CLIMATE EMERGENCY INSTITUTE

The medical and human rights approach to global climate change

3rd Annual Pacific Northwest Climate Science Conference
Boise Idaho
1 October 2012

Climate change vulnerability assessment and the Pacific North West

Food and nutrition implications of committed global climate change

Peter D Carter

Commitment Due to Unavoidable Global System Lags (Delays)

Total Lags in Climate System = 3.0°C by 2100

CLIMATE SCIENCE CONTRIBUTORY FACTORS TO TOTAL MINIMUM UNAVOIDABLE WARMING

Inertia, lags, and momentum cause delayed, unavoidable, additional global average temperature increases.*

1. **Duration of warming** – 1000s of years
   NRC, Climate Stabilization Targets, 2010

2. **Lifetime of GHG emissions in the atmosphere**
   20% of CO2 lasts 1000 years (IPCC, 2007)

3. **Today's global emissions scenario**
   Highest emissions IPCC A1FI (fossil fuel intensive)

4. **Time from rapid reduction of emissions to atmospheric GHG stabilization** (assuming an emergency response to a zero-carbon emissions target)

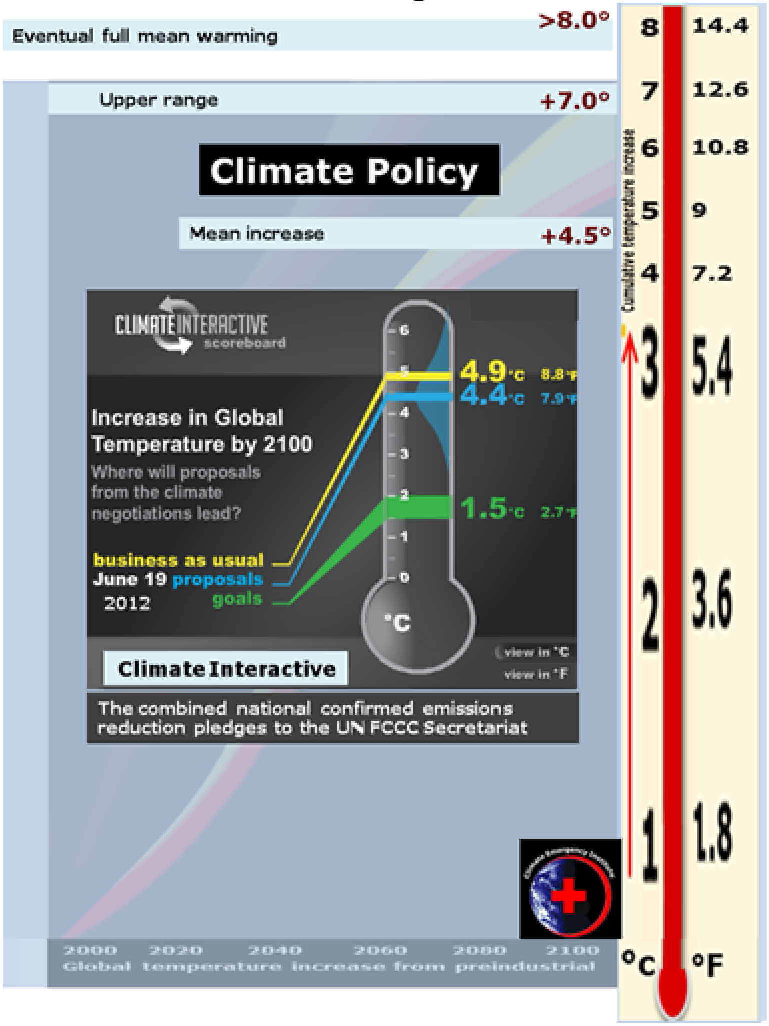
5. Delayed warming from **ocean heat lag** (NRC, 2010)

6. Deferred warming due to **air pollution aerosol cooling** (we apply to 2100)

7. Additional incurred warming from **positive feedbacks**

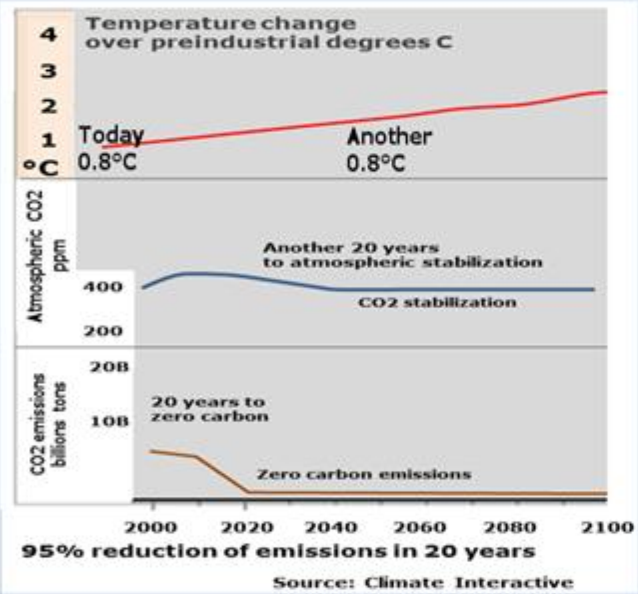
*All are from pre-industrial.

Socio-Economic Inertia = 4.4°C by 2100

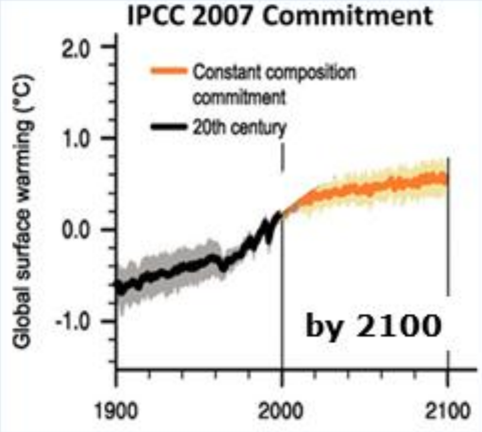


Unavoidable Sources of Warming

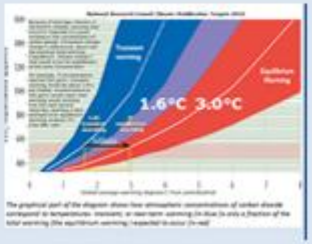
4. Shortest possible time to atmospheric GHG stabilization



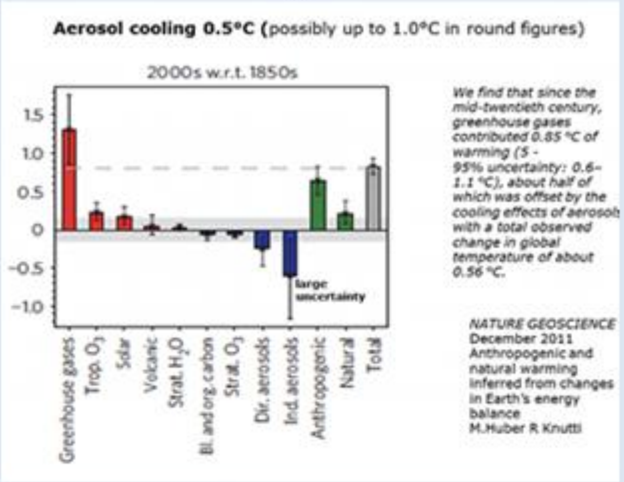
5. Ocean heat lag



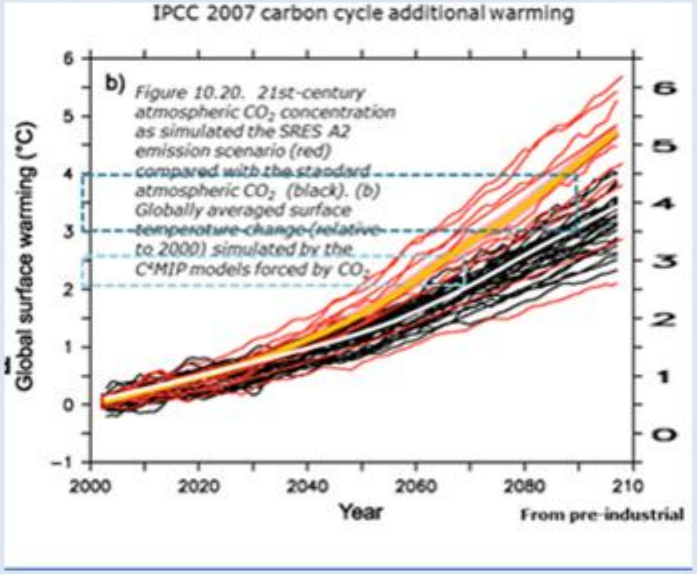
Best Estimate Equilibrium Warming (°C)	Estimated Likely Range of Equilibrium Warming (°C)
1	0.7-1.4
2.2	1.4-3.0
3.1	2.1-4.3
3.9	2.6-5.4
5.9	3.9-8.1
9.1	6.0-12.5



