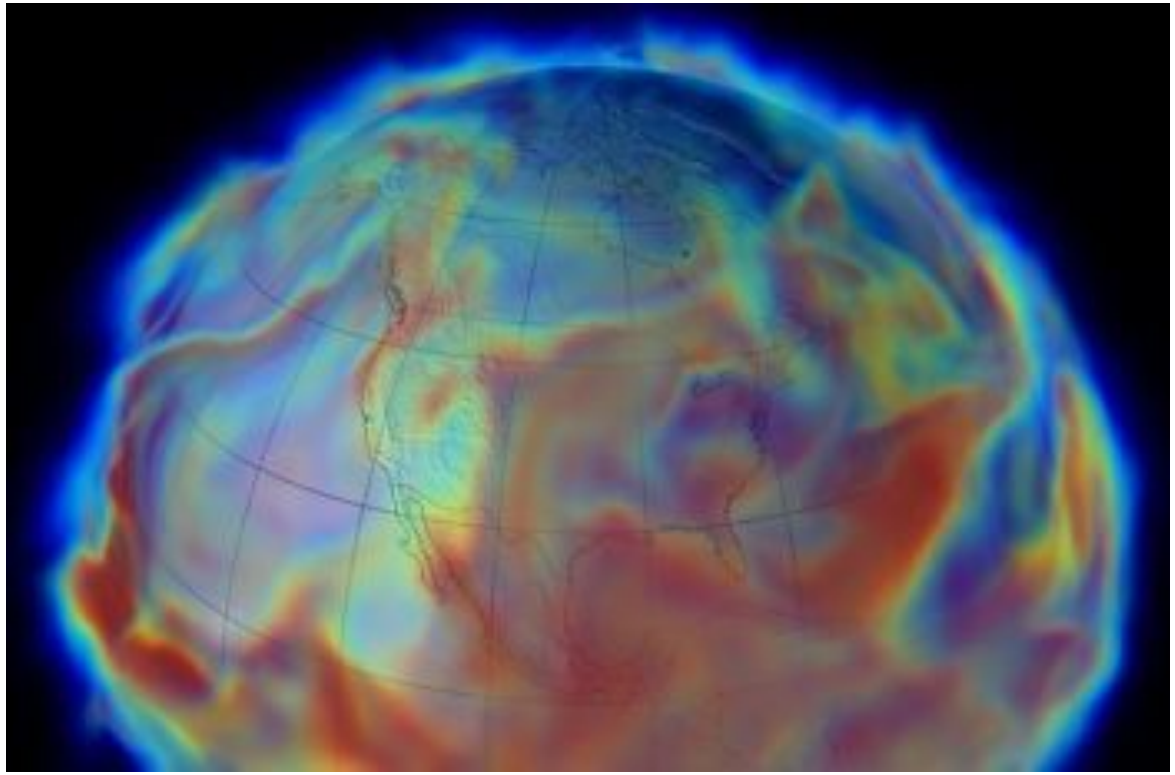
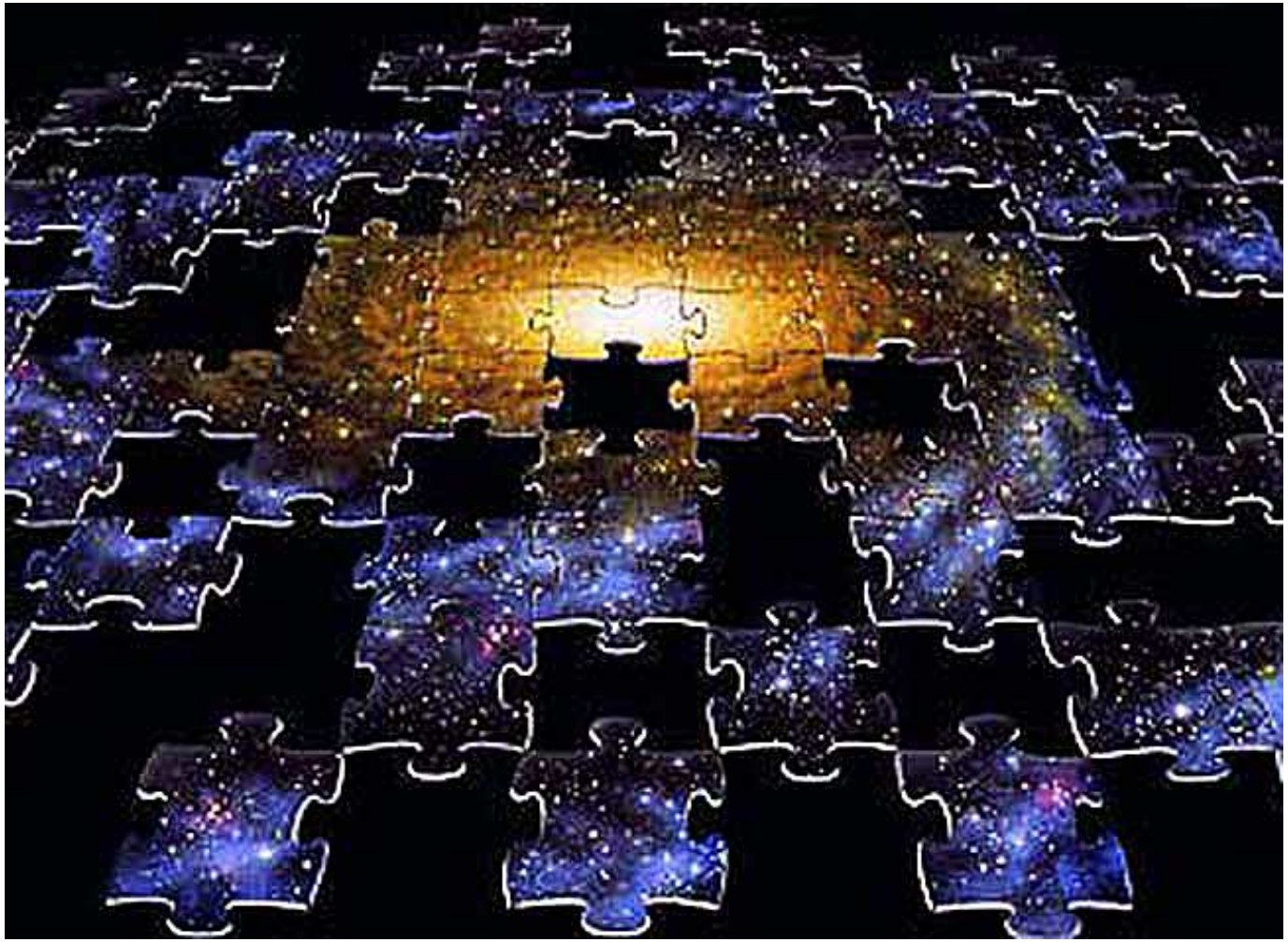
Global Climate Disruption: What's Really Going On?



