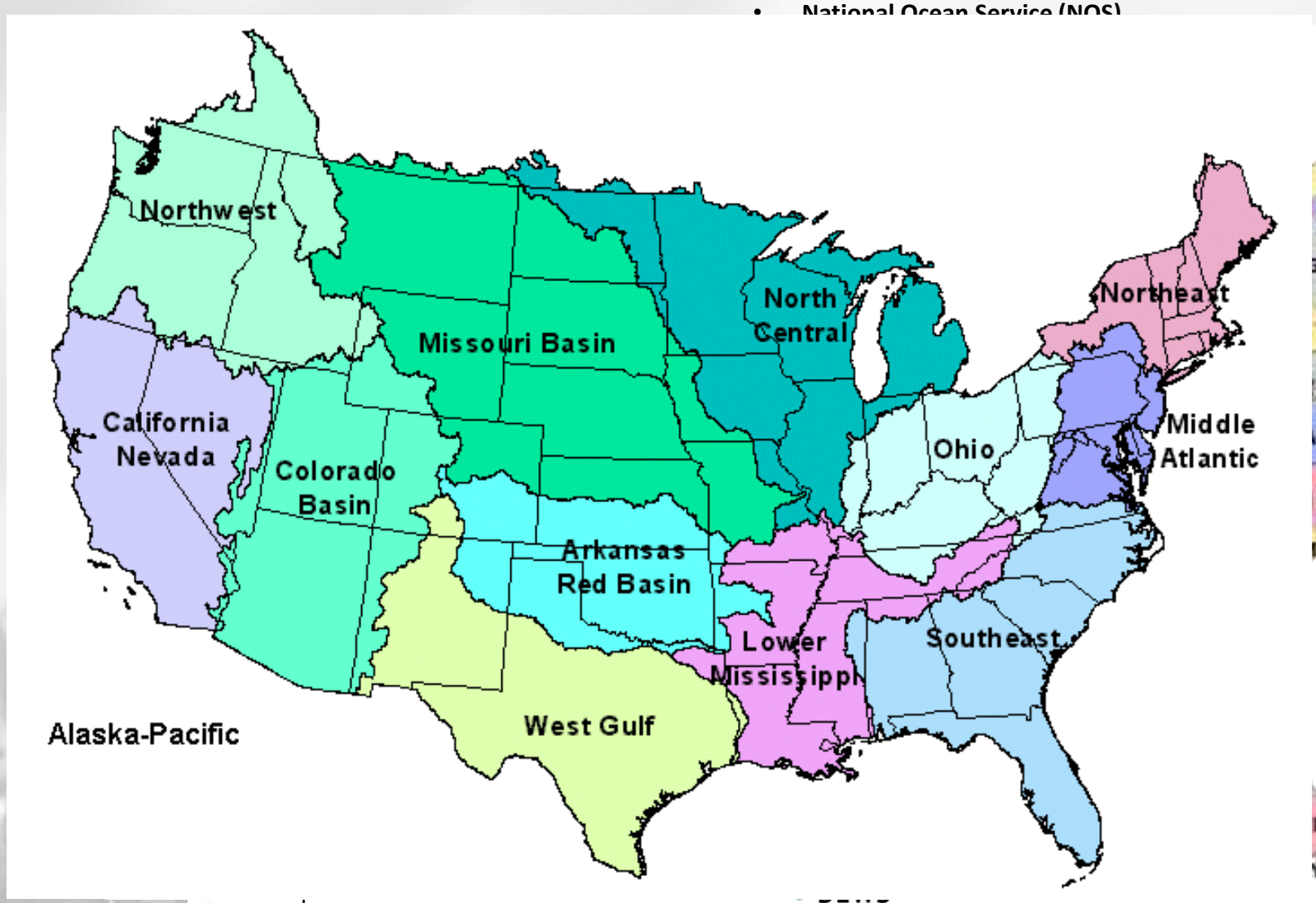
- What food do you like?
  - Where grown?
  - How could climate changes impact it?
    - (think broadly).

