



Climate Change

Is it real? And what does it mean in Alaska?

Interior Alaska, Fairbanks Vicinity, June 26th, 2014

- Weather v Climate
- Is climate change happening? For how long?
- Greenhouse Gases, especially CO₂
- Predicting Climate Change
- Are we to blame?
- Climate change in Alaska
- Future

Presentation Topics

Weather vs. Climate

Weather tells you that you'd better bring your raincoat to watch the game tonight.



Climate is telling your visitors to pack woolies and leave the swimsuit at home for their Christmas trip. (Unless they're going to the hot springs...)



Forecasting Weather vs Climate

Weather forecasts will be short term, attempting to give specifics on weather elements.

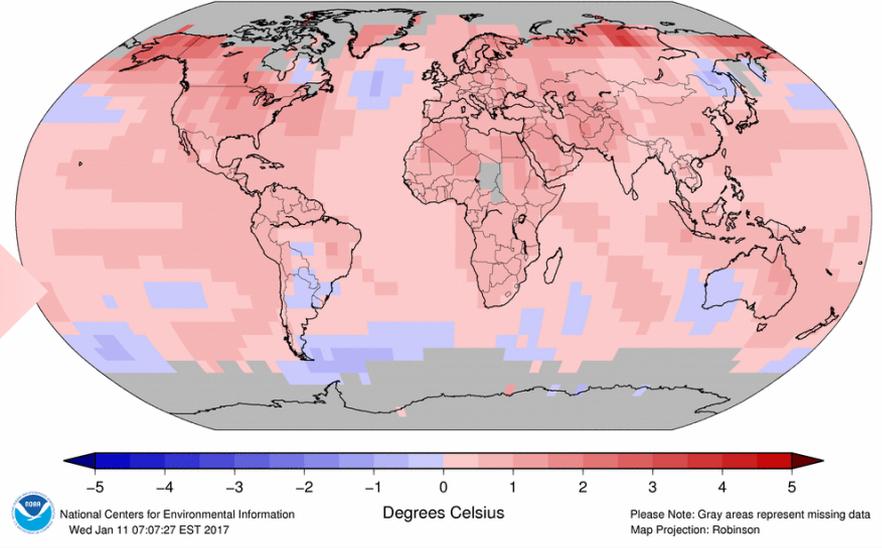
1-2" of rain expected at Denali in the next 12 hours.

By 2050, it will be 25% more likely to have a heatwave with temps over 100°F in England in August

Climate forecasts will identify that certain events are more or less likely to happen, perhaps in a particular place, under specific conditions and at a certain time of year

Land & Ocean Temperature Departure from Average Jan–Dec 2016
(with respect to a 1981–2010 base period)

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



2014 was the hottest year on record

Til 2015 showed up and became the hottest year on record

Til 2016 eclipsed that as the hottest year on record

16 of the 17 hottest years on record have happened since 2000. (+1998)

Comparing 2003-2012 with 1850-1900 shows +1.4°F temp change

How does the heat stack up?

*Records go back to 1880s

❖ There is near-unanimous scientific agreement that climate change is happening, and that the burning of fossil fuels is at least partly (if not mostly) responsible

❖ Arctic summer sea ice volume is down 75% since 1980

❖ Heat waves in Europe and Russia are breaking records and killing thousands

❖ Japan's Sakura Cherry Festival moved a month earlier to accommodate earlier blossoms

❖ Extreme precipitation swings are leading to more frequent droughts and floods

❖ Highbush blueberries near Walden Pond (MA) blooming 6 weeks earlier than 1850s

Climate change is happening;
impacts are felt worldwide!