Metropolitan Planning Council
February 6, 2015

Douglas Sisterson
Environmental Science Division
Argonne National Laboratory

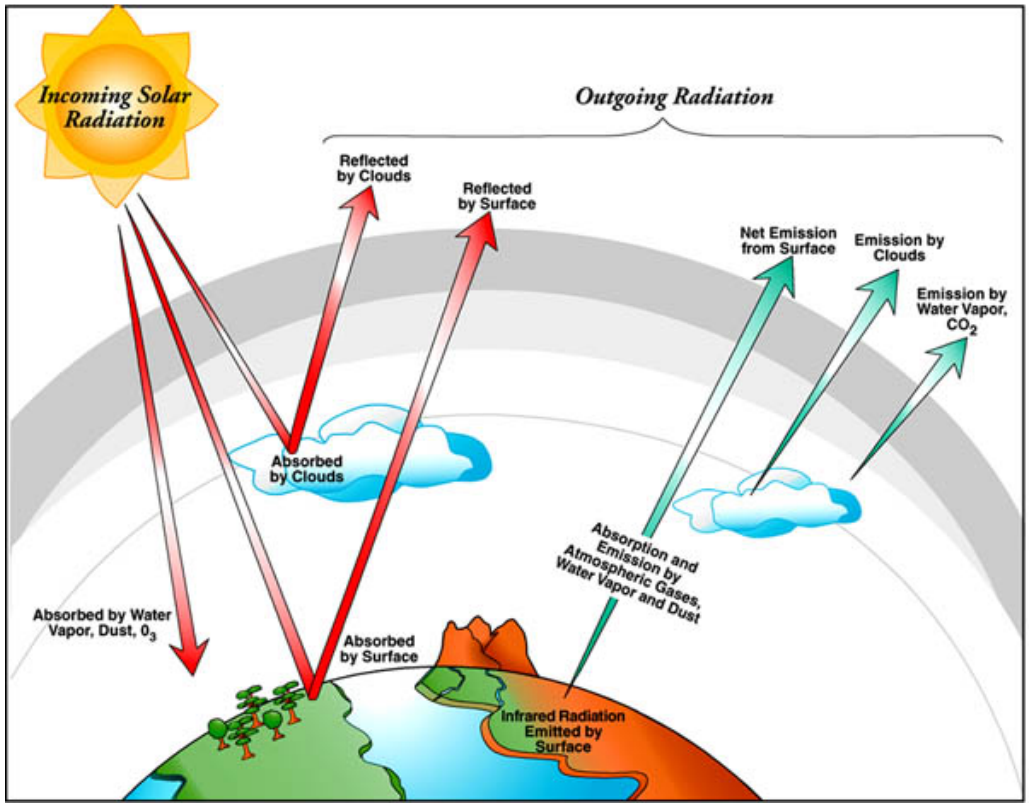
Earth's Climate: the BIG Picture



Climate 101: Radiation, Clouds, Greenhouse Gases, and Aerosols

The Earth's Radiation Budget

Incoming energy



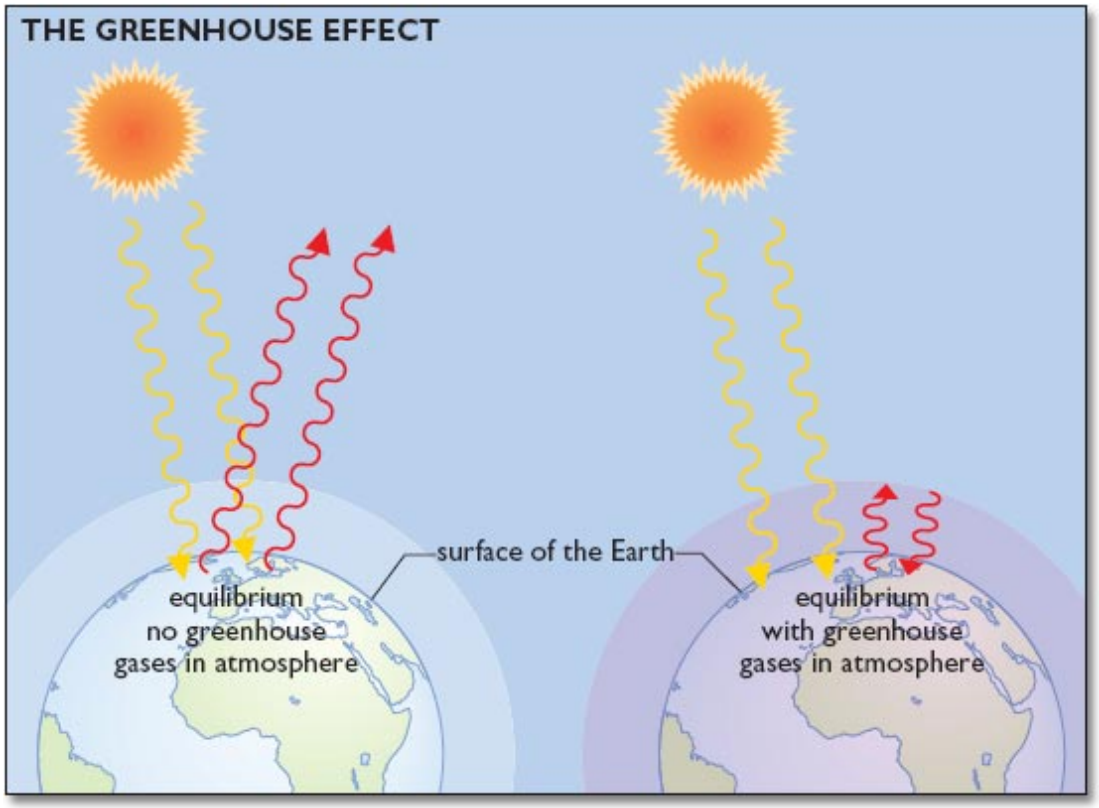