6. Aerosol cooling deferred warming

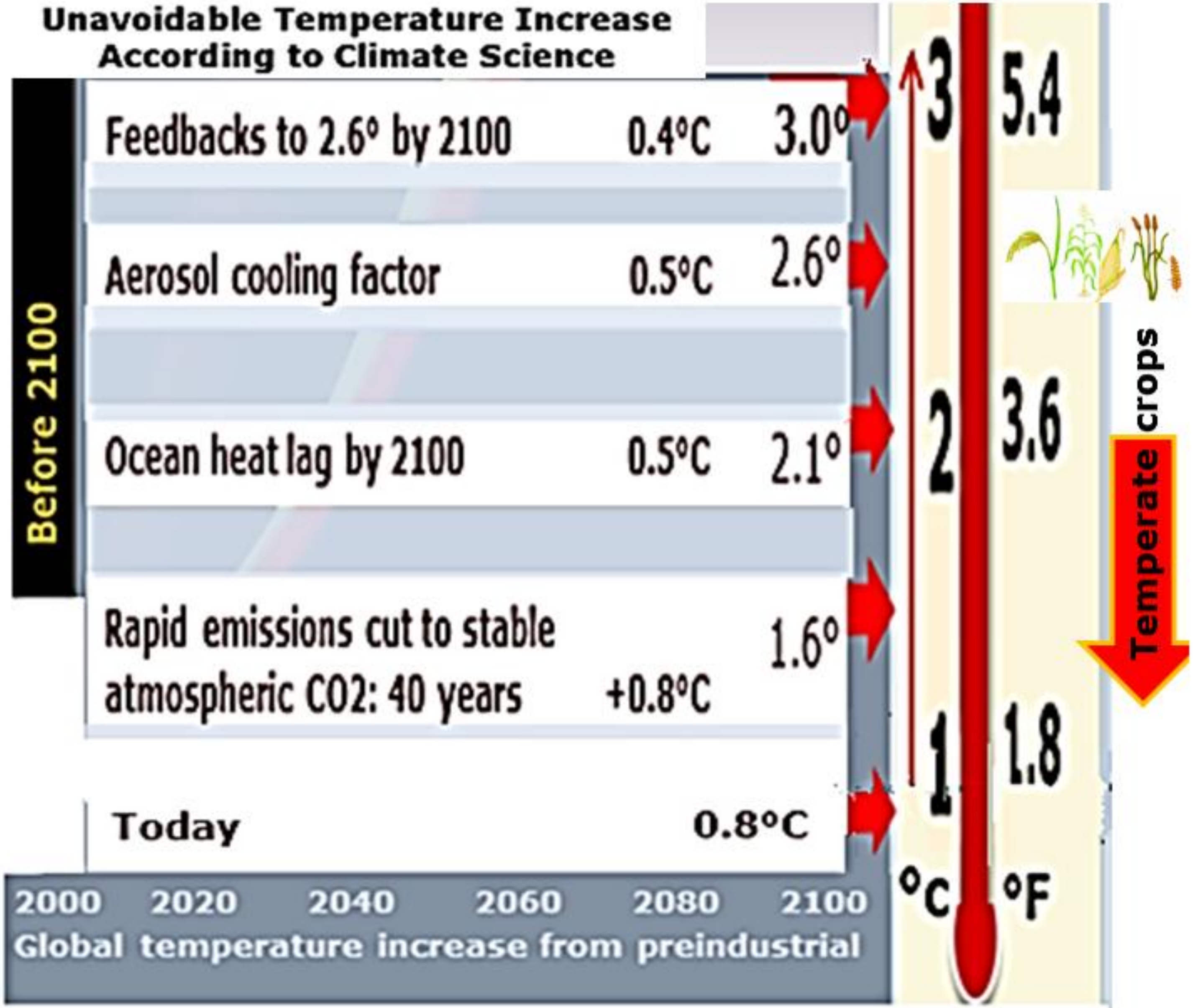


7. Feedback-incurred added warming



Total Committed Warming

Unavoidable Temperature Increase According to Climate Science



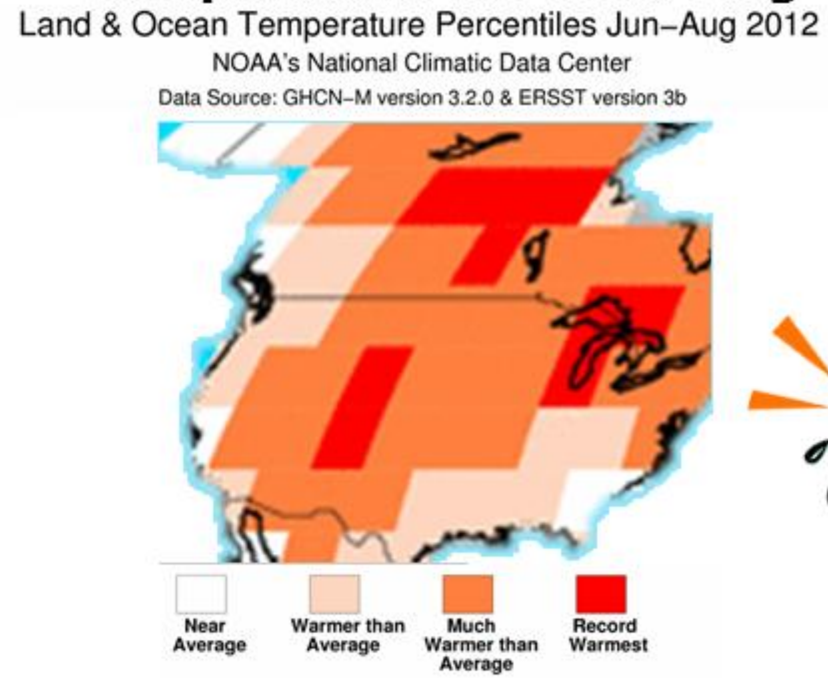
Actual temperature increase by 2100 will eventually double after 2100 due to the ocean heat lag.

By our summation the minimum unavoidable eventual commitment is 4.5° C

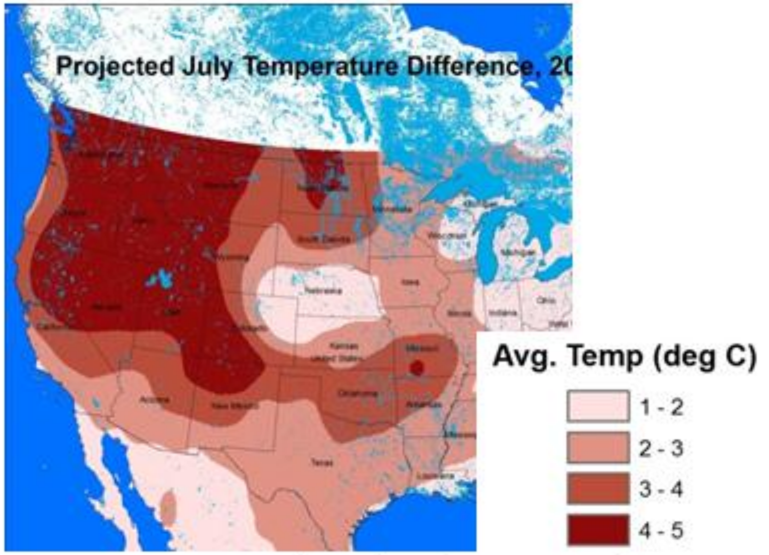
For the science and calculation
http://www.climatechange-foodsecurity.org/commitment.html