Who Are Partners to Work with

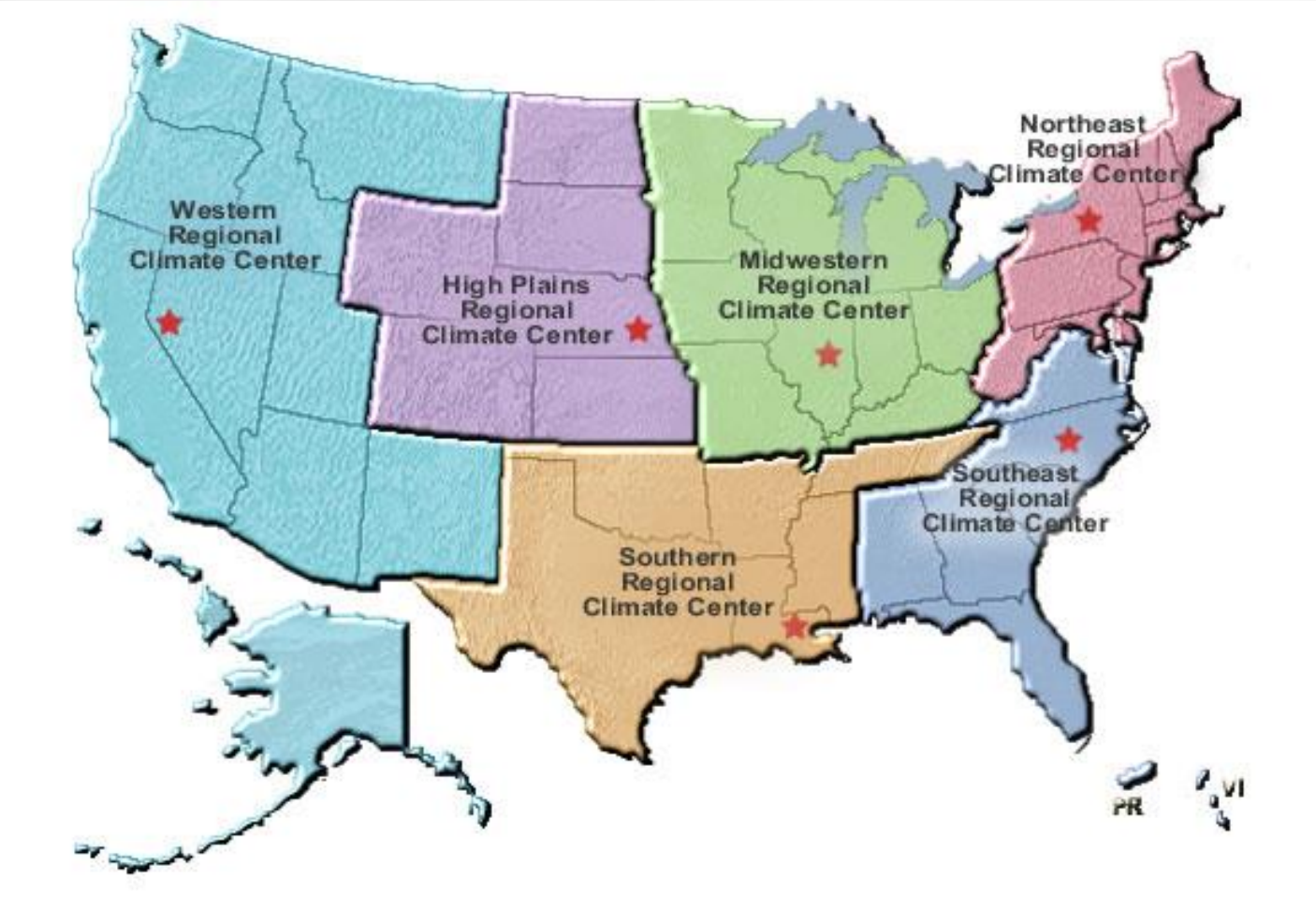
- People who deal with climate/change issues across the country.

NOAA Related Groups

- Regional Climate Services Directors (RCSDs)
- NOAA Regional Collaboration Teams (RECOs)
- National Integrated Drought Information System (NIDIS)
- American Association of State Climatologists
- National Marine Fisheries Services (NMFS)
- Regional Integrated Science Assessment (RISA)
- Regional Climate Centers (RCCs)
- National Weather Service (NWS)
- National Ocean Service (NOS)



Midwestern Regional Climate Center (MRCC):
Climate Data, Services, and Applied Science