Outgoing heat

The Earth receives almost all its energy to heat the planet from the sun: (solar radiation).

Greenhouse Gasses Keep Earth's Climate Comfortable for Humans

Without greenhouse gases: ~0F

Burrrr!

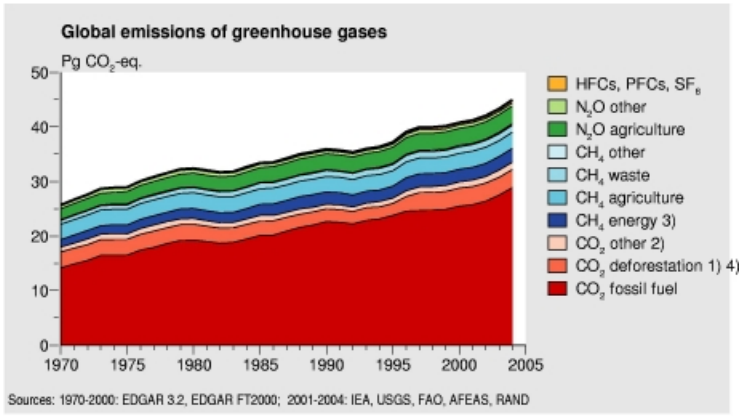


With greenhouse gases: ~60F

There are natural and human produced greenhouse gasses.