Increasing Temperatures

2012 Record U.S. Land Temperature for June-Aug

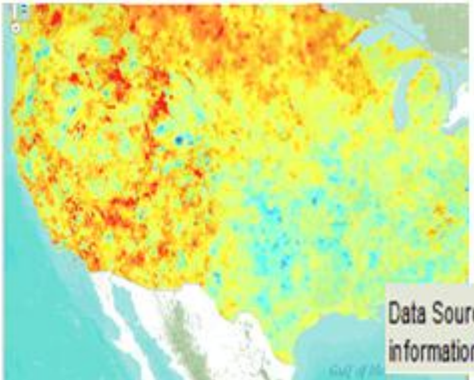


Projected July Temperature Difference, 2000-2050



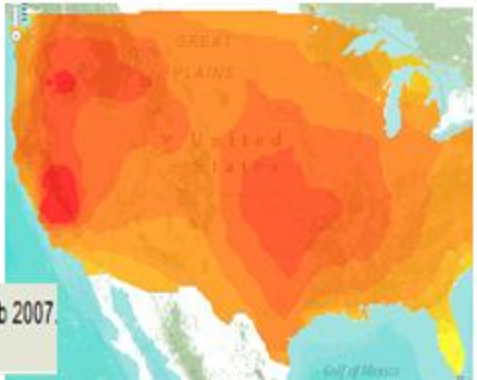
Climate Extremes Research, Oakridge National Laboratory, 2008
http://www.ornl.gov/sci/knowledgediscovery/WarGaming/USA/us2050td.jpg

Change in Annual Temperature 1951-2006



Data Source: PRISM Group, Oregon State University, created 4 Feb 2007. information. http://www.prism.oregonstate.edu/

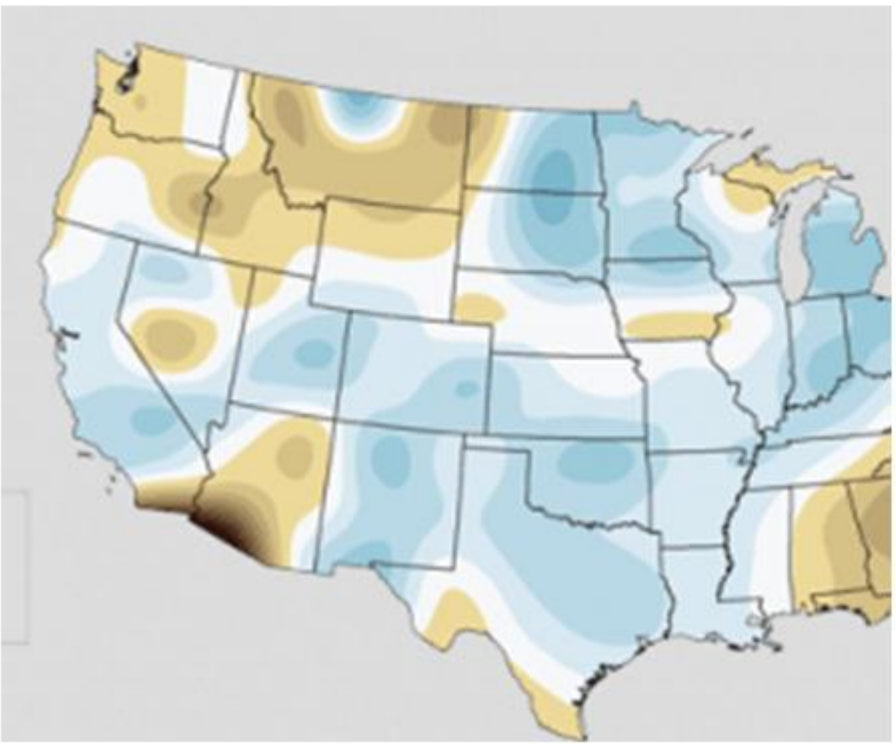
Change in Annual Temperature by the 2050s



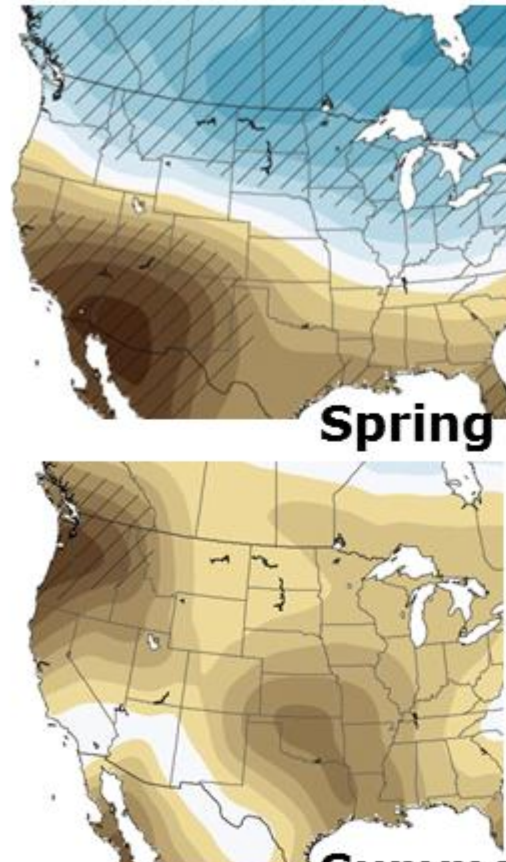
We are tracking the worst-case, highest emissions scenario: A1FI

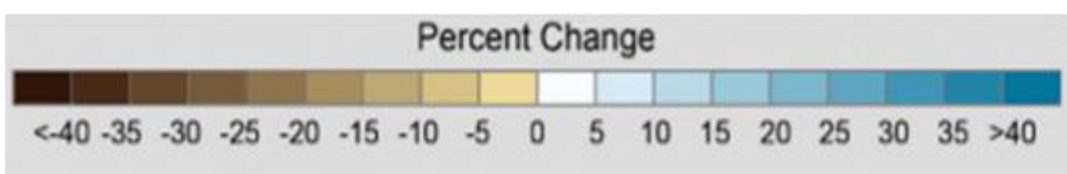
U.S. Global Change Research Program
Global Climate Change Impacts in the United States
2009 Report

Observed Changes in Annual Average Precipitation 1958-2008



We are tracking the highest emissions scenario for late 2100





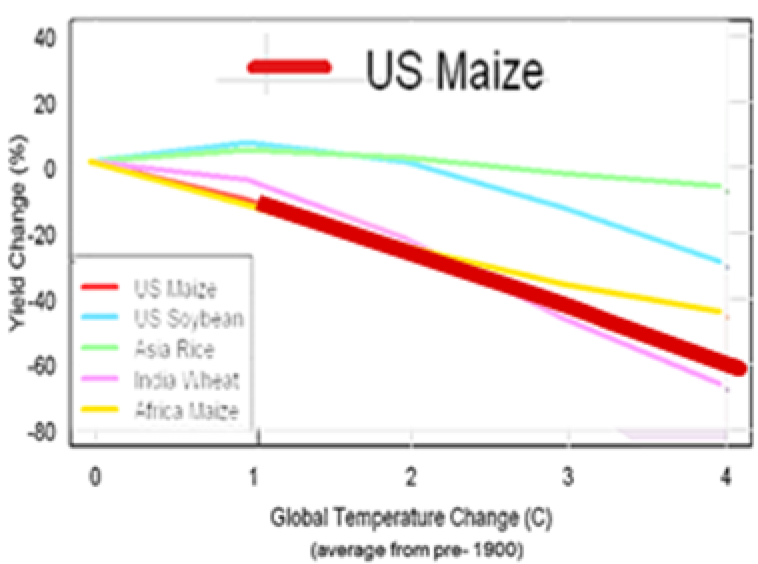
Impacts on Food

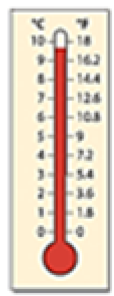
NRC Climate Stabilization Targets 2010

*For C3 crops (rice, wheat, soybeans, fine grains, legumes) in temperate regions, models show decline at **+1.25-2°C** in global average temperature.*

For C4 crops (maize, sugar cane, millet, sorghum), even modest amounts of warming are detrimental in major growing regions given the small response to CO2.