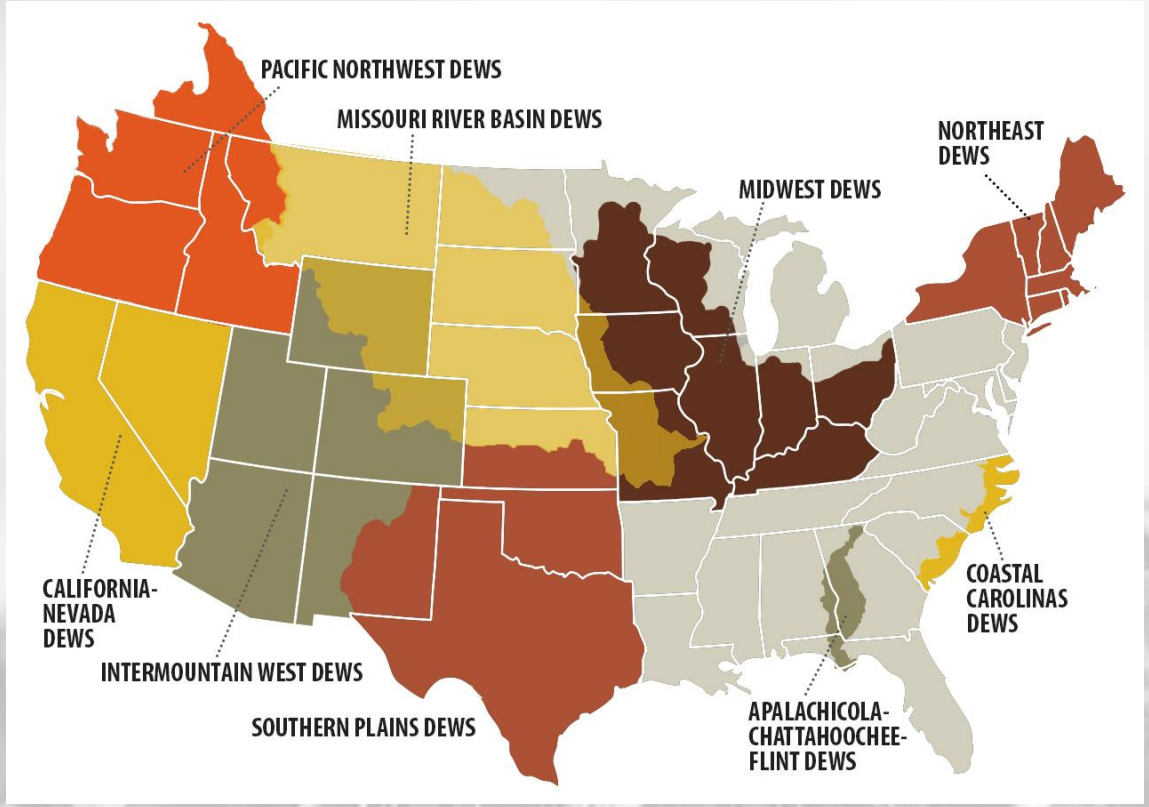


What is the National Integrated Drought Information System (NIDIS)?

- Authorized by Congress in 2006 and re-authorized 2014.
- Interagency mandate to develop and provide a national **drought early warning information system**.

"Enable the Nation to move from a reactive to a more proactive approach to managing drought risks and impacts."

NIDIS has 9 Regional Drought Early Warning Systems (DEWS)