Only ~0.05% of the Earth's atmosphere by mass is composed of greenhouse gases (excluding water vapor) and carbon dioxide is the most prevalent. Don't mess with greenhouse gases!

Consensus: Global Warming is the real deal!

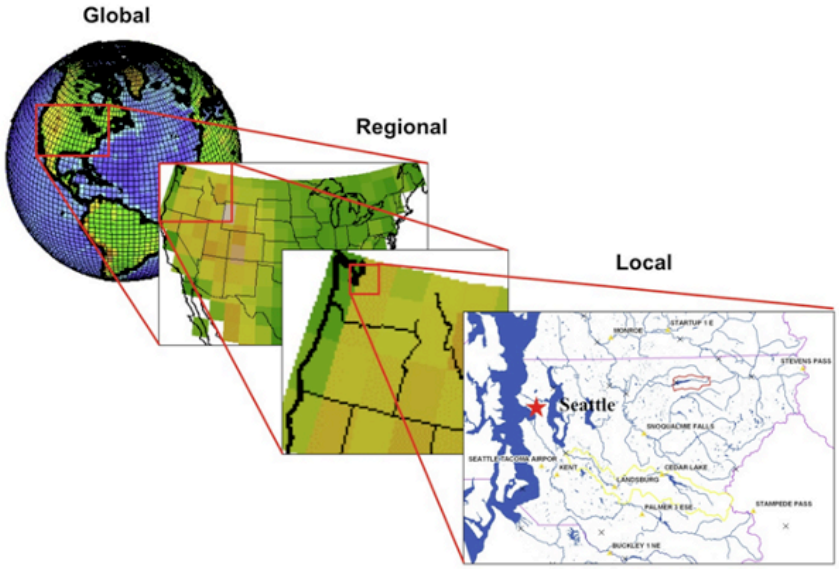


Scientific Consensus:

There is little doubt that our Earth on an global scale is warming and it is due to increased, human produced carbon dioxide.

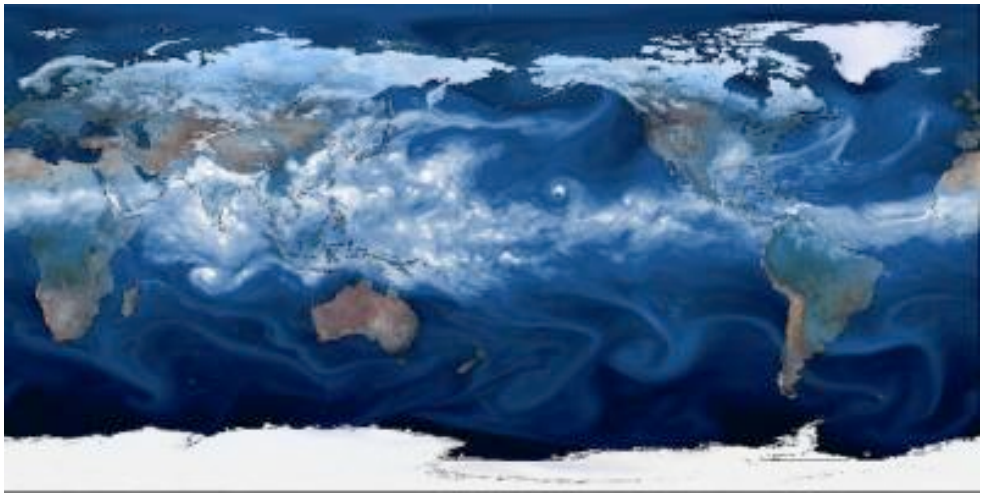
BUT.....Scientists have not reached consensus on **timing** or ***regional*** or ***local*** impacts where we live!