Climate Stabilization Targets NRC 2010





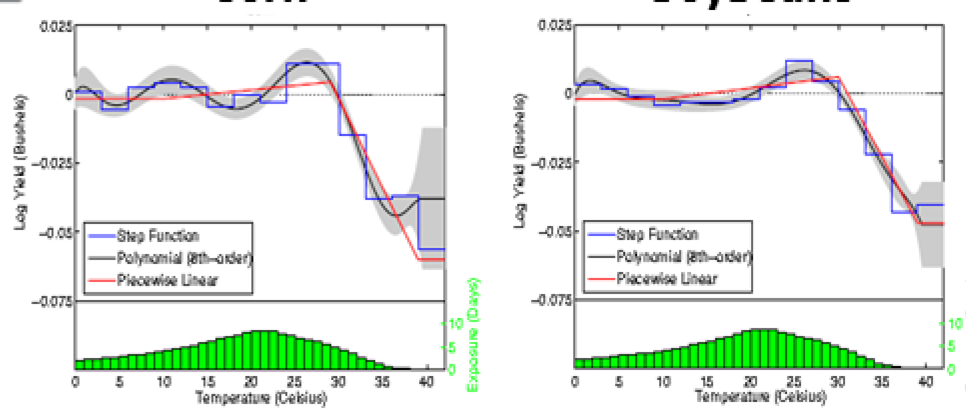
Processes not adequately quantified
(nor captured in the models):

- *responses of weeds*
- *insects*
- *pathogens*
- *changes in water resources - irrigation*
- *effects of changes in surface ozone levels*
- *effects of increased flood frequencies*
- *responses to extremely high temperatures*

Most crop modeling studies have not considered changes in sustained droughts.

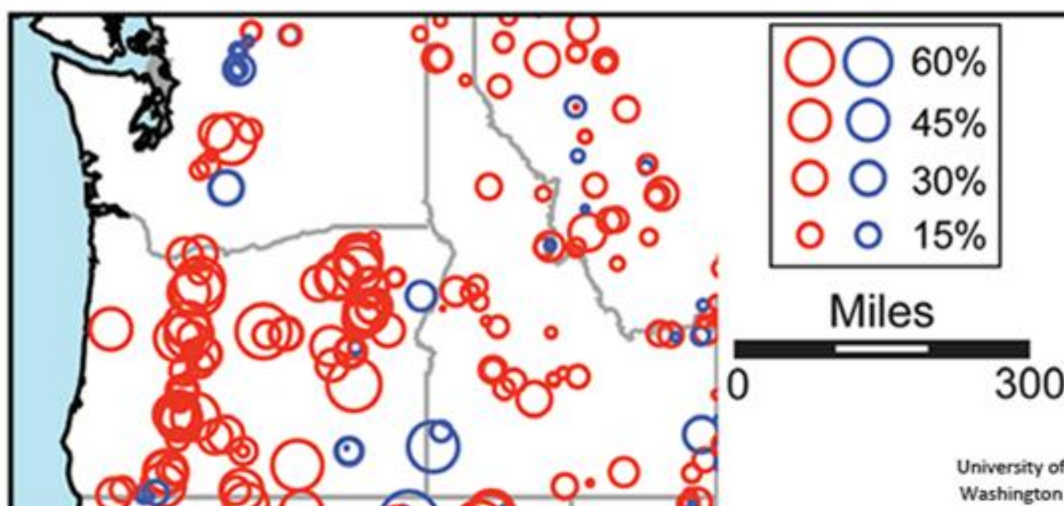
Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change.
— W. Schlenkera, M. J. Roberts, PNAS 2009

Corn **Soybeans**



Agriculture in the Northwest

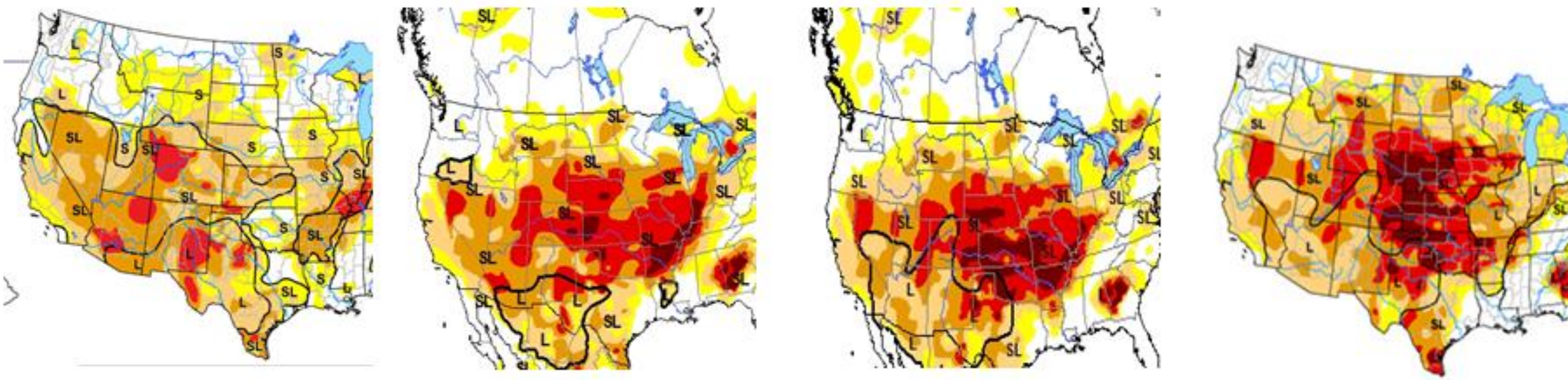
"Agriculture, especially production of tree fruit such as apples, is also an important part of the regional economy. Decreasing irrigation supplies, increasing pests and disease, and increased competition from weeds are likely to have negative effects on agricultural production."



U.S. Drought 2012

U.S. Drought Monitor

June 19 | **July 31** | **August 31** | **September 18**



Drought Severity

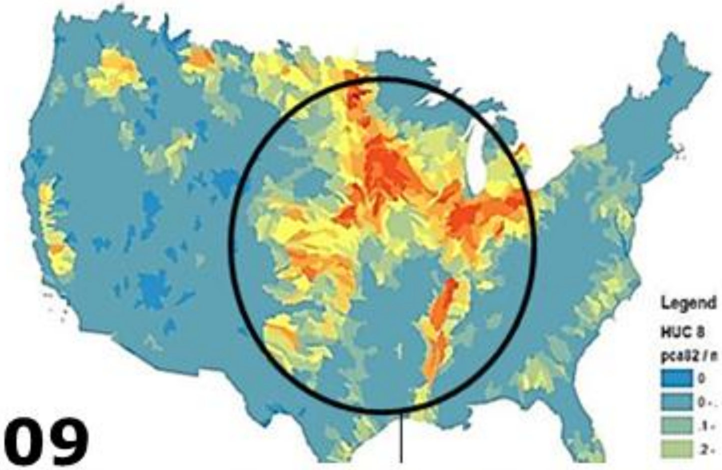
- Minor Drought
- Moderate Drought
- Severe Drought
- Extreme Drought
- Exceptional Drought