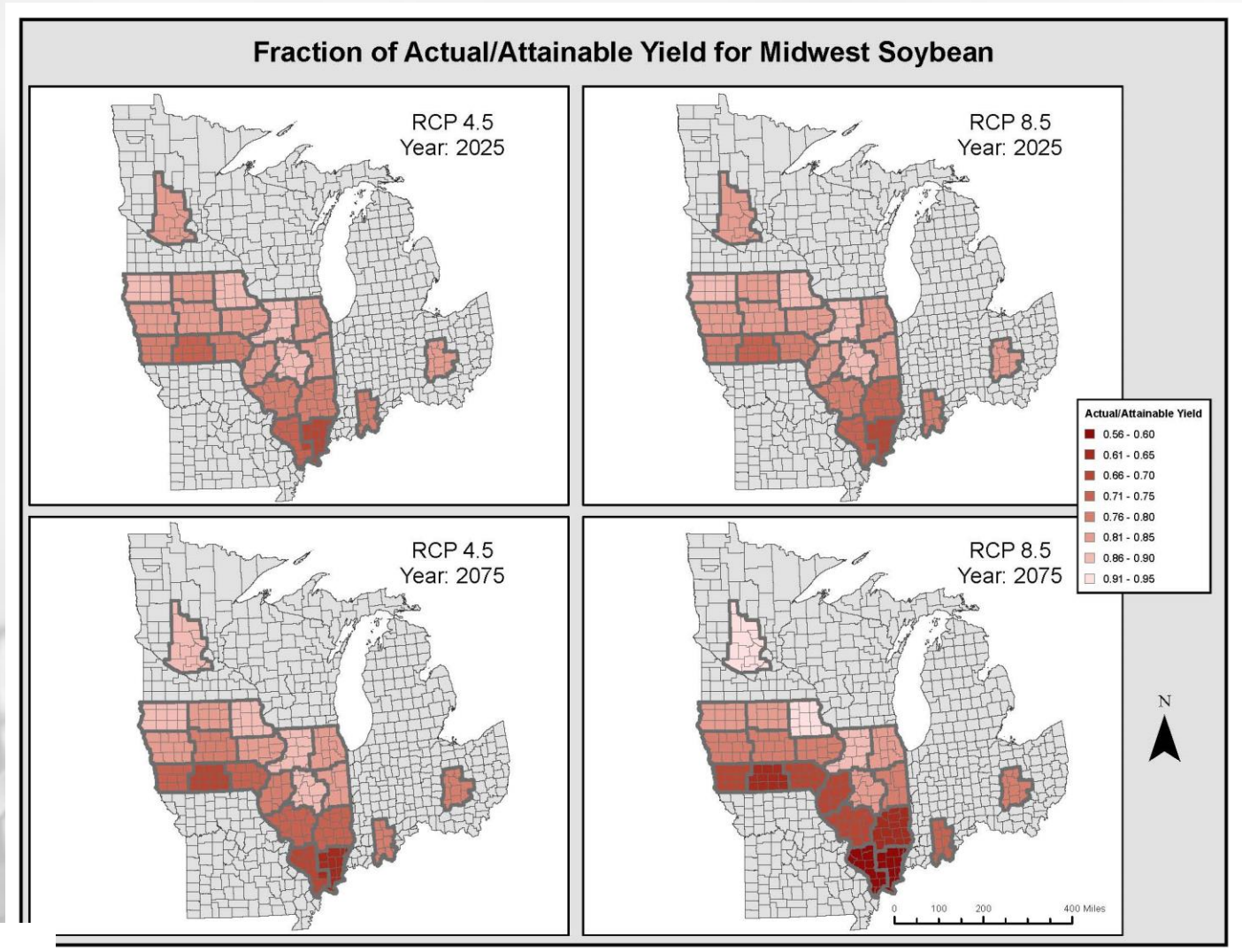
- ✓ Network coordination (public, private, NGOs, academia)
- ✓ Regional perspectives and priorities for the five components of a DEWS

Climate Issues for Agriculture

- Changing precipitation (timing/amount)
- Changing temperatures (warming – summer minimums)
- Increased atmos. moisture (dewpoint)
- Growing season shifts/freeze dates

Climate-Impacted Issues for Agriculture

- Changing field work times
- Disease/insect/weed pressures
- More extremes
- Nutrient loss
- Increased variability (seeming)


Fraction of Actual/Attainable Yield for Midwest Soybean
RCP 4.5
Year: 2025
RCP 8.5
Year: 2025
RCP 4.5
Year: 2075
RCP 8.5
Year: 2075
Actual/Attainable Yield
0.56 - 0.60
0.61 - 0.65
0.66 - 0.70
0.71 - 0.75
0.76 - 0.80
0.81 - 0.85
0.86 - 0.90
0.91 - 0.95
N
0
100
200
400 Miles

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Erosion

- Soil removed by
  - Wind
  - water
- Agricultural cause:
  - Plowing
  - bare fields
    - Absence of roots

Physical degradation of soil

Soil compaction

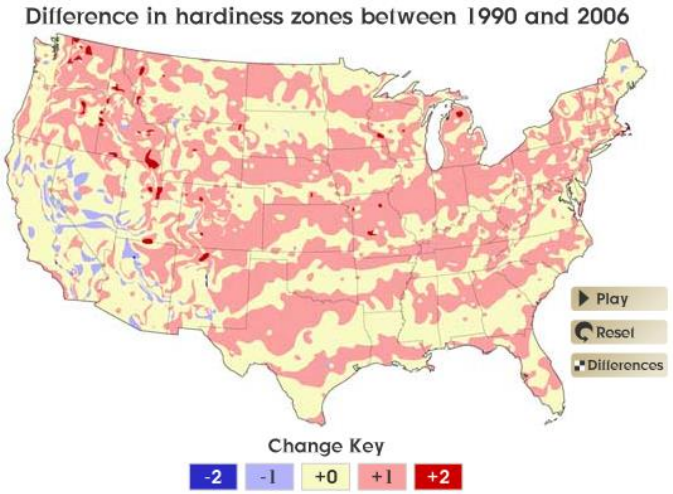
- Less porous
  - Compaction by
    - Heavy machines
    - Animals
- Water logging
  - Roots die
  - Due to
    - Over irrigation
    - Poor drainage

http://www.dpi.vic.gov.au/CA25677D007DC87D/LUbyDesc/Pugged+soil/$File/PUGGED-1.jpg

Hardiness Zone Changes

Zone Changes

This animation illustrates the general warming that has occurred from 1990 to 2006. Click the play button to see how the hardiness zones have changed.