Climate Models: Used To Make Forecasts



Input what processes we know into climate models

And see how well what we know represents what we observe



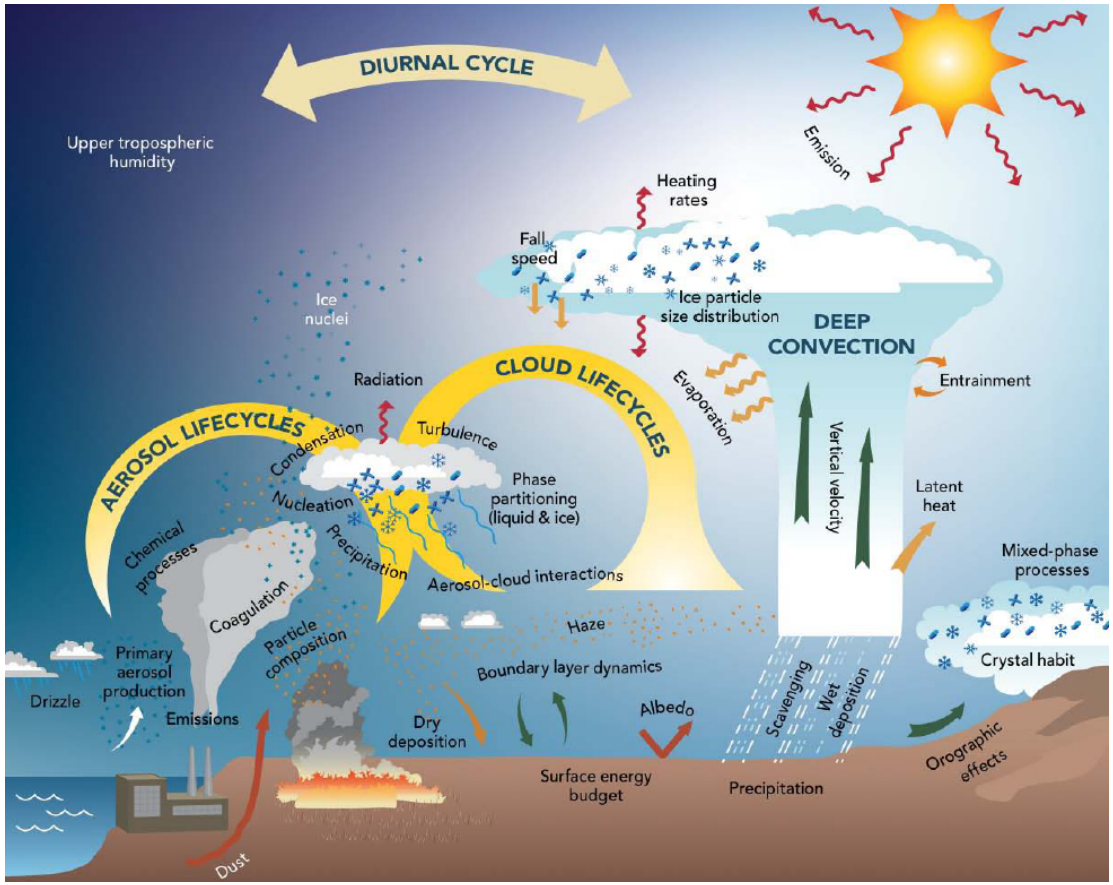
Going from Global Scale to Regional Scale Adds Complexity and Uncertainty!

And these are only the Atmospheric Processes!

Need to also consider:

- Oceans
- Glacial/Ice Systems
- Terrestrial Ecology
- Biological Systems

Clearly, the "picture" we are trying to understand gets substantially more complex as we go from global to regional scales!



We don't live in average: we want to know what will happen where we live!

The Term "Global Warming" Can Be Misleading As We Go To Smaller Scales!

On the ***global*** scale, increased greenhouse gases result an increase of the ***average*** temperature of the Earth if it was a static system.

But temperature change itself isn't the most severe effect of change to Earth's climate. ***Changes to precipitation patterns and sea level are likely to have much greater human impact than the higher temperatures alone***.

Therefore, it is more appropriate to think of increased greenhouse gases causing ***climate change***, not just global warming.

Is It Global Warming or Climate Change—What's The Difference?