http://droughtmonitor.unl.edu/drmon.gif

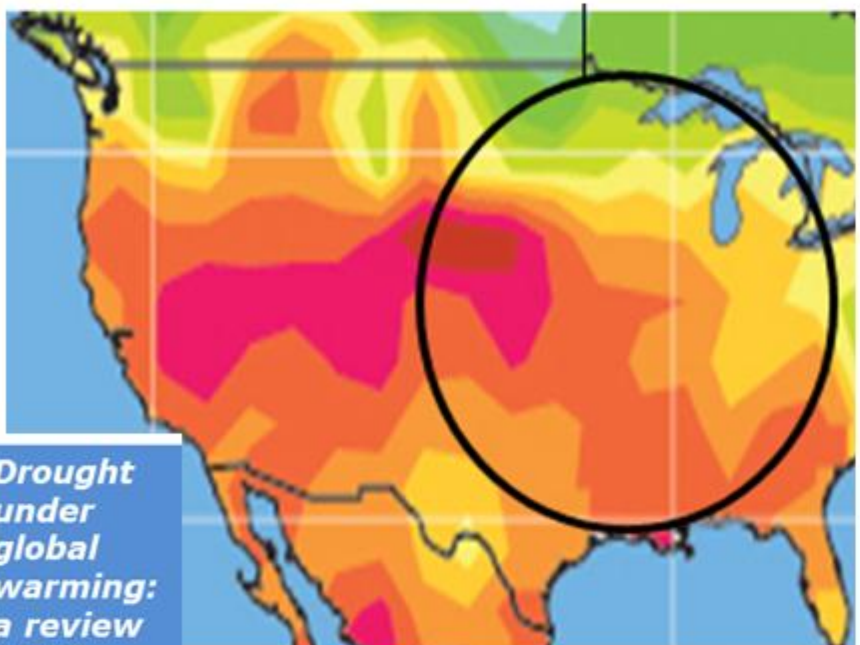
Drought in the United States

Crop productivity

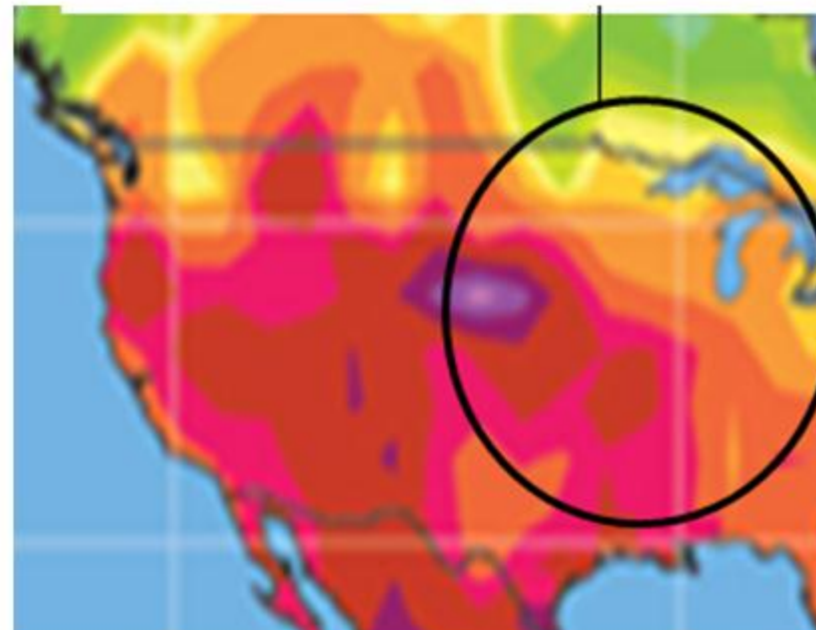
US agriculture EPA

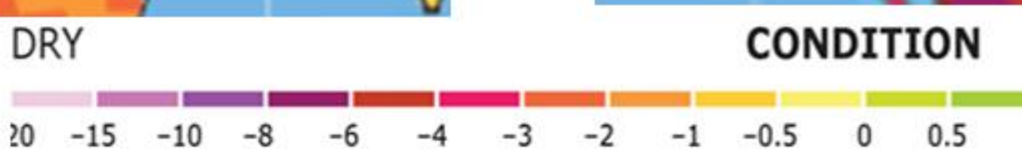


2000 - 2009



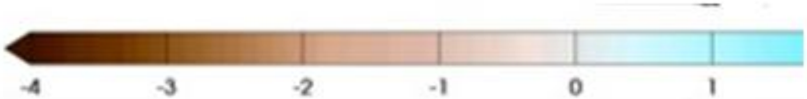
+ 1.8°C

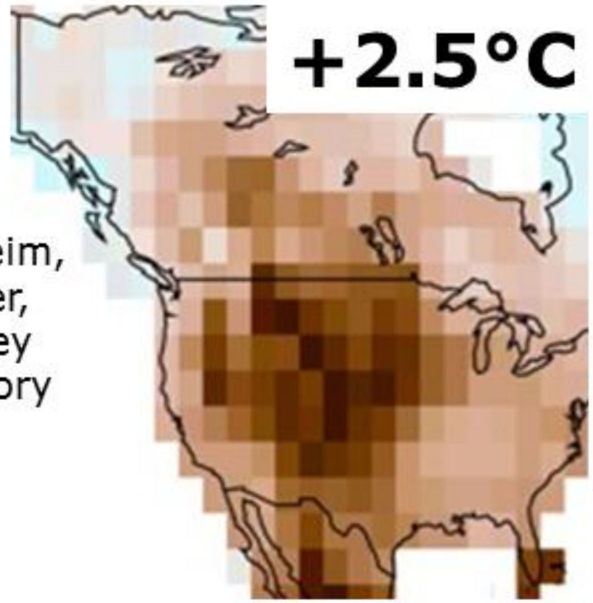




Drought under global warming: a review
A Dai
UCAR
Wiley
2010

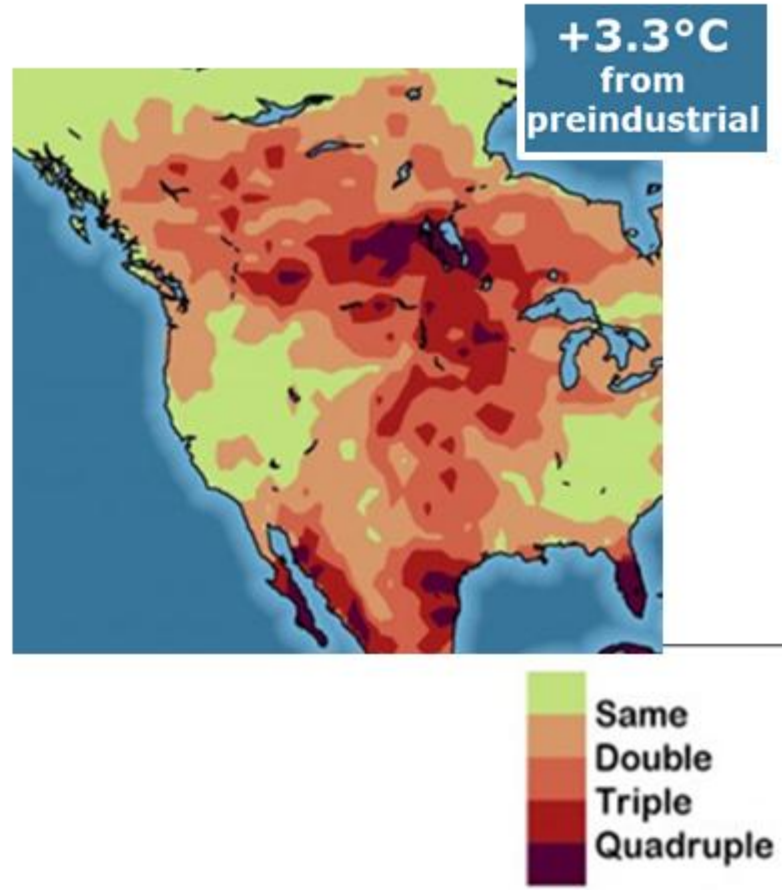
Projections of Future Drought in the Continental U.S. and Mexico





2011
M. Wehner, R. Heim, R. Vose, B. Santer, Lawrence Berkeley National Laboratory

Increase in Summer Drought



"Even in regions where rainfall increases, the soils will get drier. This is a very robust finding."

"The areas colored dark red-brown will suffer severe and permanent drought conditions if the average global temperature rises 2.5 degrees this century."