If Earth had no atmosphere,
our average global temp
would be 0°F

80F



Mars

-205F

Mercury

800F



-292F

The Greenhouse Effect

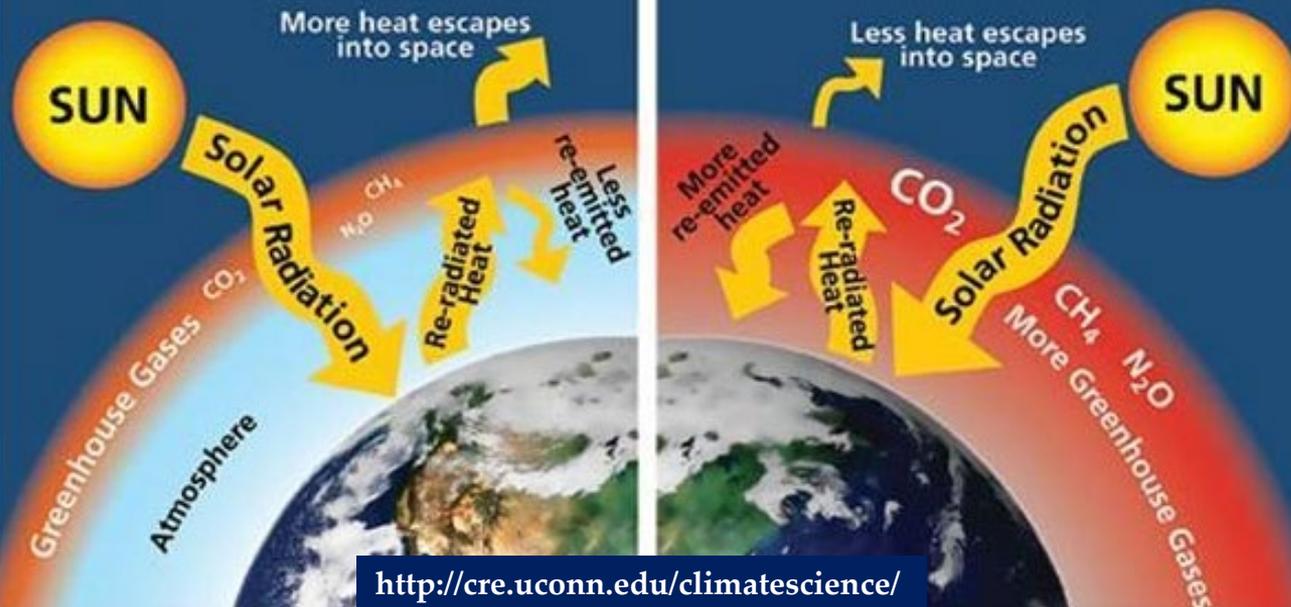
864 F



Venus

Natural
Greenhouse Effect

Human Enhanced
Greenhouse Effect



Greenhouse
gases prevent
loss of heat back
to space

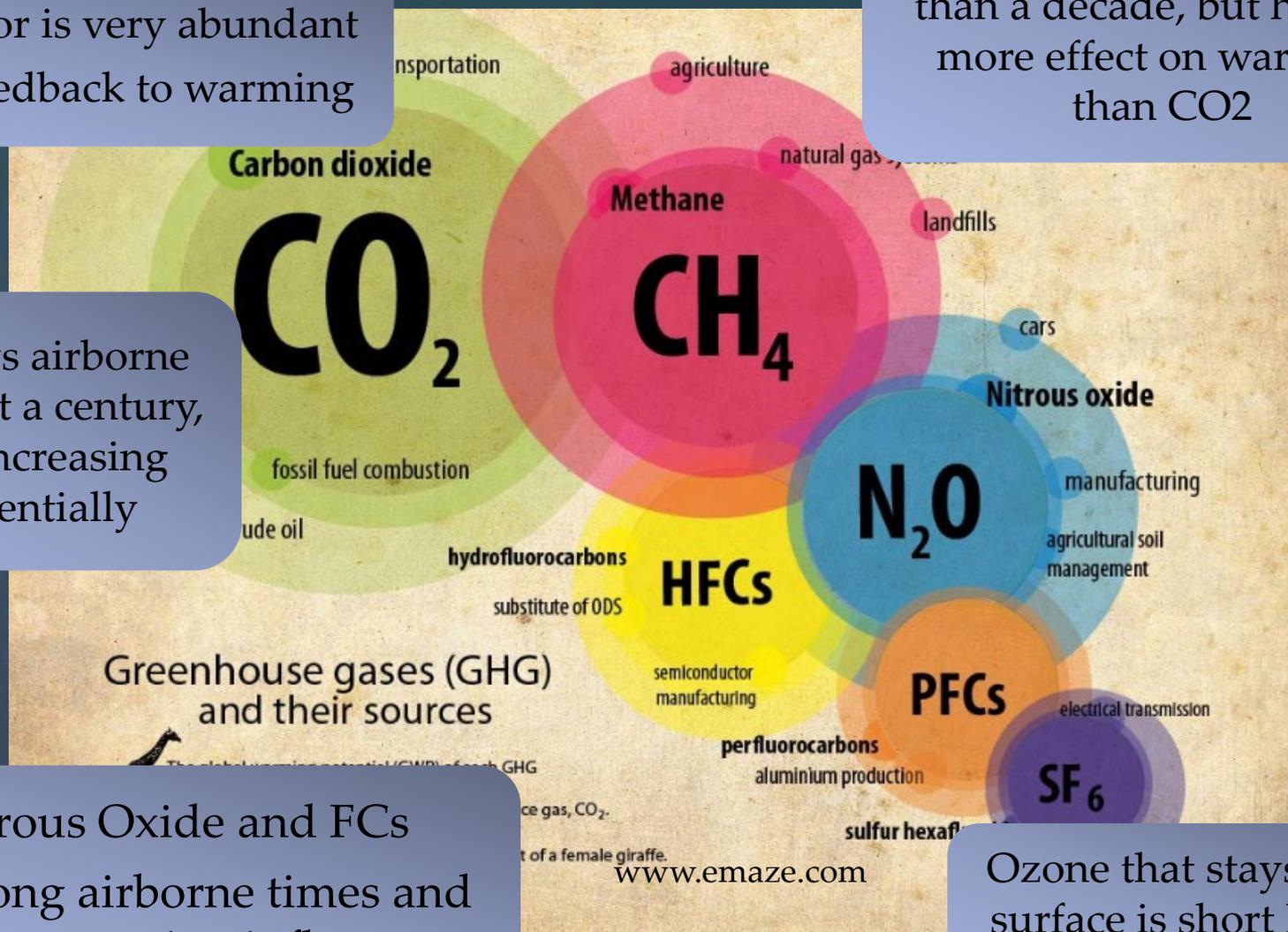
Earth's ave
temp = 61F

Greenhouse Gases

Water Vapor is very abundant
Positive feedback to warming

Methane is airborne for less than a decade, but has 25x more effect on warming than CO₂

CO₂ stays airborne for at least a century, and is increasing exponentially

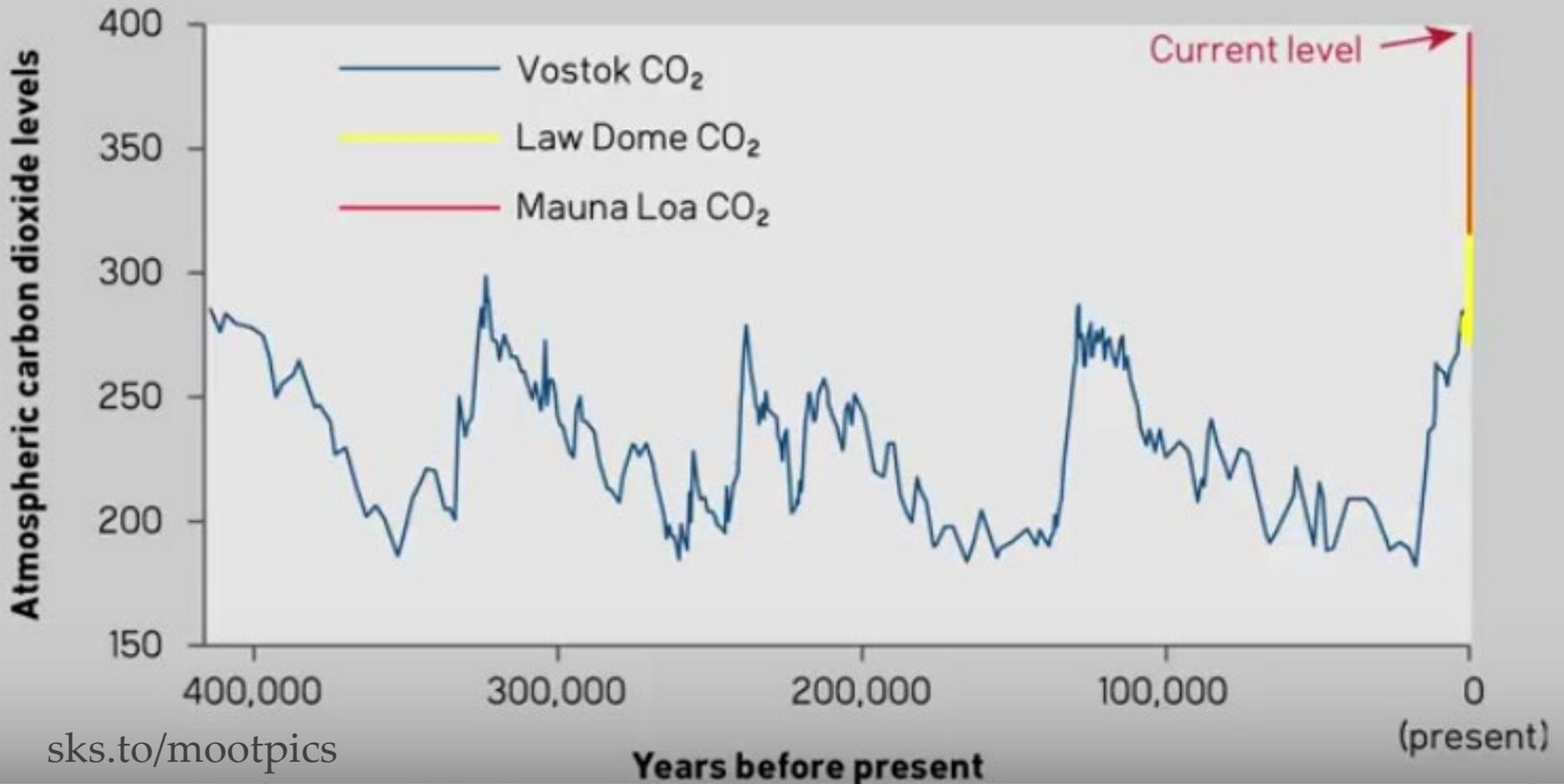


Nitrous Oxide and FCs
Very long airborne times and strong warming influence

Ozone that stays near surface is short lived. Local effects only.