Details

Play will change the map from the 1990 USDA hardiness zones to the 2006 Arborday.org hardiness zones.

Reset will change the map to show the 1990 USDA hardiness zones.

Differences shows colors that represent how much each zone has changed since 1990. For example, the pink areas of the map have warmed up enough to change one hardiness zone (e.g. the top half of Nebraska has increased by one zone).

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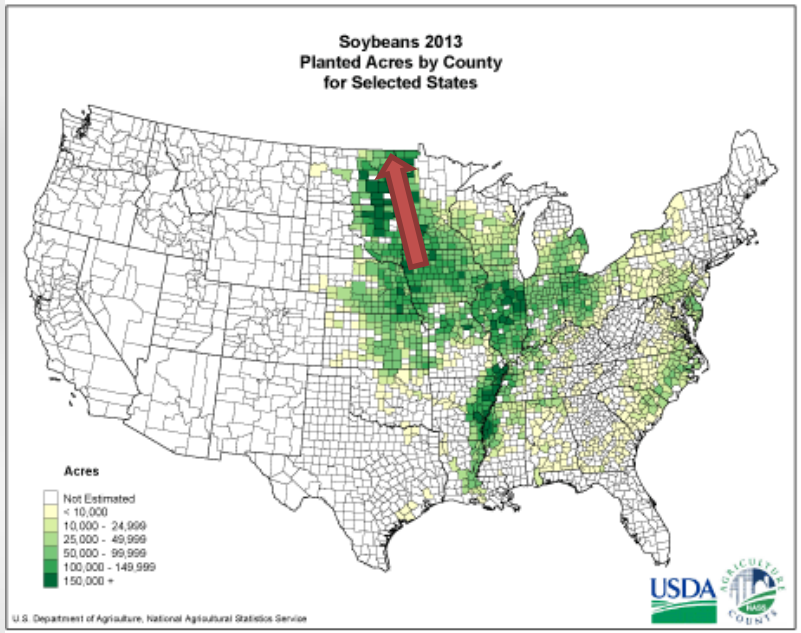
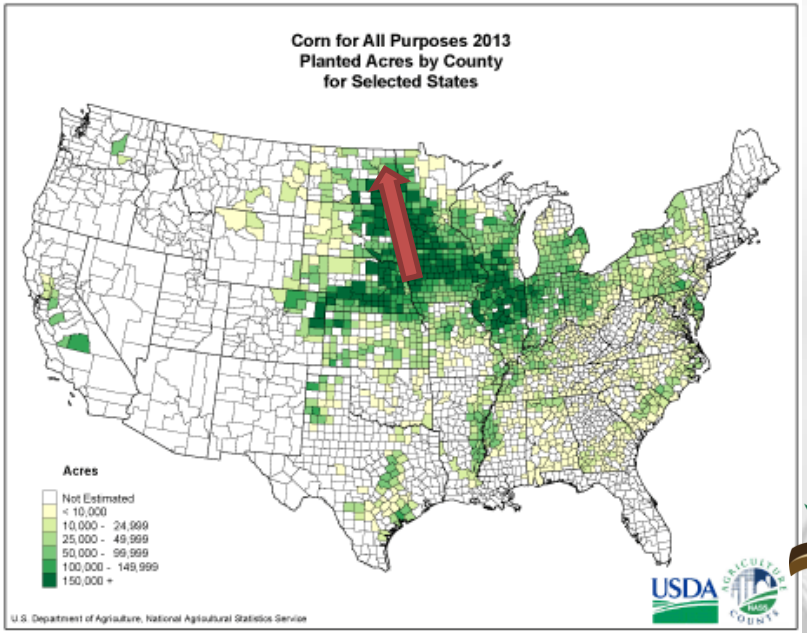
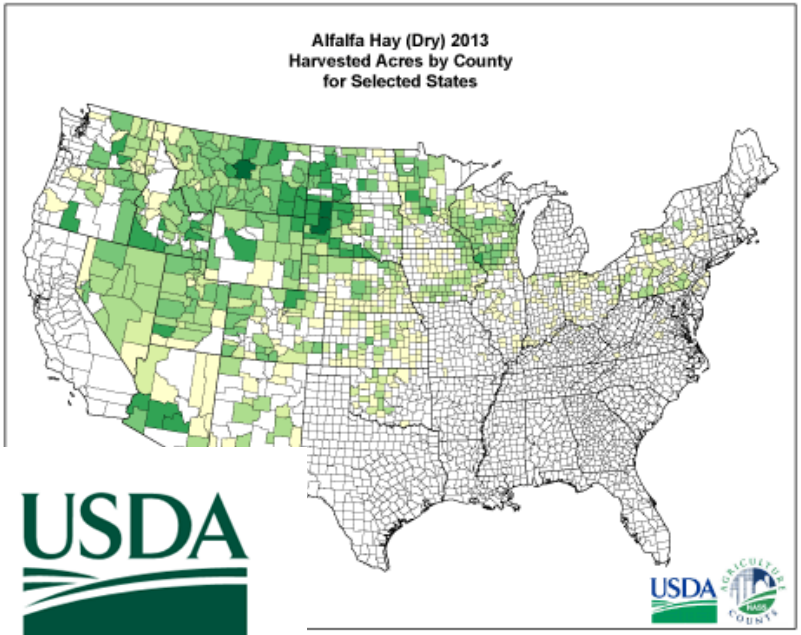
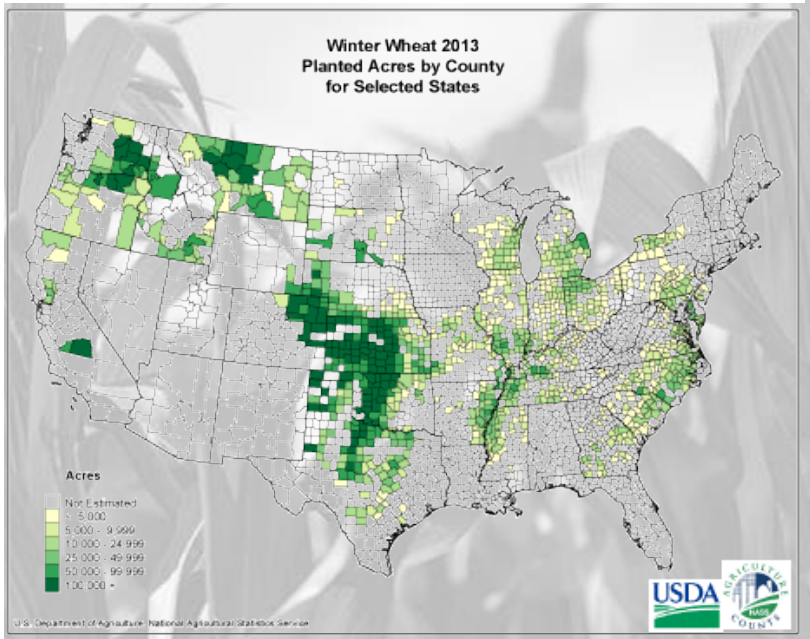
https://www.arborday.org/media/mapchanges.cfm