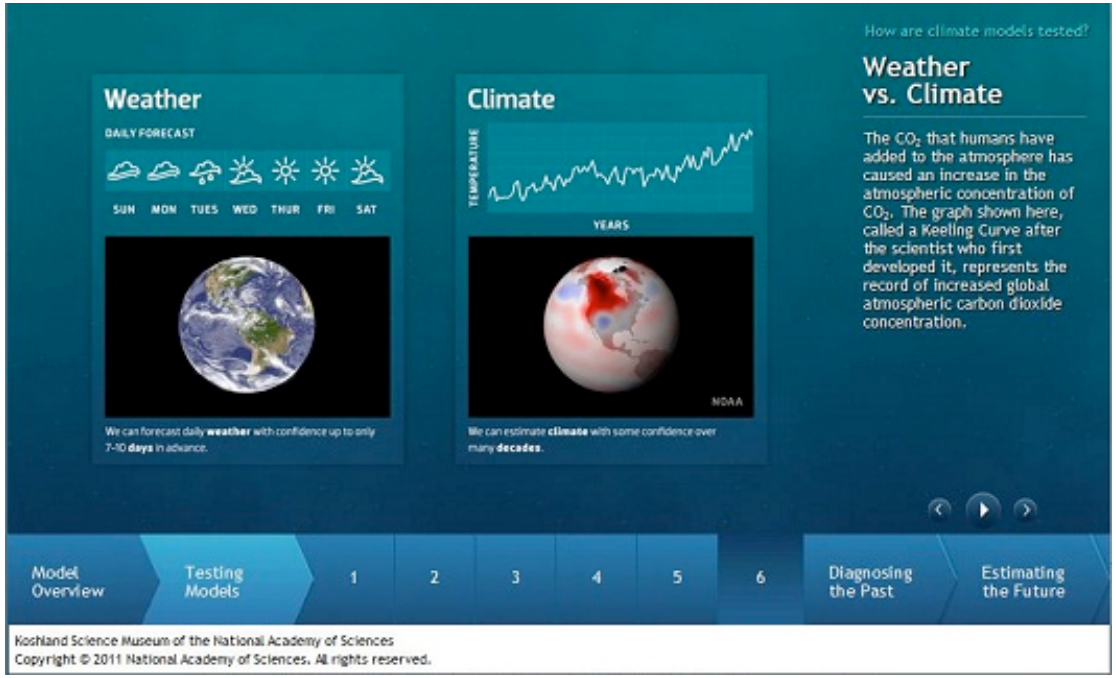
Increasing greenhouse gases will theoretically lead to a warmer atmosphere, but the Earth is not a static system. Increased heat (energy!) will quickly be distributed and used by other processes: melting ice, heating oceans, evaporating water, sunlight interactions with clouds and aerosols, and other factors that drive weather.

Connection Between Climate and Weather

Climate is usually defined as the ”30-year average weather” where you live. When you watch weather on TV, the weather forecasters always talk about the normal or average high and low for that day.

The weather is the day-to-day variance in the local occurrence of temperature, cloudiness, humidity, rainfall, pressure, etc.; weather is what you get where you live.

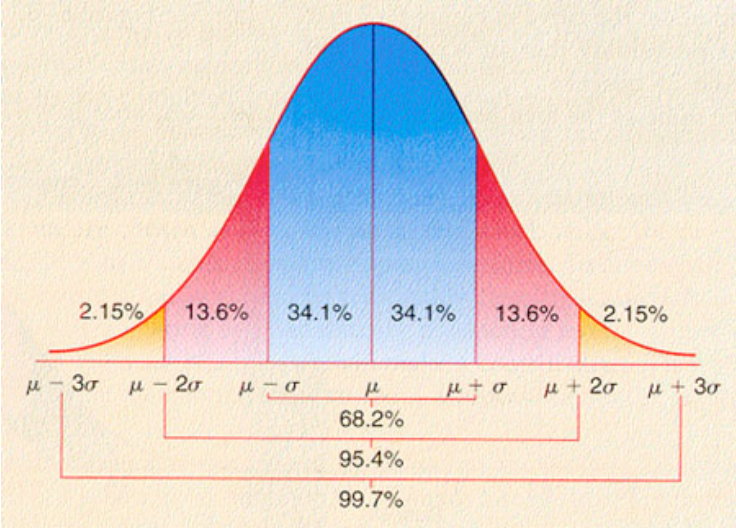
The **variance** in weather is predictable as long as the climate is not changing.



Climate constrains weather

Weather and Extreme Events

The weather is normally predicable because the climate is not changing.



The 100 year flood is defined as the 1% (or less) exceedance probability of the occurrence of a single weather event (i.e. a rainfall amount) for 100 years of data.