Atmospheric CO₂ is Key

Atmospheric Carbon Dioxide



sks.to/mootpics

Haven't past climate changes happened?

Yes

We know this from ice cores, lipids in marine sediment, element ratios

But they occurred much more slowly, giving Earth's residents time to adapt

And haven't there been periods of cooling recently?

Yes

But they were minimal and short-lived

And quickly surpassed by more heating

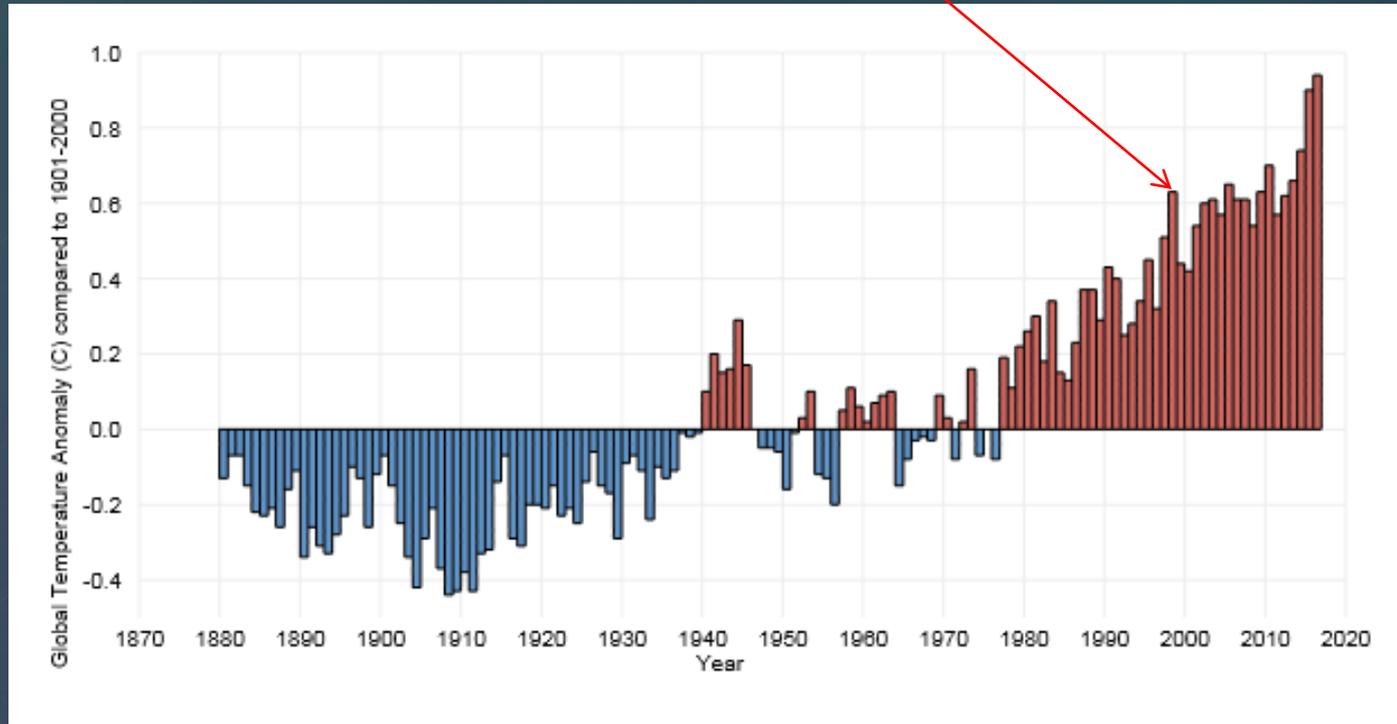
And didn't the records show that CO₂ increased before temperatures warmed?

Yes

In Antarctica

But not the rest of the globe

- ❖ During the 1980s, global warming became evident
- ❖ Some claimed it “stopped” in 1998. In fact, it just wasn’t as drastic; more ups and downs, but still warm.



Really, the warming has been clear for most of our lives

Climate Change Modeling is Uncertain

- ❖ How much will it warm? How fast? What about precipitation- where will it increase or decrease?
- ❖ IPCC has a number of internationally used climate emission scenarios, with different projections of warming
- ❖ Latest tools: Representation Concentration Pathways (RCPs)- focus on a specific GHG concentration by the year 2100

❖ Low-end warming

- Cuts in emissions
- Slowing population growth
- Major economic shifts
- +1.5°C (+2.7°F)

❖ Mid-Range

- CO2 levels off by mid-century, then drop
- Still leads to 2 - 5°F additional warming!

❖ High-end warming

- Emissions continue to worsen
- Population growth continues unchecked
- No economic controls
- +4.5°C (+8.1°F)

Wait, is it really CO₂?

It can't be our fault!

We can't change the world, can we?

- ❖ Sure, there could be unknown stuff happening.
- ❖ But, using the principal of Occam's Razor, or even the KISS principal:
- ❖ **The simplest solution, the one with the least assumptions, is probably the best answer.**



AND

- ❖ Why wouldn't the increase in CO₂ be causing such heating, when we know the physics and math behind how this works?
- ❖ Where else did the rapid rise in CO₂ come from, when we can mathematically calculate pollution and emissions?

Also, atmospheric modeling with CO₂ shows the Arctic will warm significantly faster than mid and low latitudes...



no other way has been identified that heats the planet in this same manner, which matches Arctic observations.

So how is Alaska's climate changing?