Crop Production Changes









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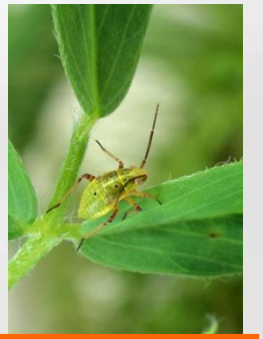
Biotic Impacts

Cheatgrass fire hazard?

- Changing habitats
- Enhanced CO_2 fertilization

C:N ratio + lodging?



Weeds, vines, invasive plants
Insects
Pathogens
Animals

Herbicide effectiveness??

Nutrient poor forage?

Issues with insects

- Changing insects/range
- More life cycles/year
- Less winter die-off
- Larger range

- Increased cost of production
- Increased/changing management
- More potential crop loss or damage (quality)

Climate Change and Agricultural Pests

1)Expanding geographic ranges northward

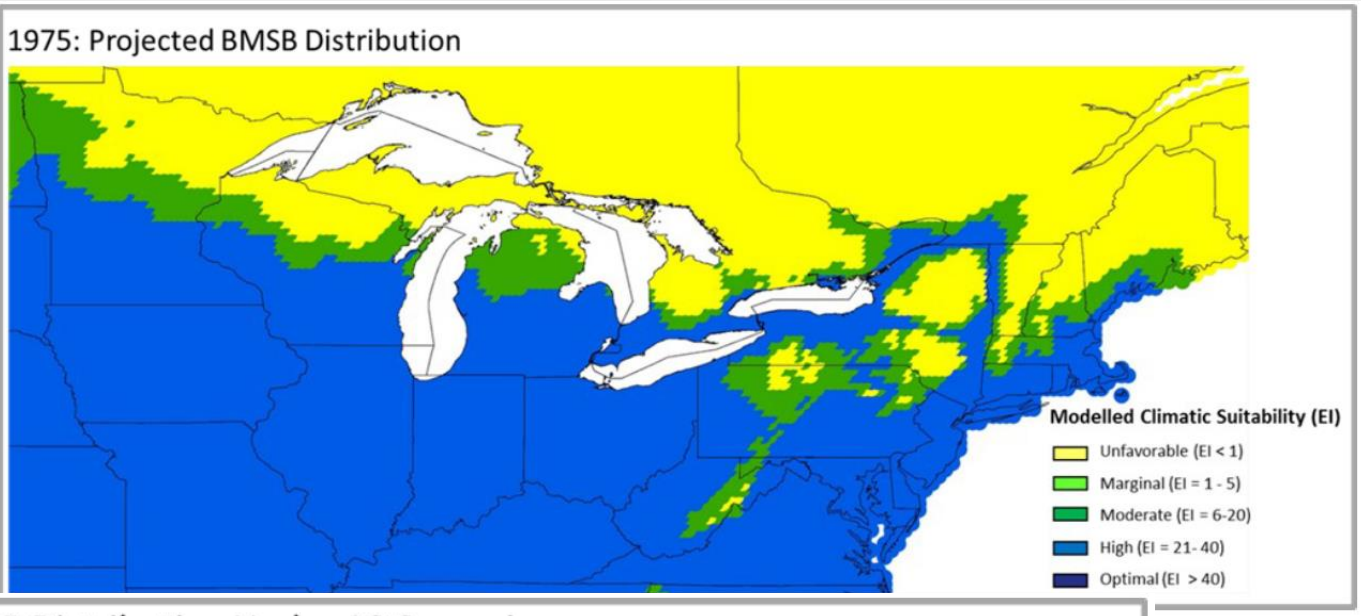
2) Reducing winter die offs

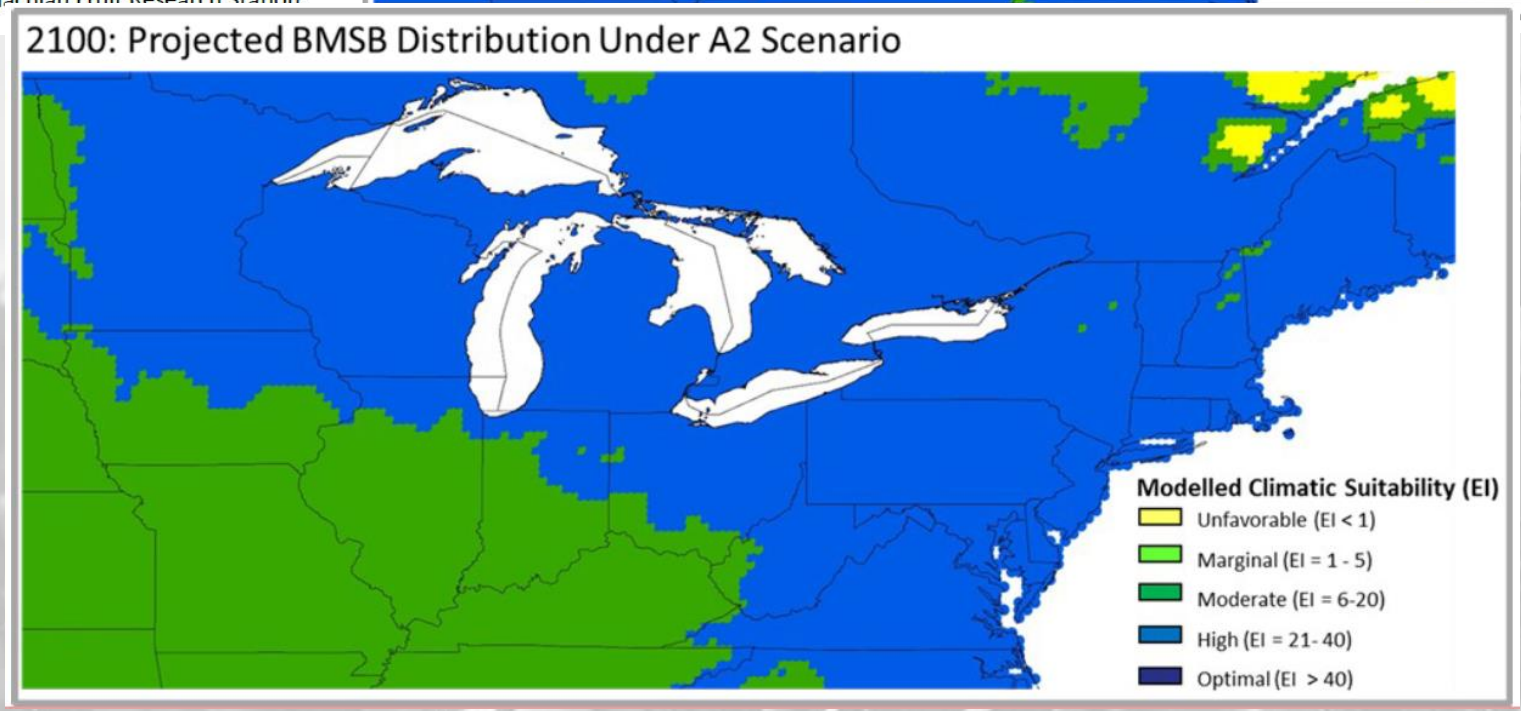
3)Earlier spring emergence

4) Increased generations per year

- Invasive insects are of particular concern since they often limited more by climate in their non-native ranges (no natural enemies and abundant food)

Figure 1. BMSB eating an apple. In 2010, the mid-Atlantic apple industry suffered ~ US$37 million in losses from BMSB feeding damage. Photo by Tracy Leskey, USDA -ARS Appalachian Fruit Research Station





http://www.ipcc.ch/report/graphics/index.php?t=Assessment%20Reports&r=AR5%20-%20WG1&f=Chapter%2011

Issues with weeds

- Weeds often more competitive than crops
- CO_2 fertilization

- Increased cost of production
- Increased management
- More potential crop loss