— Credit: Michael Wehner

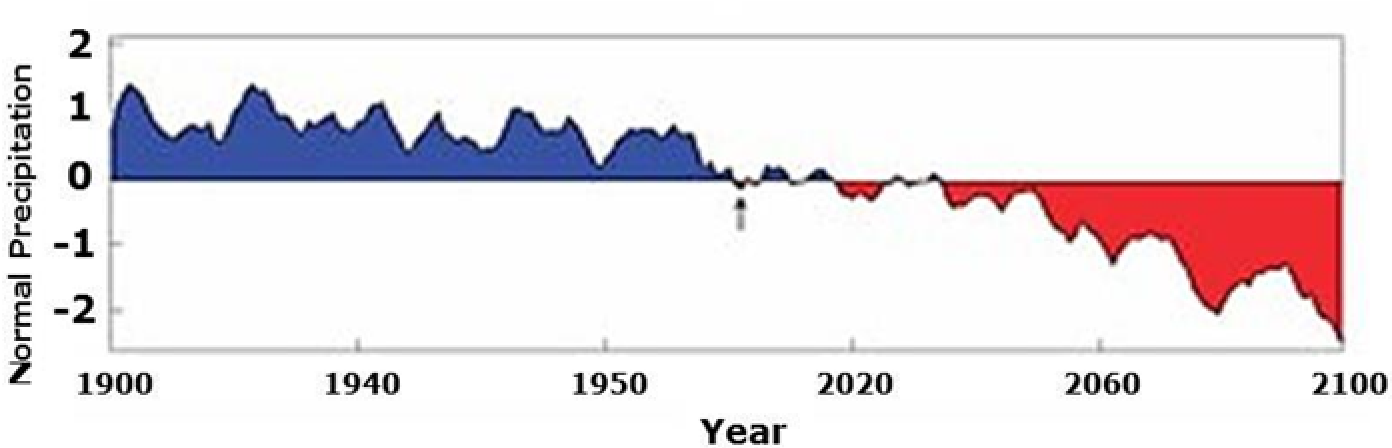
http://www.ipsnews.net/2012/05/action-needed-now-to-prepare-for-severe-drought/

Floods and Droughts in a Changing Climate – Now and the Future
April 29th, 2011 Paul A. Dirmeyer
Center for Ocean-Land-Atmosphere Studies
Calverton, Maryland

Even the Pacific Northwest is Committed to Increasing Drought

Chronic 2000-04 Drought, Worst in 800 Years, May Be the 'New Normal'
Science Daily, 29 July 2012
"The chronic drought that hit western North America from 2000 to 2004 [...] was the strongest in 800 years, scientists have concluded, but they say those conditions will become the "new normal" for most of the coming century. Such climatic extremes have increased as a result of global warming, a group of 10 researchers reported July 29 in Nature Geoscience."

> *Reduction in carbon uptake during turn of the century drought in western North America*
> — C. R. Schwalm et al, Nature Geoscience, 29 July 2012



6000-Year Climate Record Suggests Longer Droughts, Drier Climate for Pacific Northwest
Science Daily, 23 February 2011
"Western states will likely suffer severe water shortages as El Niño/La Niña wields greater influence on the region."

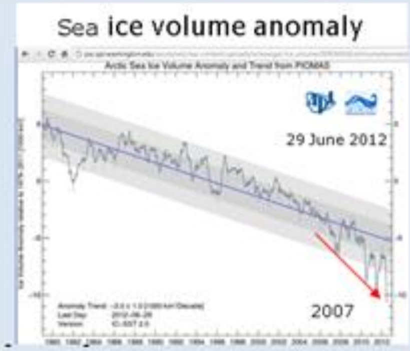
> *Drought variability in the Pacific Northwest from a 6,000-yr lake sediment record*
> — D. B. Nelson et al, PNAS, March 2011

The Arctic Factor

Loss of Northern Hemisphere Snow and Summer Sea Ice Albedo Cooling

Unavoidable loss of Arctic albedo – feedback affecting the temperate N hemisphere.

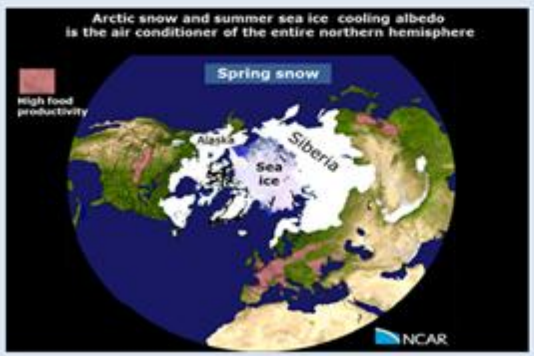
All sea ice models project virtual total loss of Arctic summer ice, >50% project possible abrupt loss. Most experts, based on sea ice extent models, say it is decades away. A few say it is years away, by accounting for the very rapid loss of sea ice volume.

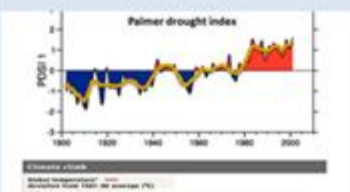


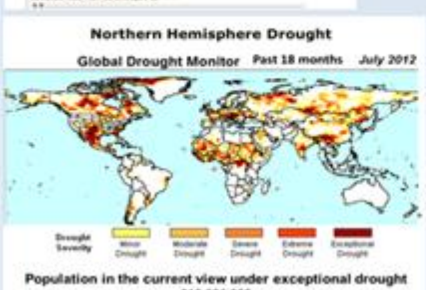
Impact on N.H. crop productivity

Expected effects are increasing:

- **climate variability**
- **severe storms**
- **heat waves**
- **drought**
- **floods**





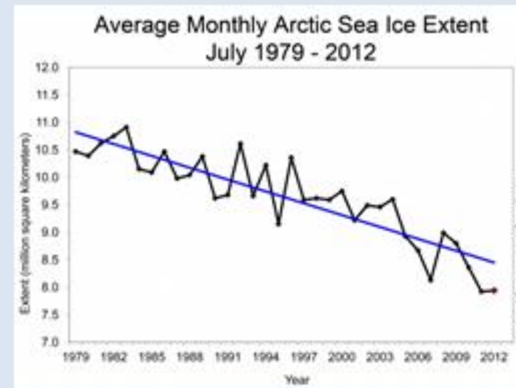


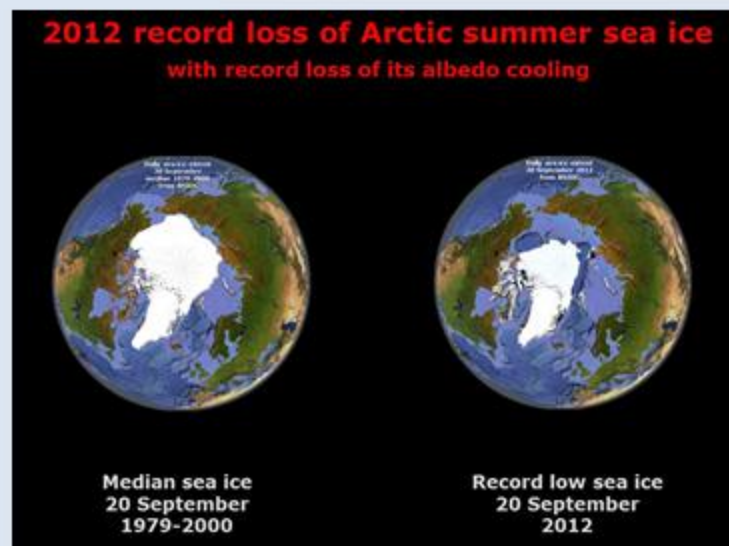
Global drought (PDSI) has been steadily increasing for the past 30 years. There is a recent trend of increasing N. hemisphere drought .

Our 3°C total by 2100 does not include the large Arctic feedbacks, which are not in the models. They are all operant already.