Bettles
Ft. Yukon
Galena
Fairbanks
Tok
McGrath
Anchorage
King Salmon

Smoke over Alaska,
Jun 24th, 2015

GINA Imagery



August 15, 1976



September 8, 2003

Glacier Bay: Muir Glacier
USGS Repeat Photography of Alaskan Glaciers

Changes microclimates



which affects
Vegetation and Wildlife



which affects
Subsistence,
Recreation, Tourism

Shrinking Glaciers



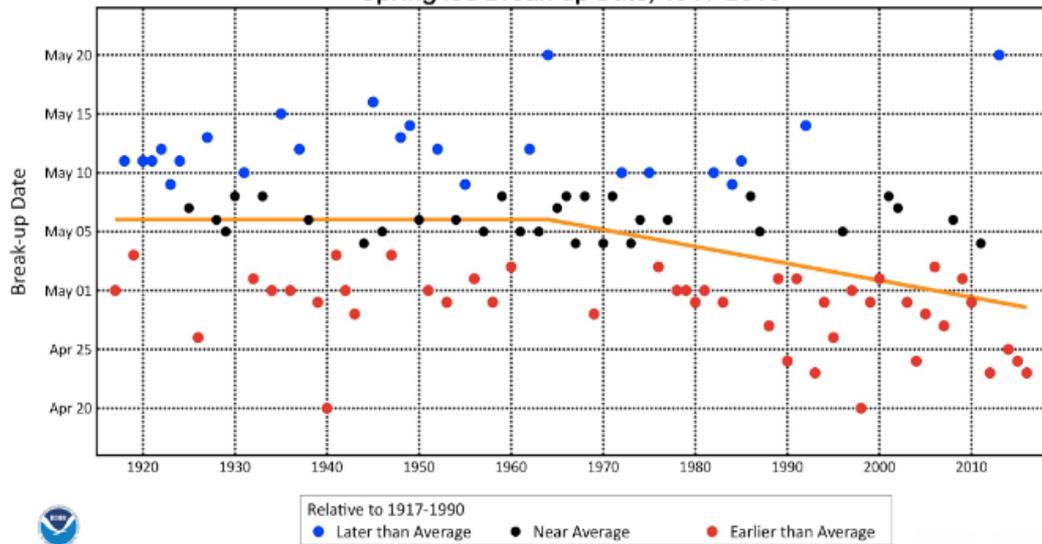
Gulkana Glacier 1967



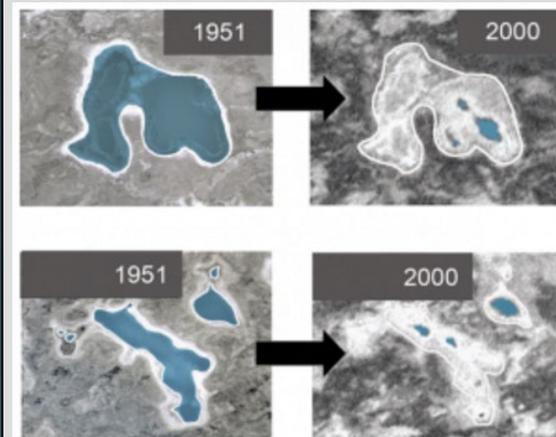
Gulkana Glacier 2016

Figure 27. Repeat oblique photographs of Gulkana glaciers in Alaska. 1967, Unknown USGS photographer. 2016, L. Sass, USGS.

Tanana River at Nenana
Spring Ice Break-up Date, 1917-2016

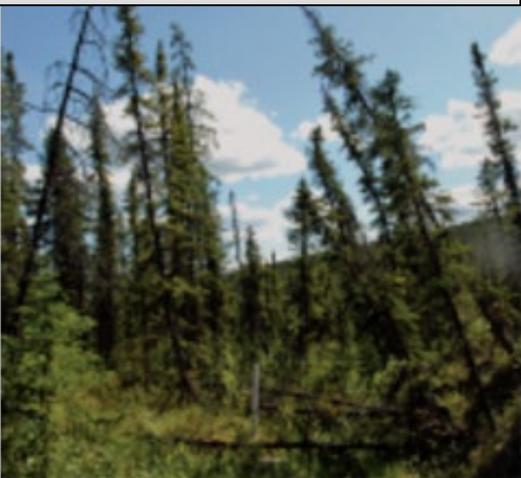


Ponds in Alaska are Shrinking (1951 to 2000): Yukon Flats National Wildlife Refuge



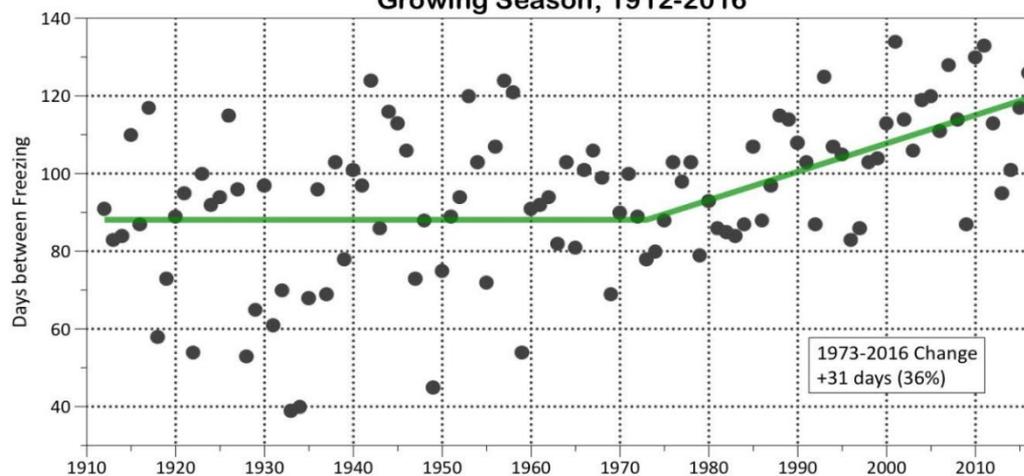
Ponds across Alaska, including those shown above in the northeastern interior of the state, have shrunk as a result of increased evaporation and permafrost thawing. The pond in the top pair of images shrank from 180 to 10 acres; the larger pond in the bottom pair of images shrank from 90 to 4 acres. Image Reference: Riordan et al.²⁰