- More use of chemicals

But can CO_2 affect herbicide efficacy?

As carbon dioxide increases, glyphosate efficacy is reduced

Ziska et al. 1999. Weed Science. 47:608-615, inter alia

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Issues with diseases

- Changing disease conditions
- Wetter – more likely disease
- Livestock stresses/disease
- Increased cost of production
- Increased management

Other considerations

- Annual versus perennial crops (time frames)
- Variability in seasons (storage of crops) – can't have big and small seasons regularly
- Warming winters reduces chilling hours for tree fruits
- Changing springs impacts perennials

Other considerations

- Water – dryland vs. irrigation
  - Irrigated agriculture represents 20 percent of the total cultivated land, but contributes 40 percent of the total food produced worldwide.

http://www.fao.org/nr/water/aquastat/didyouknow/index3.stm

But can CO_2 affect herbicide efficacy?

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Ziska et al. 1999. Weed Science. 47:608-615, inter alia

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For More Information

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OPTIONAL SLIDES

XXXXX

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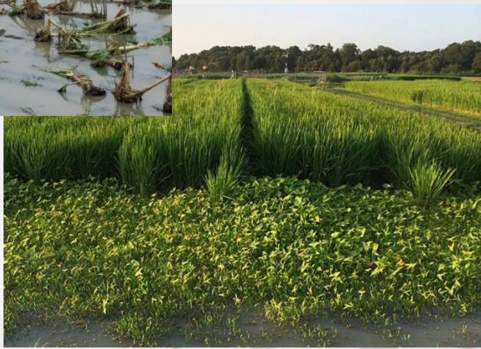
Extra Photos

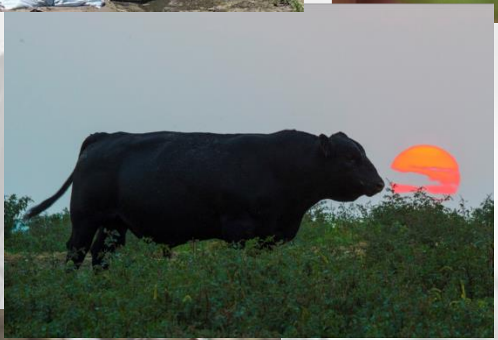














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