1. Loss of snow and summer sea ice albedo cooling
2. Warming peat-rich wetlands (CH4)
3. Thawing permafrost (CH4, CO2 & N2O)
4. 'Melting' subsea floor methane hydrate

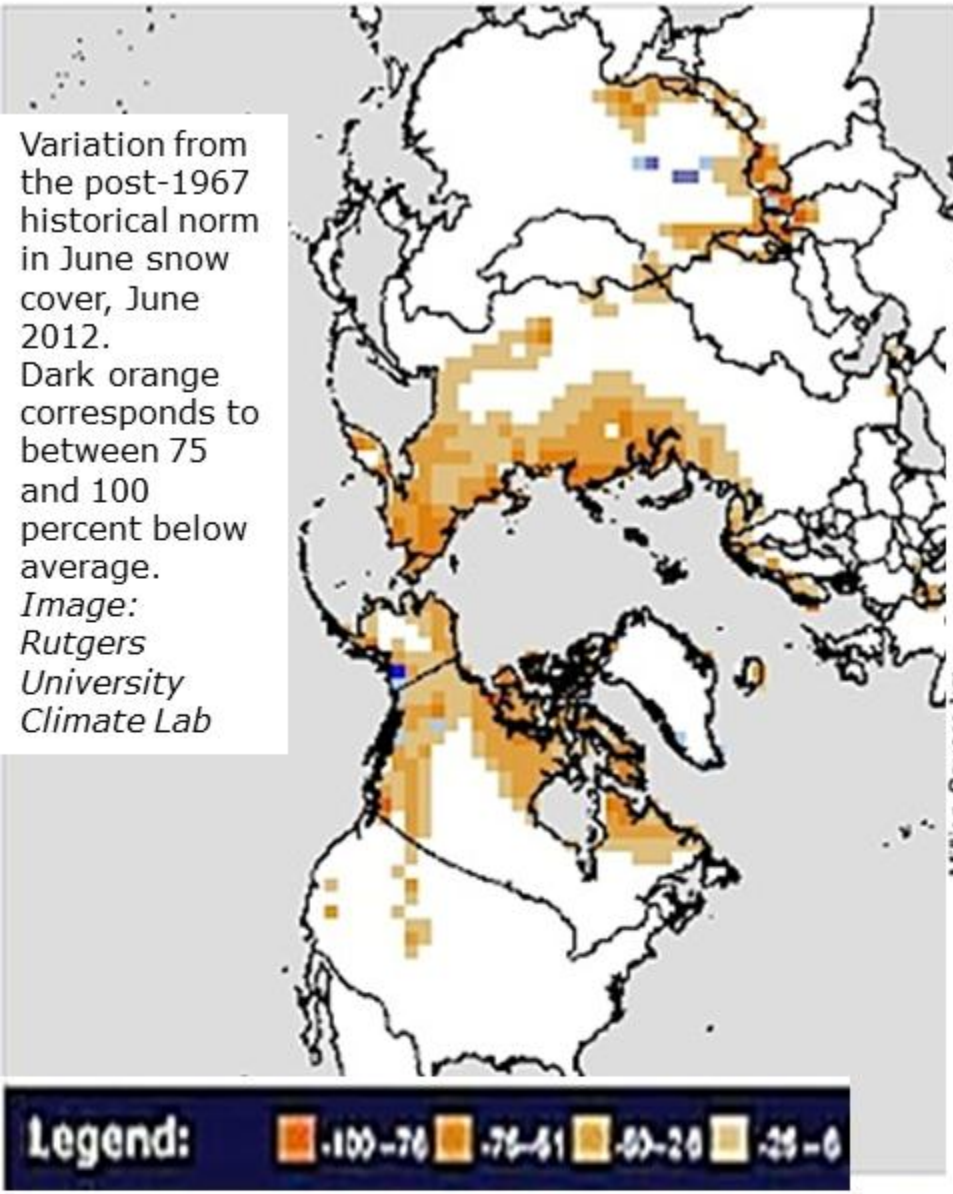
Record 2012 Arctic Sea Ice Loss





Loss of Albedo from Loss of Snow Cover

Departure from Normal - June 2012

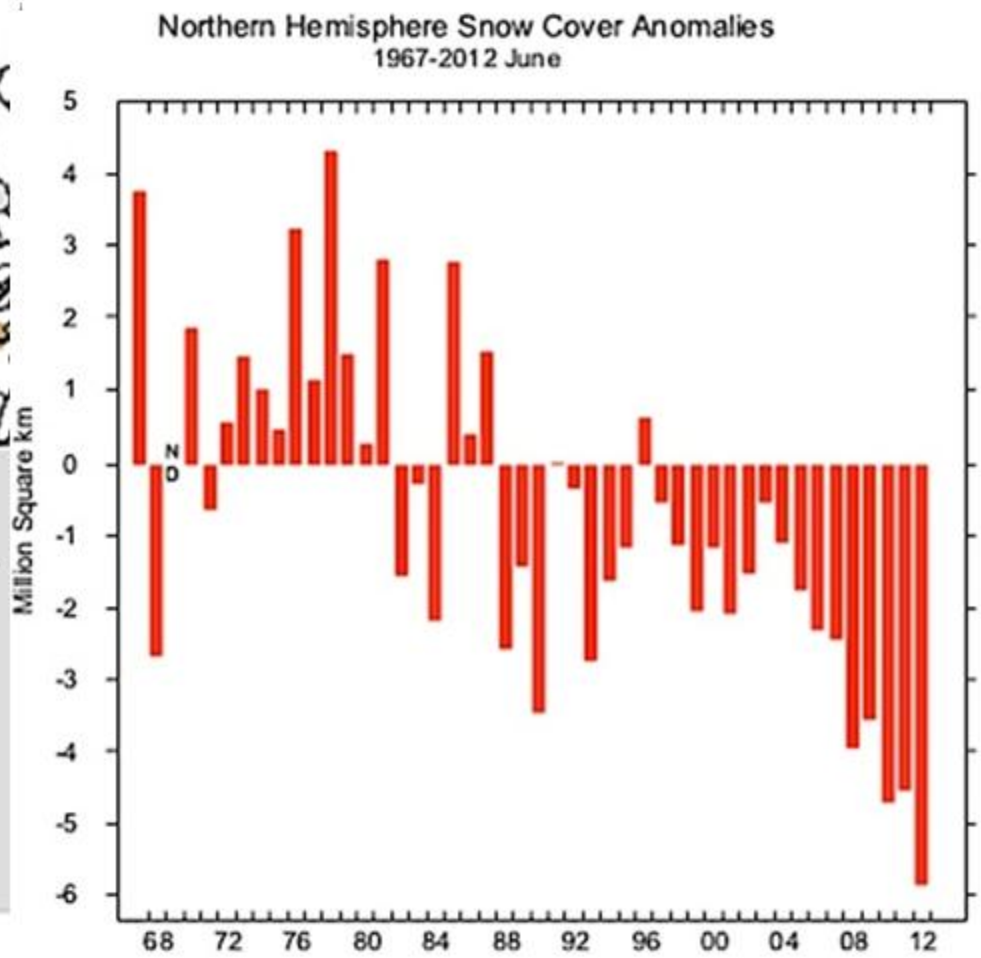


Variation from the post-1967 historical norm in June snow cover, June 2012.
Dark orange corresponds to between 75 and 100 percent below average.
Image: Rutgers University Climate Lab

Record Arctic Snow Loss May Be Increasing North American Drought

Northern hemisphere snow coverage, in millions of square kilometers, as compared to the post-1967 average.

Image: Rutgers University Climate Lab



N.H. Snow and Arctic Sea Ice Albedo Cooling

The albedo of Arctic sea ice and North Hemisphere snow are about the same and about double previous estimates.
—M. Flanner, Nature Geosc, 2011