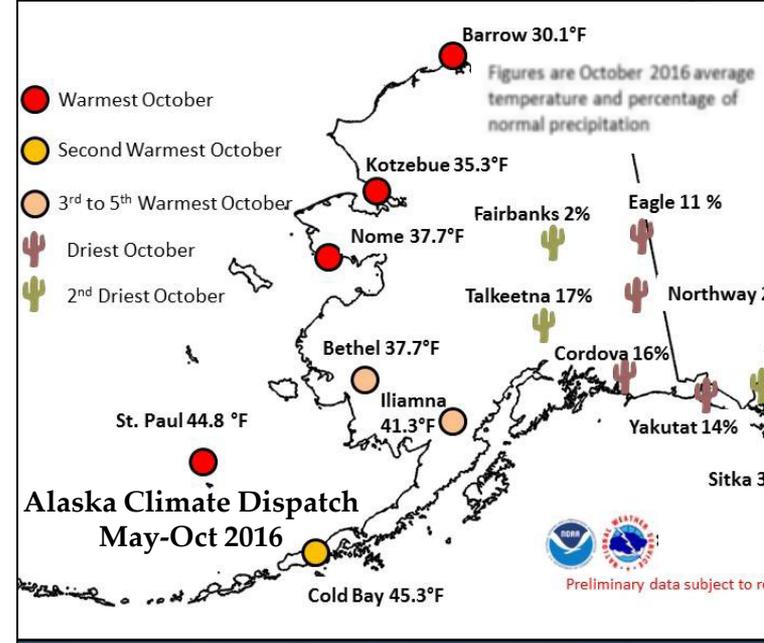
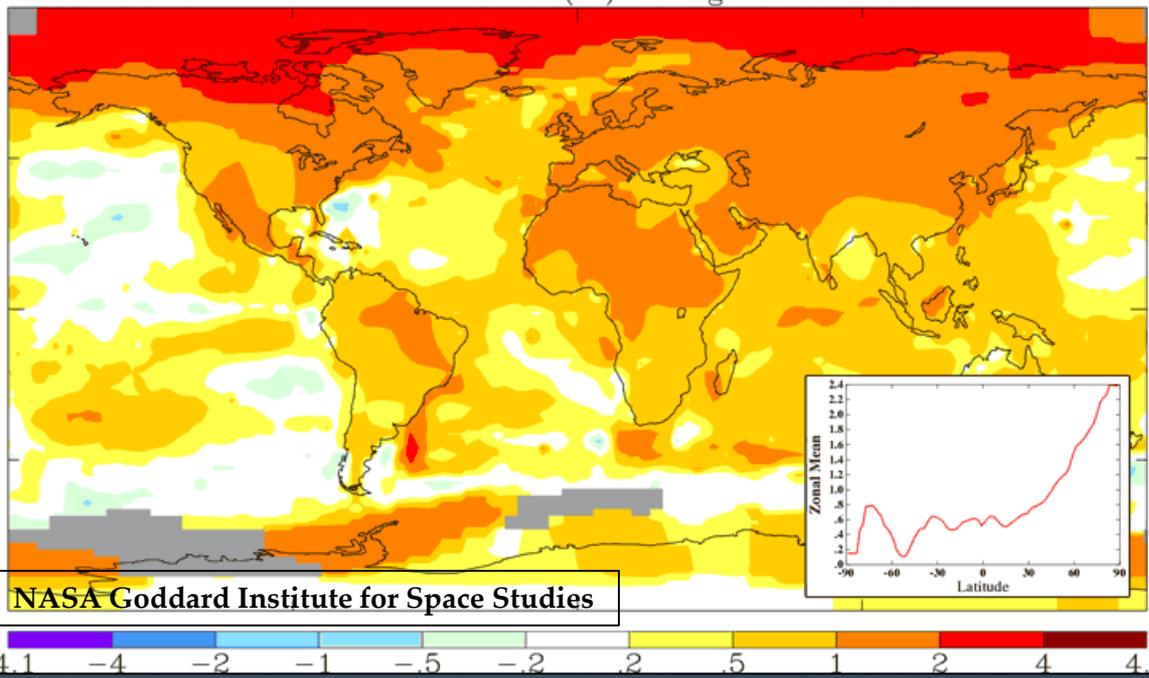
Alaska: Drunken Forest:
Leaning trees in this Alaska forest tilt because the ground beneath them, which used to be permanently frozen, has thawed. Forests like this are named "drunken forests."



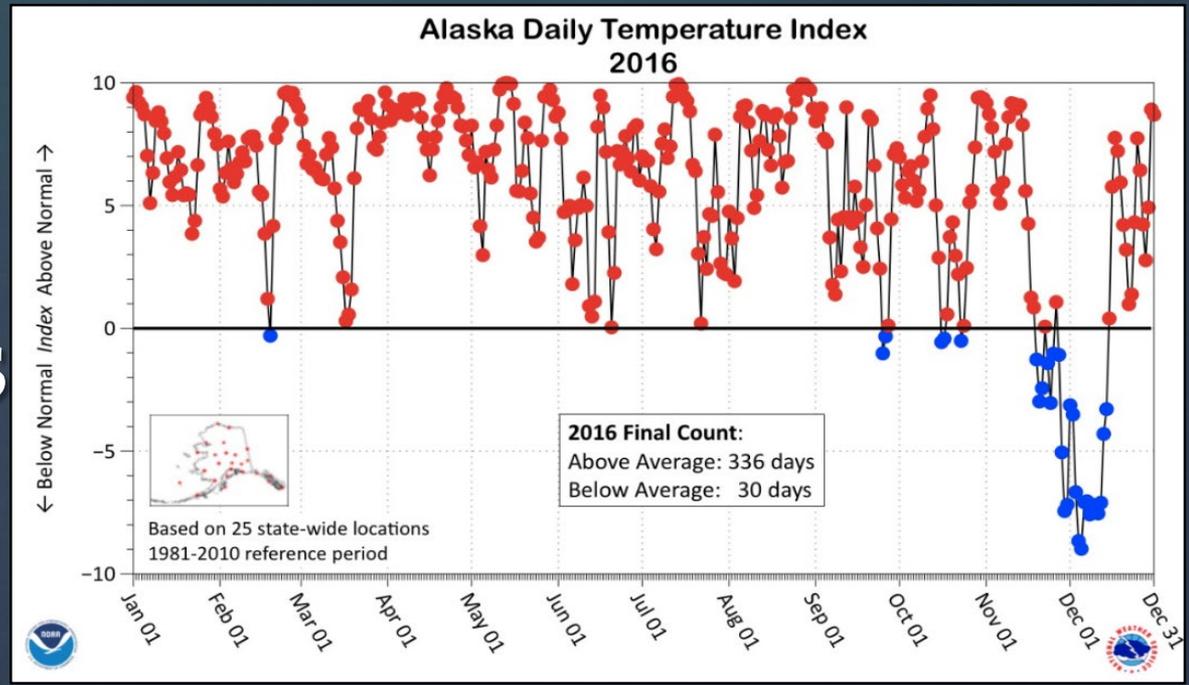
△ Landscape

University Agriculture Farm (Fairbanks)
Growing Season, 1912-2016





Increasing Temperatures



The Blob

Very warm pocket of water
in North Pacific

Began in late 2012

~300
1000s of mi

What is it?

ted

What were the Effects?