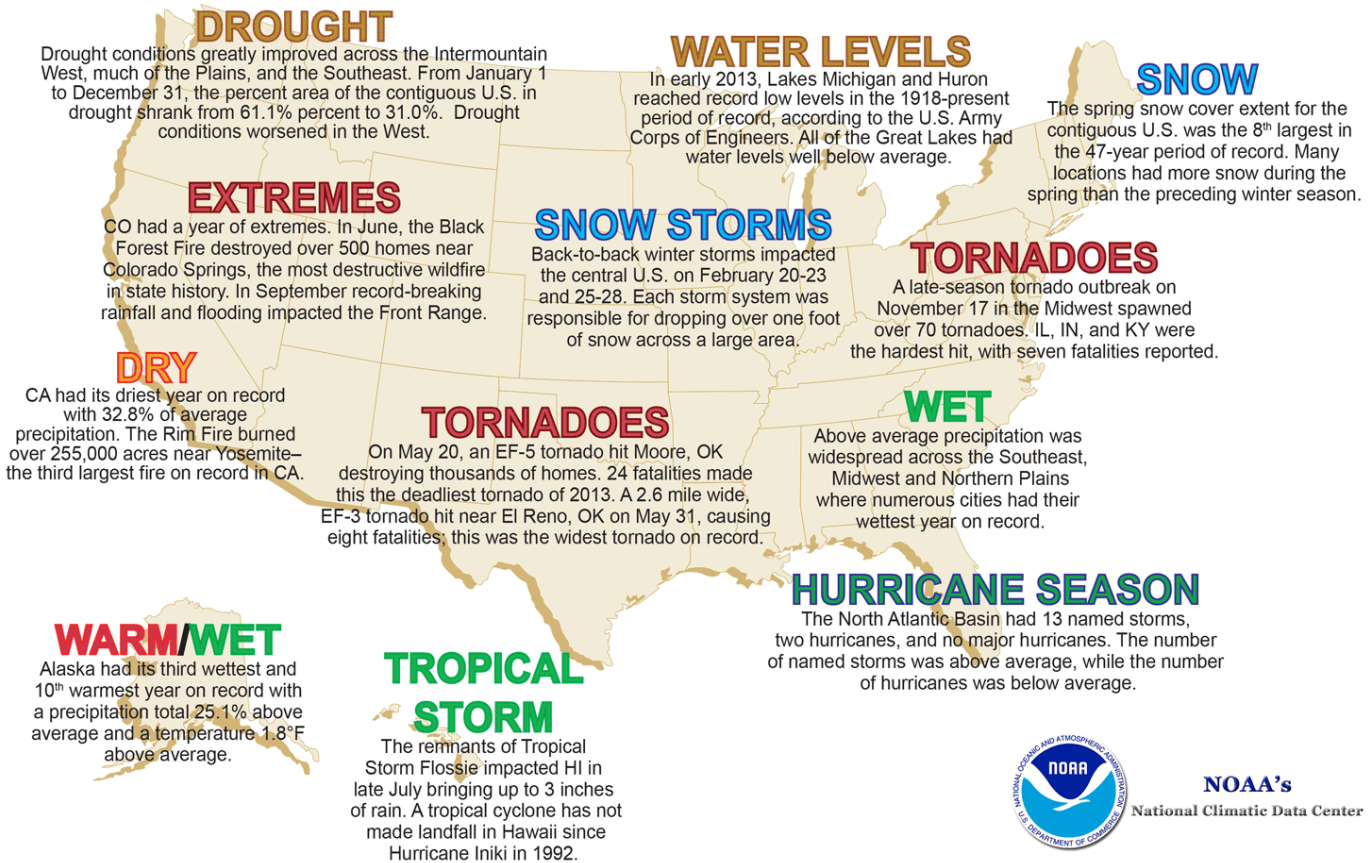
Imagine this to be a plot of 100 years of rain event amounts on the X-axis and the frequency of occurrence of those amounts on the Y-axis. The larger the event, the smaller the chance.

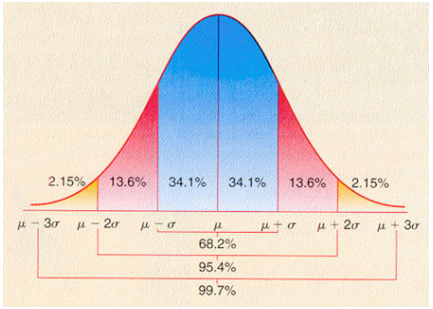
But what happens to weather if the climate is changing?

Current thinking is much higher frequency of weather extremes!

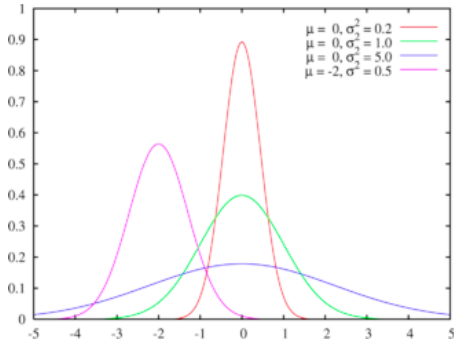
What Are the Odds?

Preliminary Significant U.S. Weather and Climate Events for 2013





Weather patterns used to be known and therefore predictable



Weather patterns are becoming more extreme and therefore less predictable

Where's Your Global Warming?

2014 was the warmest globally averaged year since record keeping!

- Australia: For the second year in a row, Australians saw heat records topple from the Gold Coast to the Coral Coast. The country kicked off January with an extreme heat wave; temperatures soared higher than 120 F (49 C). Heat waves in the autumn (March to May) and spring (September to November) also drove temperatures into the record books.