Snow cover
April 2001
NSIDC
KML

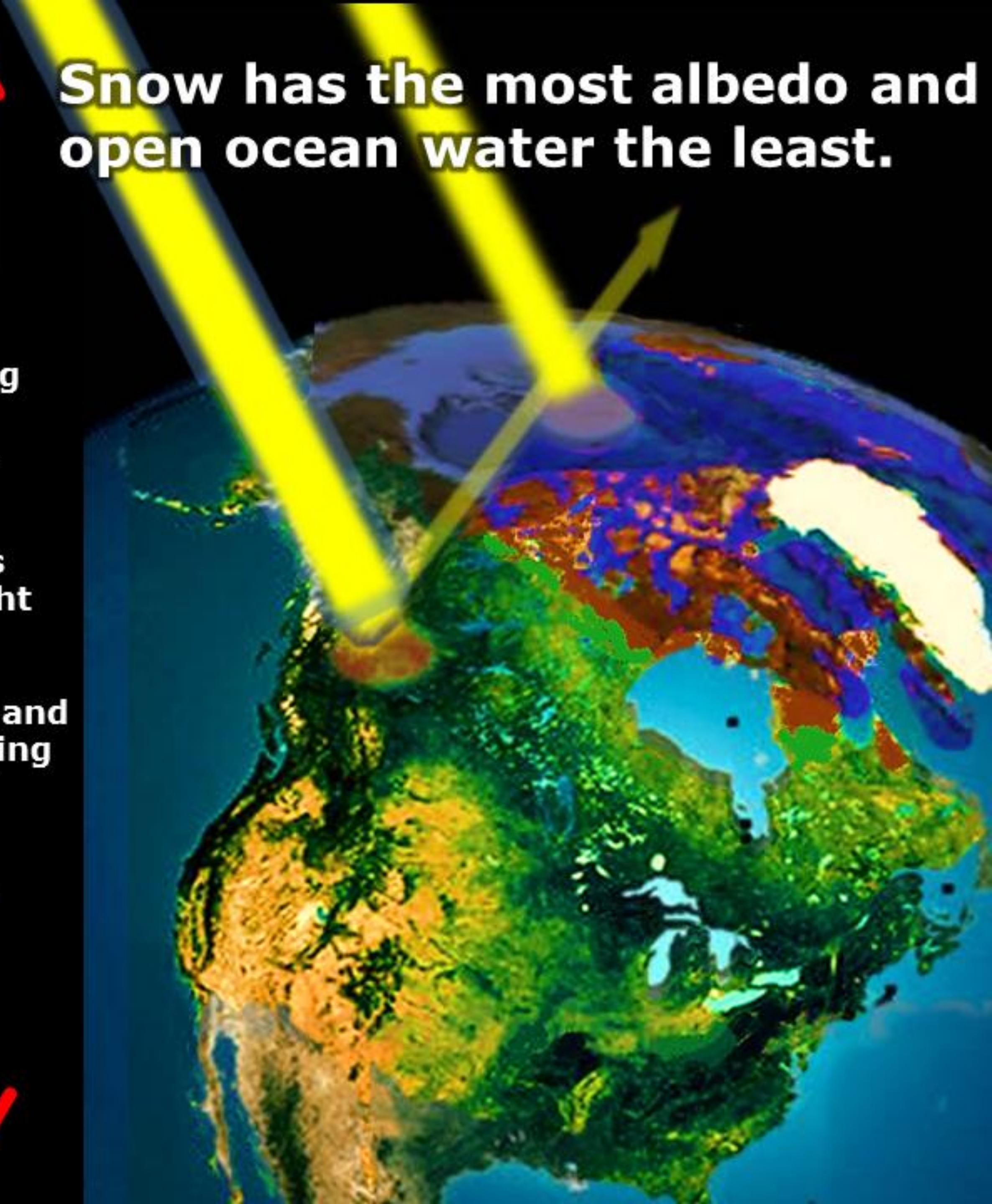
Arctic Albedo loss - more NH drought

Rapid loss of NH snow (record 2012) may be further increasing NH drought.

— David Robinson, Snow Lab, Rutgers University 2012

Loss of Arctic summer sea ice is projected to increase NH drought and climate variability. It is affecting the jet stream with tropical weather moving north, and the "blocking effect" is prolonging extreme weather.

— J. Francis, 2009, 2012



Arctic Albedo loss - more NH drought

Snow has the most albedo and open ocean water the least.

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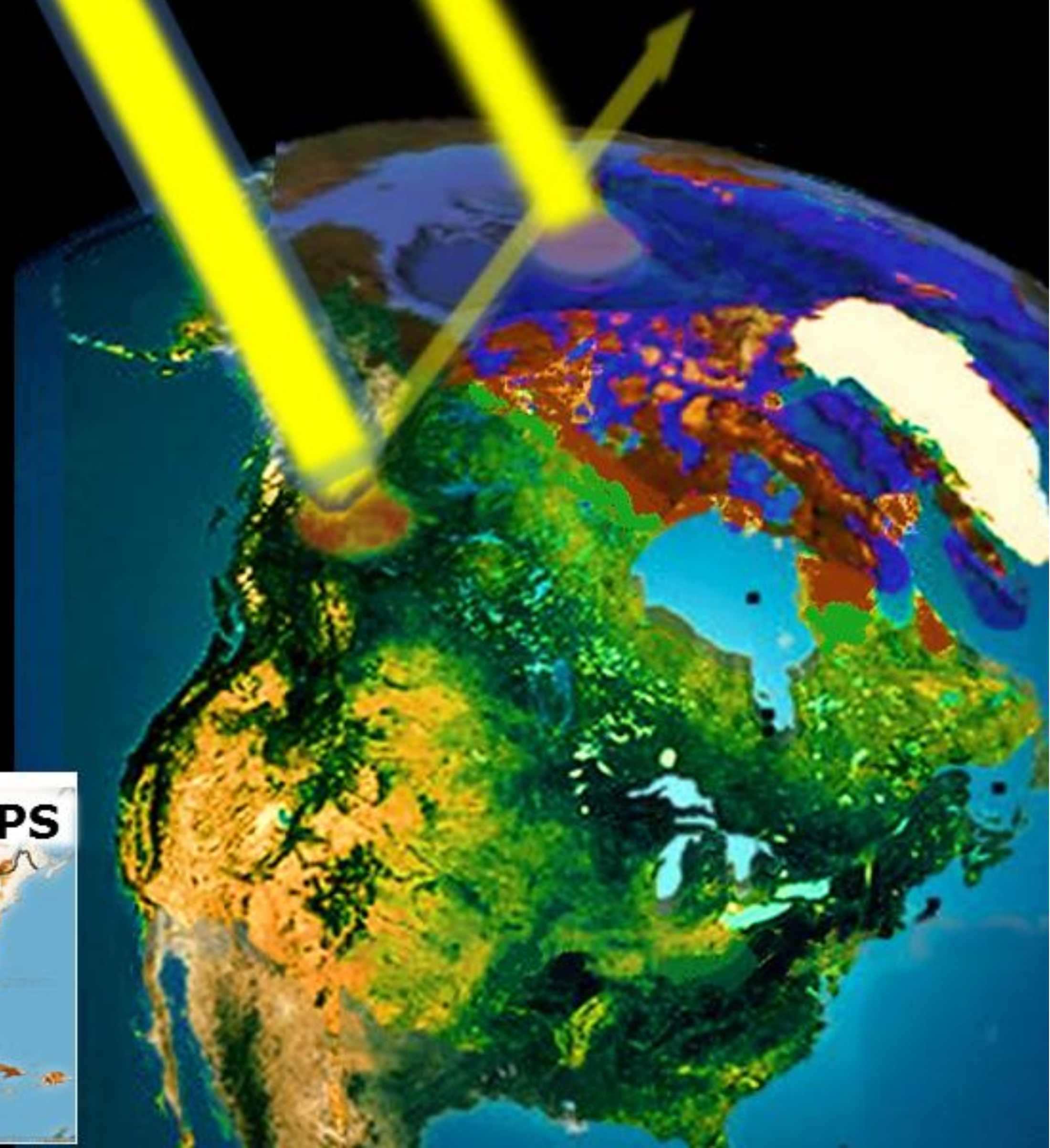


Where are we headed ?

3. The Current Emissions Scenario

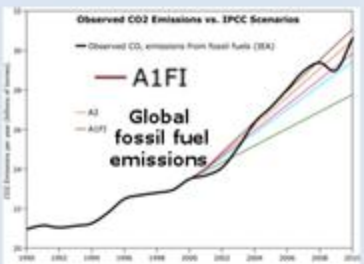
Worst case IPCC A1FI

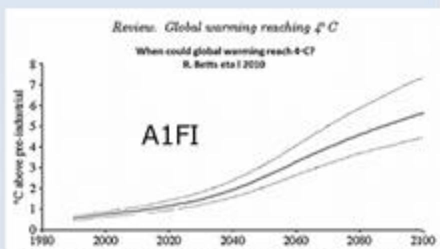
Significance:

- Unavoidable potentially irreversible greater degree of warming by locking in fossil fuel energy dependency
- Continued deferred warming from aerosol cooling
- Higher unavoidable warming from larger incurred feedbacks

Today's world economy is fixed on the worst case IPCC fossil fuel intensive emissions scenario of A1FI, with no agreement or plan to be changed.

For A1FI the UK Met Office and Betts (2010) project a mean warming of 5.5°C (1 in 10 chance of over 7.2°C) by 2100, including terrestrial carbon feedback. That is a full eventual mean warming after 2100 of over 9.0°C.





Global mean temperature change over the twenty-first century relative to pre-industrial, under the A1FI emissions scenario, ...The central thick line shows the median projection, and the two dashed lines show the 10th and 90th percentiles of the frequency distribution of the 729 MAGICC experiments.