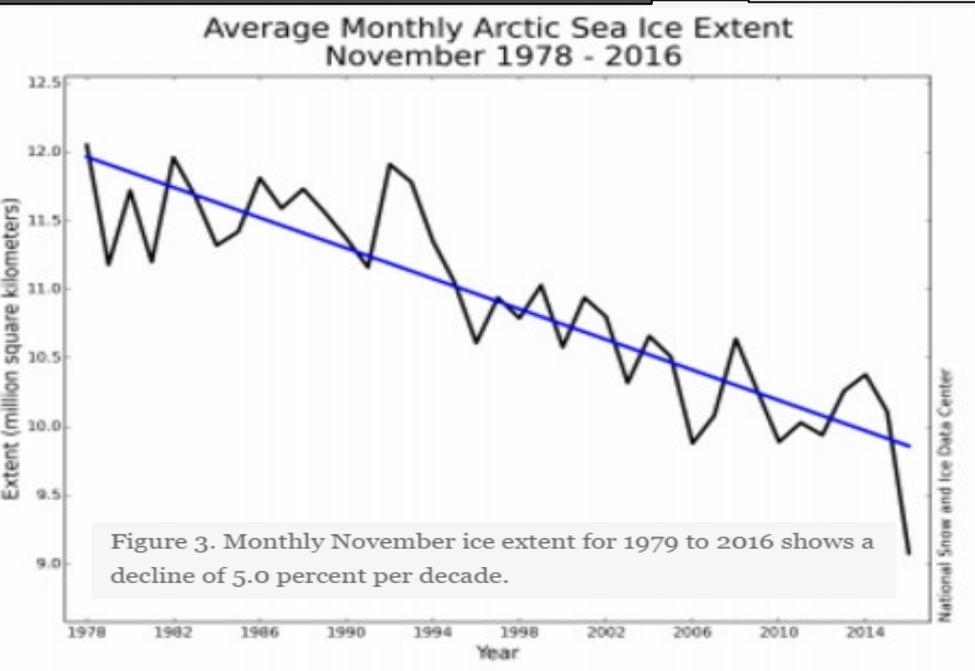
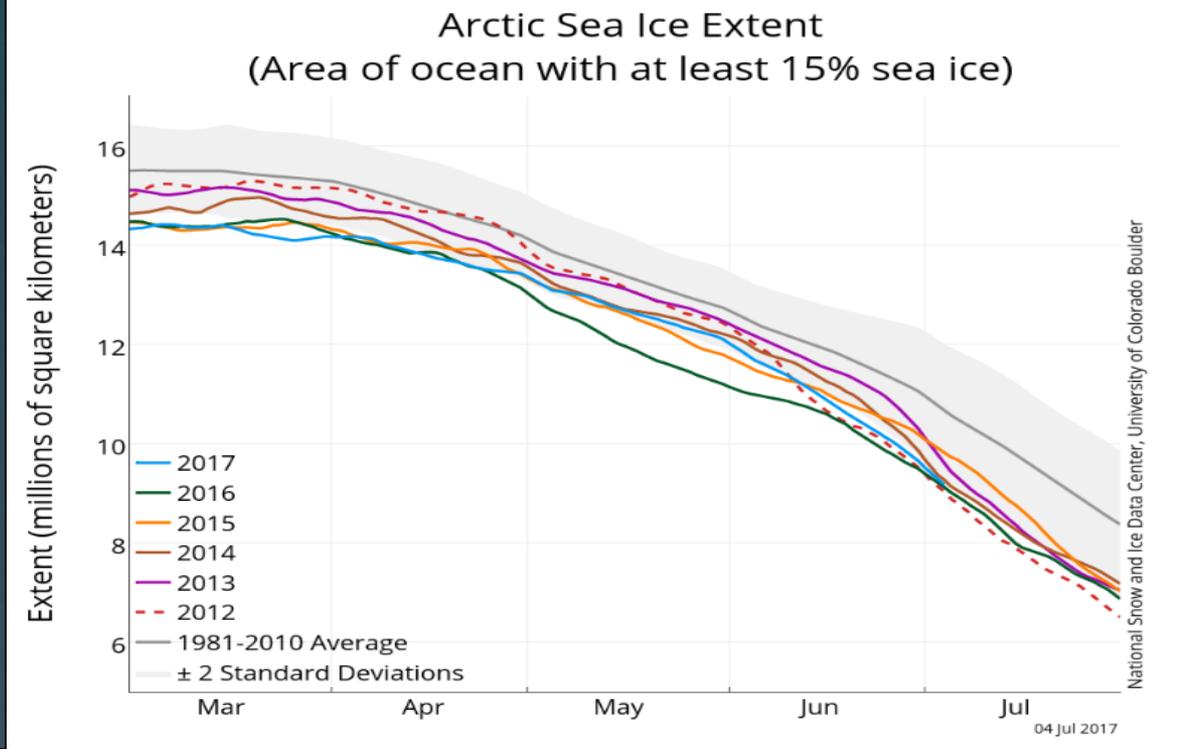
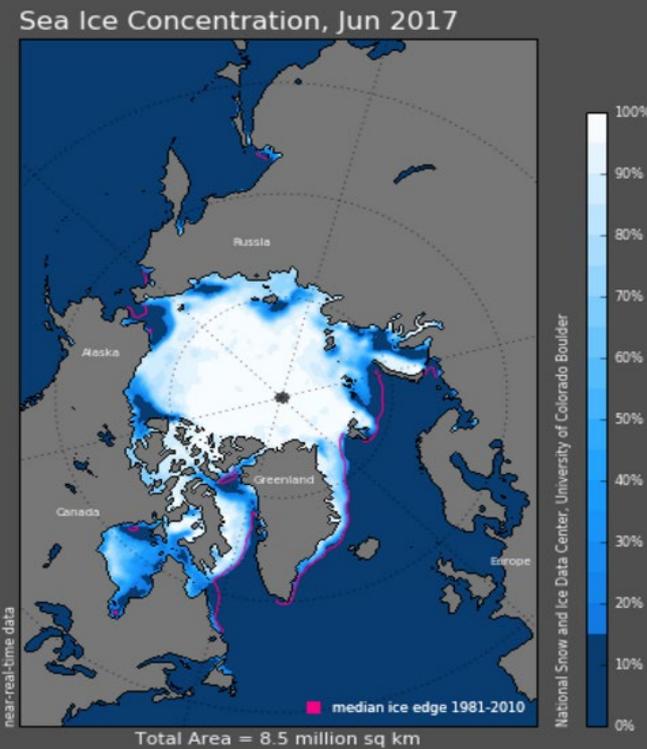
Crazy weather
CA, winter ra

and caused
oms

Ocean curre

h and
ie offs

Likely that Gulf of AK SSTs will be
5.8°F warmer by second half of
this century than they were the
second half of twentieth century.