- Eastern Pacific Ocean: Toasty temperatures developed in the eastern Pacific Ocean, despite an El Niño that never appeared. The heat was especially notable off the western coast of the United States. Fishing boats spotted species well north of their range, such as a giant ocean sunfish offshore of Alaska. For the global ocean, the September to November sea surface temperature was 1.13 F (0.63 C) above the 20th century average of 60.7 F (16.0 C), surpassing the previous record by 0.11 F (0.06 C), according to NOAA.

- Siberia: Central Siberia defrosted in spring and early summer under temperatures more than 9 F (5 C) above its 1981 to 2010 average. Ice on the Ob River began to break up two weeks earlier than normal. The heat may have unleashed methane gas trapped in previously frozen permafrost, triggering underground explosions that formed spectacularly deep holes.

- California: The long-running drought in California was made worse in 2014 by record heat. The first 10 months of 2014 were the warmest in California's history since 1895, further burdening the state's water demands.

- Northern Europe: The same weather pattern that froze North America in early 2014 brought an unusually warm spring to countries including Denmark, Norway and Turkey. The sultry spring was the warmest in a century or more in these countries. In addition, January to October was the warmest 10-month period on record for Central England since 1659, and the warmest such period for the Netherlands since 1706.

Climate Disruption?

We have been conditioned to believe that not all change is bad, so perhaps, Climate Disruption might be a better characterization than Global Warming or Climate Change!

Where are we, then?

So what ***might*** the climate look like in upper Midwest in the next 100 years?

Remember, the timing and impacts of the Earth's changing climate on weather at the regional and local scale is still speculation.

Regional Climatic Impacts: The Future

What does the average output of over a dozen climate models used by the International Panel on Climate Change predict for the Midwest for 2099? http://globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/midwest

- Summer temperature patterns in Illinois will be more like summers currently experience in southeast Texas: considerably warmer but less summertime precipitation.

- Under lower emissions scenario, heat waves like that in Chicago 1995 are projected to occur once every three years; under higher emissions scenario (the worst case), they will occur nearly three times per year.

- Under high emissions scenario, the balance between precipitation and evaporation ands outflow indicate that Lake Michigan will drop nearly 2 feet.

Regional Climatic Impacts: The Future (Continued)

What does the average output of over a dozen climate models used by the International Panel on Climate Change predict for the Midwest for 2099?

- Precipitation will decrease during summer leading to water deficits, but will increase during winter and spring. When precipitation occurs, it will be more as heavy downpours. Hence, there will be periods of both floods and water deficits.

- A longer growing season provides the potential for increased crop yields, but heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing corps, livestock, and forests.

Regional Climatic Impacts: The Future (Continued)

What does the average output of over a dozen climate models used by the International Panel on Climate Change predict for the Midwest for 2099?

- By the end of the century, plants now associated with the Southeast are likely to become established throughout the Midwest.

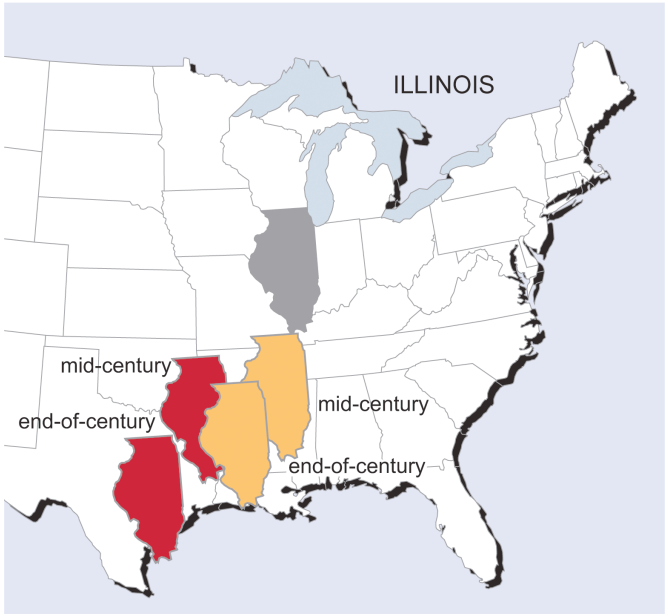
- Native species are very likely to face increasing threats from rapidly changing climate conditions, pest, diseases, and invasive species moving in from warmer regions.

Regional Climatic Impacts

Scientists have **NOT** reached consensus on **timing** or ***regional*** impact, but we are getting some ideas.

What is the Impact of Global Warming in the Midwest?

Think Houston Texas!



Hayhoe *et al.*[283]

Model projections of summer average temperature and precipitation changes in Illinois for mid-century (2040-2059), and end-of-century (2080-2099), indicate that summers in this state are expected to feel progressively more like summers currently experienced in states south and west. Illinois is projected to get considerably warmer and have less summer precipitation.

THANK YOU!

Questions