Shrinking Arctic Sea Ice

Ice reflects light + heat

So, less ice

more absorption of heat

harder for ice to reform

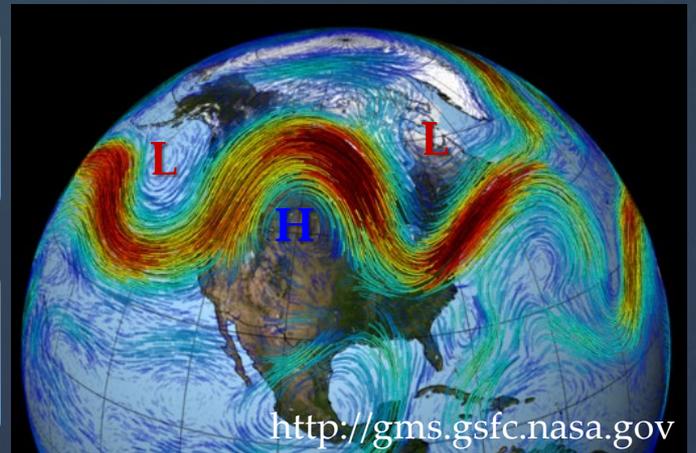
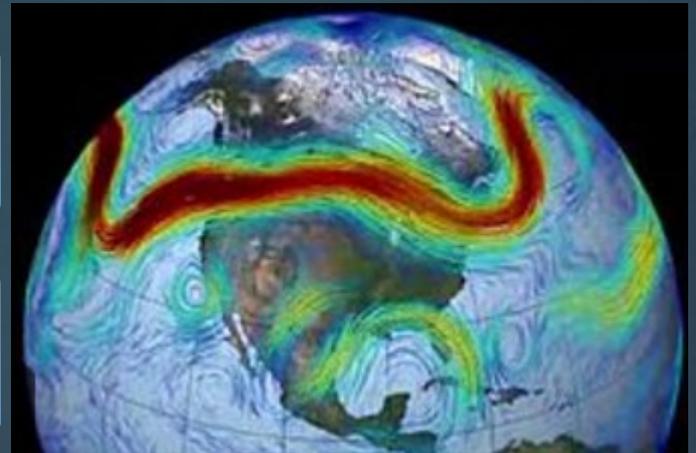
Link between Arctic Sea Ice and Jet Stream?

Positive Feedback Mechanism

Less ice = more warm water = warmer air near surface = more ice melts

Jet stream follows boundary between warm air in south and cold air in north.

- ❖ Warmer temperatures in the Arctic mean less temp gradient
- ❖ Less drastic gradient means a weaker jet stream that meanders a lot
- ❖ More likely to set up a blocking pattern, lengthening weather events



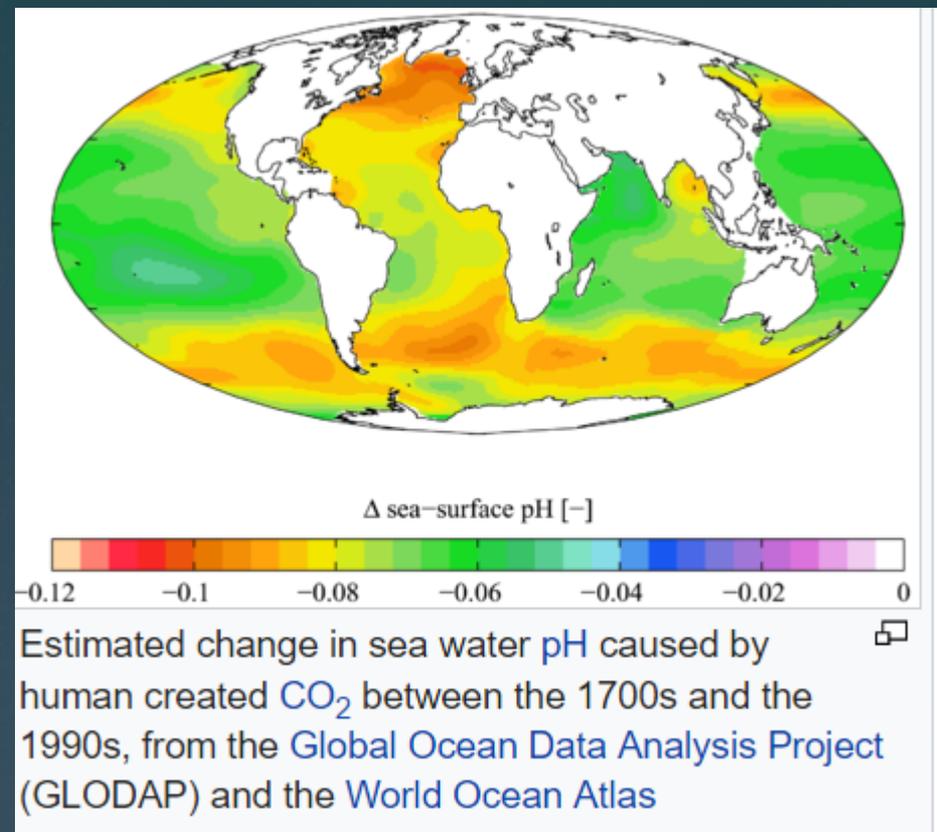
25% of CO₂ emissions are currently absorbed by oceans

CO₂ increases acidity of water by creating carbonic acid

Average ocean acidity has been rising since preindustrial times...10x faster than ever seen in the historical record.

Prevents ocean mixing, stratifies water to create "dead zones": die-offs of sea birds, mammals, kelp forests, coral reefs

Won't the Oceans absorb excess CO₂?

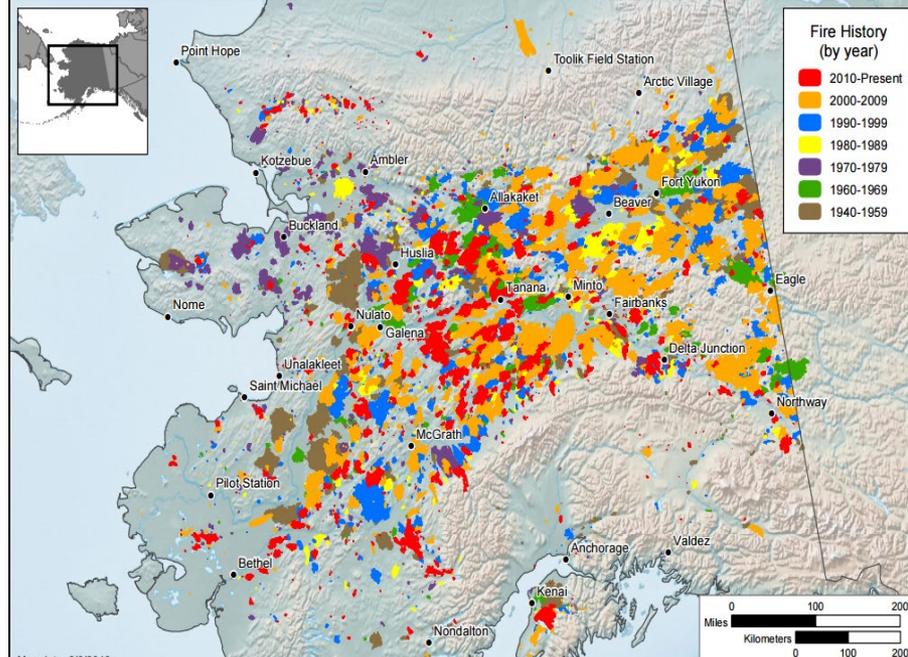
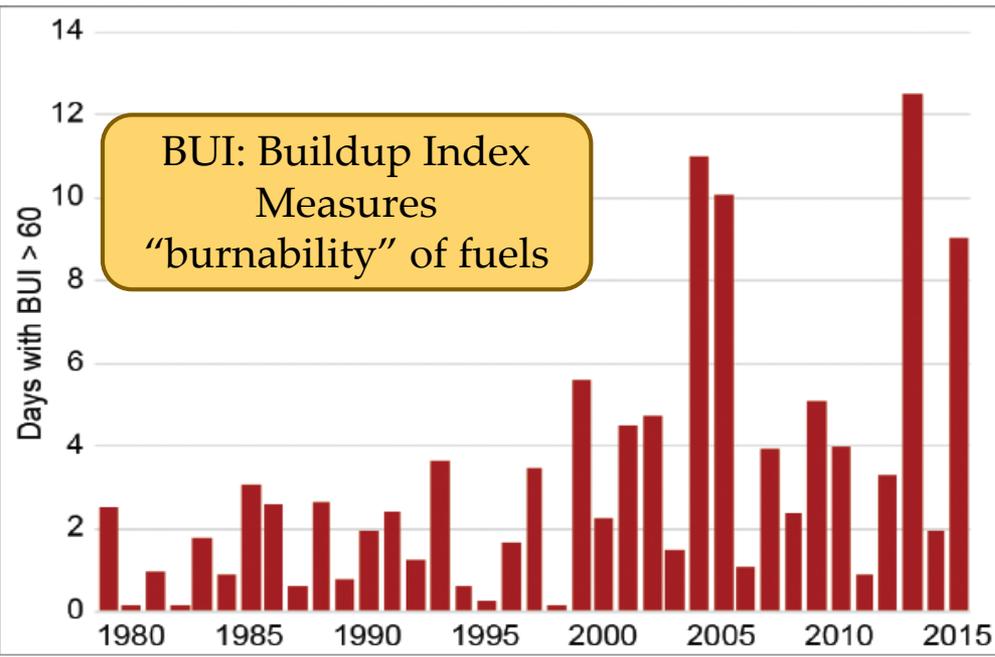
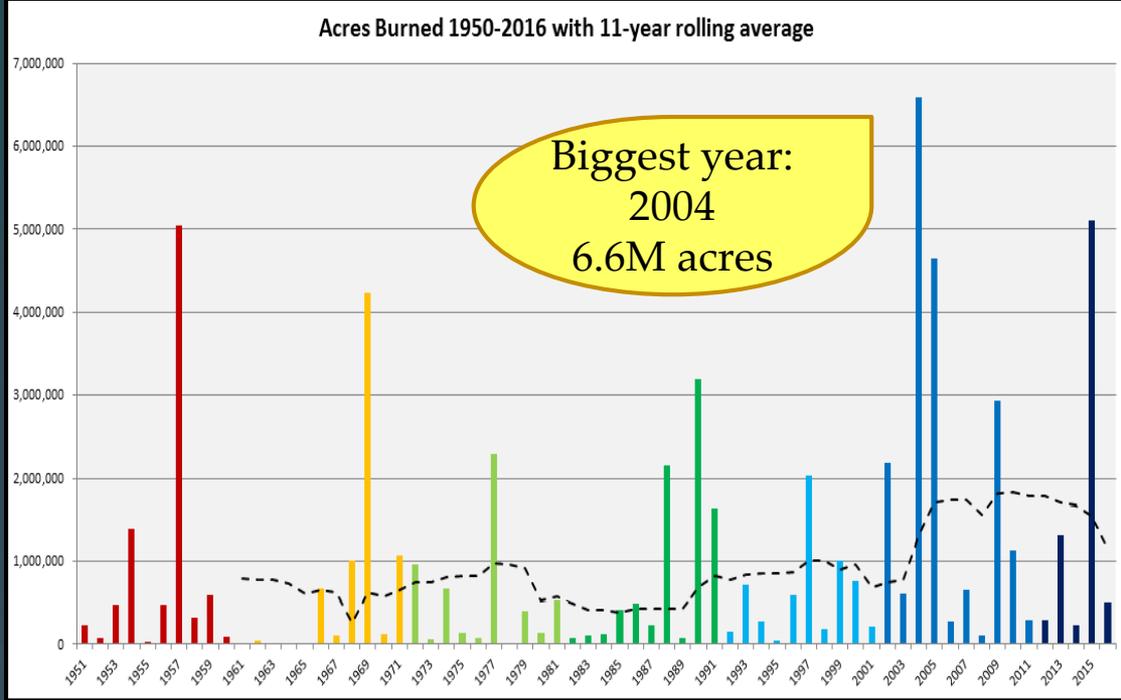


Effects are worst in the Arctic due to cold temperatures and low salt content

P.S.- Warmer water holds less gas, the earth is warming, so...

Analysis shows Alaska's 2015 fuel conditions are 34-60% more likely to occur in today's anthropogenically changed climate.

Wildland Fire Season



The Arctic is the world's refrigerator, dissipating excess heat to space



Why such changes in the Arctic?

Positive Feedback Effects

Shifts in the jet stream

Increased sea ice/glacial ice/snow/permafrost melt greatly increases solar heat absorption

More strong storms move farther north, breakup ice pack, bring in more warm air

Strong storms come later in the fall and earlier in the spring

The Arctic is a precursor to the rest of the globe

- ✓ No summertime sea ice in Arctic
- ✓ No wintertime
- ✓ Acidifying
- ✓ Change in
- ✓ More severe
- ✓ Sudden and
- ✓ Less snow,
- ✓ Some big s
- ✓ More severe
- ✓ Bad air qua
- ✓ More high
- ✓ A few low
- ✓ Large die-off

BIGGER

&

more v**A**Ri**a**b**L**e

weather events

ound the globe
 dfire seasons
 seasons
 n events
 o
 s
 politicians
 rastructure
 sing
 eather events

What will Climate Change bring?

- The Thinking Person's Guide to Climate Change, Robert Henson, 2014
- Skeptical Science Website, <https://www.skepticalscience.com/>
- Making Sense of Climate Science Denial Online Course, University of Queensland, <https://www.edx.org/course/making-sense-climate-science-denial-uqx-denial101x-3>
- NASA Global Climate Change Website <https://climate.nasa.gov/news/>
- The Guardian: Environment Website <https://www.theguardian.com/us/environment>

References